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# EMERGING COMPUTING PARADIGMS

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## 6.1 Introduction

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## 6

## Computational Intelligence Paradigms in Radiological Image Processing—Recent Trends and Challenges

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### 6.1 Introduction

A current boom in the modeling intelligence in algorithm to solve complex applications, this intelligence could be achieved through natural and biological intelligence, resulted a technology known as intelligent systems, these algorithms use soft computing tools. AI aim to make the machines and computers smarter, that make a computer to mimic like human brain in specific applications. AI algorithms are a blend of many research areas, such as biology, sociology, philosophy, and computer science. The purpose of AI is not to substitute human beings, instead offer us a more prevailing tool to support in our work, provide more computing ability, permitting them to exhibit more intelligent behavior.

### 6.2 Computational Intelligence

CI is a fragment of AI, which deals with study of adaptive mechanisms to enable intelligent behaviour in complex changing environment Figure 6.1. Shows all paradigm. Three main columns of CI are Fuzzy Systems, Neural Networks, and Evolutionary Computation, individual components have certain weakness and these could be improved by combining them tougher and they are referred as hybrid CI. Computers learn specific tasks from diverse forms of data or experimental observation, the ability to make computers learn and adapt is usually referred to as CI. It is considered to have the ability of computational adaptation, high computational speed, and fault tolerance. Computational adaptation means the ability of a system to adapt the changes happens in its input and output instances.

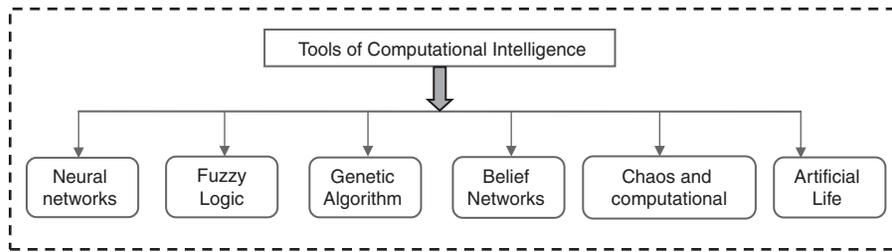
#### 6.2.1 Difference between AI and CI

AI deals with study of intelligent behavior exhibited by machines, mimicking natural intelligence similar to humans, AI aims to develop an intelligent machine which can think, act, and take decision similar to human. CI is the study of adapting and building intelligent behaviors based on a changing complex environment. CI is to recognize the computational model which make intelligent behavior of artificial and

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**Figure 6.1** Computation intelligence paradigm.

natural system in complex environment. AI and CI and have nearly similar type of goals but they are moderately different from each other.

### 6.2.2 Tools of Computational Intelligence

CI is the theory design, application, and development of a biologically motivated computational model. Traditionally it has three pillars, they are neural networks, fuzzy system, and evolutionary computational. It encloses computing models like artificial life, culture learning, social reasoning, and artificial hormone network. CI plays a major role in developing successful intelligent systems that includes games and a cognitive developmental system. In reality, some of the greatest successful AI systems depend on CI.

## 6.3 Radiological Image Processing Introduction

Information is knowledge and it can be represented in different forms, digital image or image is one of them, image is worth 1,000 words. Most commonly, humans depend on images perceived by our eyes more than any other sensory stimulus. Human eyes capture the image, the brain extracts information and interprets the objects. Today, most of the computer vision and machine learning applications are working on the similar lines. The drastic improvement and proliferation of radiological imaging has changed the medicine, allowed physicians and scientists to gather information by looking noninvasively into the human body. Medical imagery role has extended beyond visualization and inspection of anatomic structures, acting as new tool for surgical planning and simulation, intraoperative navigation, disease progress tracking, and radiotherapy planning etc.

Medical diagnostics, today, extensively depend on direct digital imaging techniques, almost all radiological modalities are available in the digital formats. Complexity of information differs from one modality to other that ranges from X-ray to MRI or an ultrasound image of an organ. Radiological application started with analog imaging modalities and today all are in digital format due to improvement in sensor and computation technology, almost all radiological application is in digital today. Medical images efficiently processed, objectively assessed and accessible at several places at same time through protocols and communication networks, such as Digital Imaging and Communications in Medicine (DICOM) and Picture Archiving and Communication Systems (PACS).

Digital image processing is an area of science and mathematics that manipulate the information present in the image, after manipulation the results could be input to several applications. We find digital image processing applications in almost several areas of engineering and science that ranges from space exploration, robotics to medical applications. Digital image is a two-dimensional function that is represented in a matrix, as rows and columns, the smallest entity is referred as pixel/pel. The stages in digital image processing involves acquisition of image using sensors such as a charge-coupled device (CCD), store and process using digital computer and finally display or print. Processing of radiological digital image involves image enhancement, image restoration, image analysis, image segmentation, image compression, image synthesis, and image quantification. Digital image is represented in different forms as black and white, grey scale, color and compressed images, image resolution, and type of image are directly correlated with data dimension. A medical image is commonly blurry and noisy due to acquisition stages, the degradation of the image is due to poor contrast or illumination and noise. Biomedical image analysis involves several stages and these stages are commonly requirements for subsequent stages, the final stage involves storage and decision making on capture image by medical practitioner or by machine to assist radiologist. These stages involved are image acquisition, image enhancement and restoration, image segmentation, image classification and quantification, to perform these algorithms more efficiently and precisely they need to be intelligent and fast in computation, CI is the best tool for these algorithms.

Radiological imaging is a vastly interdisciplinary field, which is combination of physics, medicine, computer sciences, and engineering. Primarily, radiological/biomedical imaging analysis is relevance application of digital image processing to medical or biological problems. However, in radiological image application a number of other fields play a vital role, like physiology, anatomy, and physics of the imaging modality and instrumentation, etc. The diagnosis or interference in medical application delivers the basis and motivation for biomedical image analysis. The choice of an imagery modality and of possible image processing stages depends on various medical factors, such as the type of tissue to be imaged or the suspected disease. Radiological imagery applications consist of four different stages, generally each stage is connected to the future subsequent stages, but at any required stage the algorithms allow human to human intervention to make decision or the results could be recorded. Imagery application have these minimum stages as image capturing (acquisition), image enhancement and restoration, image segmentations and classification, and finally image quantification shown in Figure 6.2.

### 6.3.1 Image Acquisition

Image acquisition is the first step to form the 2-dimension object digitally, such as a suspicious tissue in a patient, spatial resolution is significant in biomedical imageries. Digital image is mapping of one or several tissue properties on the discrete quadrangular grid, these grids are pixels voxel (volume element) in 3-dimensional images, these discrete values are stored in memory as integer values. Each pixels or voxels have physical meaning, example endoscopic and photography image values that are relative to light intensities. Computed Tomography (CT) carries image values

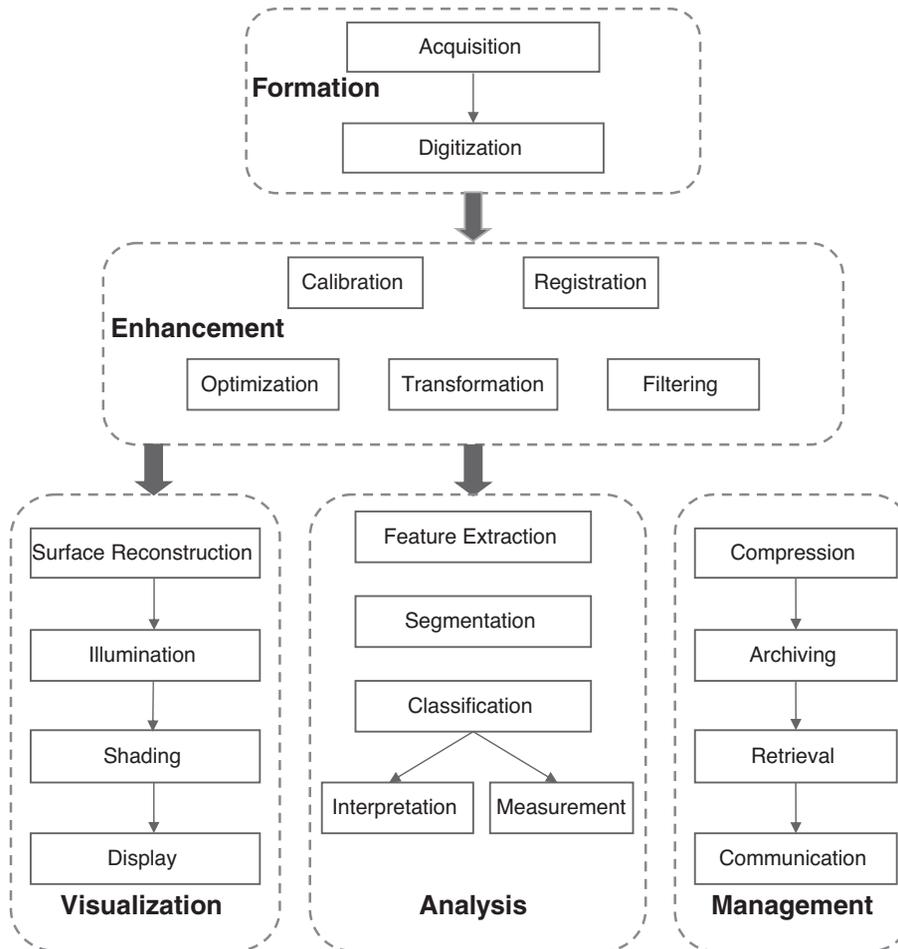


Figure 6.2 Digital radiological image processing.

that are relative to local X-ray absorption. In MRI, the image values can represent a variety of tissue properties, liable on the acquisition sequence, essentially times proton density or local echo decay. The aim of the image acquisition step is to acquire contrast of the tissues, to analyze. The human eye is enormously superior at recognizing and classifying meaningful contrast, even in condition with poor signal-to-noise (S/N) ratio. Human vision permits immediate recognition and identification of spatial associations and makes it conceivable to notice subtle differences in density and to filter the feature from the noise. Experienced radiologist will have no trouble in identifying normal and abnormal tissues from the radiological digital images, but for computer it is a challenging task to do, next steps of image processing steps involve into the role and they are more significant for automation.

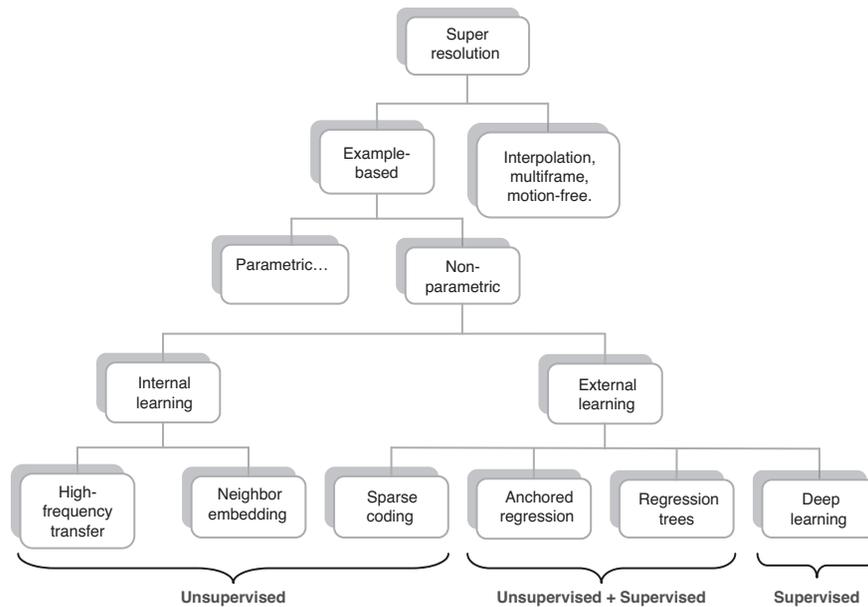
**Image Enhancement:** In computer vision and machine learning application, resolution of image is substantial for two purposes, first it improves the perception visibility features for more accurate and precise diagnosis by radiologist. Secondly, subsequent stage performs in best possible ways like segmentation, identification,

classification, and quantification image data. Pixel value remapping, filtering (spatial and frequency), and few restoration methods are most commonly used enhancement operators. Histogram equalization and histogram stretching are two linear and non-linear enhancement techniques. Filters attenuate/amplify relevant characteristics of pixels in an image, and filters make use of pixel vicinity. Filters work on pixels known as spatial domain filters and those which uses transforms such as discrete cosine transform, fourier transform and wavelet transform etc., which defines image data in terms of periodic components they all come in frequency domain filters. Filter play a vital role to improve smoothing an image, sharpening edges of objects in an image, and suppress periodic artifacts, to eliminate in an heterogenous background intensity distribution.

Image restoration and enhancement, they work on the similar line to improve the degradation in image. Image degradation occurs to due to misfocus of lenses, noise and due to motion blur of camera, degradation of image occurs at the acquisition process itself. To reverse the degradation of image we require filters and these filters work on reverse degradation process, such that errors (mean-squared error) is reduced between the restored image and idealized unknown image. Application of microscopy imaging inhomogeneous illumination play a significant role; this illumination may vary over time and this leads to introduction motion artifacts. While filters employed to overcome blur effect, they require well stable design measures, otherwise local contrast enhancement led to increase noise component and therefore decrease in the signal-to-noise ratio. Equally noise reducing filters negatively affect details of texture and edges, while these filters enhance the signal-to-noise ratio, details image may be lost and get blurred. Design of enhancement filter depend on the further steps of image processing stage. Enhanced image is always preferred may be for machine perception or human observation, human eyes distinguish particular objects from image even there is significant noise exist, but machines can't do the same. Improving resolution of image is possible by several techniques. Super Resolution (SR) image and Image Fusion (IF) are commonly employed methods in number of applications.

### 6.3.2 Super Resolution Image Reconstruction

Super Resolution (SR) is a process in which perceptual quality of image is improved by replicating neighbouring pixels, zooming pixels, or by adding multiple frames of same image to be reconstructed. Machine learning approaches contribute a large number algorithm, which is shown in Figure 6.3. Currently, the efficiency and accuracy of SR techniques based on machine learning reached a stage where high-end computational resources high resolution image reconstruction is conceivable. The choice of the finest suited algorithm must consider number of aspects, such as medical imaging, robotic supervision of objects or satellite imagery applications, etc. It is always essential to apply external learning, in terms of memory requirement and computational complexity allowed i.e., accuracy trade off and processing time. Over all the selection of SR algorithm to each problem need a careful attention of the limitations presented by the application situation. Biomedical image enhancement is a process to remove and reduce the artifacts originated due to improper illumination ambience, several researchers addressed SR in transform domain, it is observed few



**Figure 6.3** Machine learning methods in super resolution image enhancement.

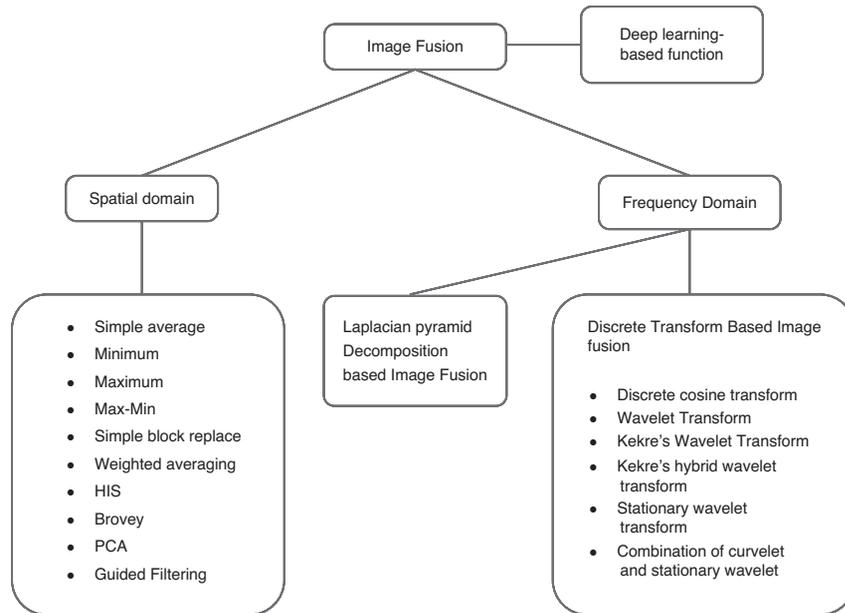
pixels are lost in the process of transformation from one domain to other. Edges of objects i.e., diseased tissues involve a significant role in image analysis, identification and vision processing. As pixels are lost due transform domain mapping edges of tissues, boundaries, and textures are degraded that leads to inappropriate diagnosis. Image enhancement algorithms are always application specific; these has to be addressed the specific radiologist sensitive to contrast ratio and their preference has to be evaluated.

### 6.3.3 Image Fusion

Image fusion is a process of combining multiplex images, from multiple sensors and combined to form single image, always this image is having more information than the individual one, and consist all relevant information. The aim of image fusion is to construct better quality, more suitable for machine and human perception. Image fusion is carried out as pixel fusion, feature fusion, and decision fusion. Image fusion has tremendous demand in the area of radiological diagnostics followed with appropriate treatment. The term multi-image fusion refers to combining multiple images of a patient from the same modalities or images taken from different modalities like MRI and CT image, etc., different image fusion techniques are available today shown in Figure 6.4.

### 6.3.4 Image Restoration

Image restoration is a mathematical operation on corrupted digital image and estimate clear original image, the degradation of image may be due to object camera misfocus, noise, random atmospheric turbulence, and motion blur. Image enhancement and



**Figure 6.4** Image fusion techniques.

image restoration are not same, this process improves features of the image which are informative in further stages. Thus, image restoration concentrates to noise function and modeling blurring, then applying inverse model to de-blurred and de-noise the image. The objective of image restoration is to develop restoration algorithm to filter and eliminate the degradation from input image in doing this soft computing and computation intelligence play vital role.

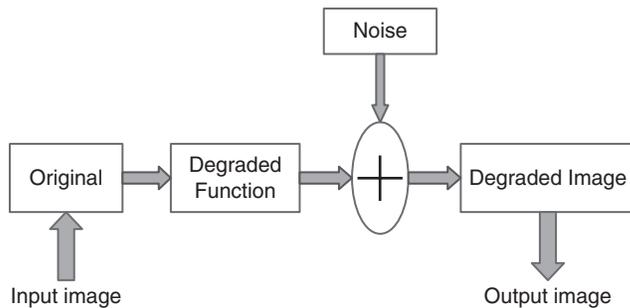
Digital image restoration deal with method used to suppress a known degradation to recover an original image. It's upcoming field of an image processing. The objective of image restoration is to restore distorted/degraded image to its original quality and content. Degradation is introduced by an image acquisition device due to nonlinearity of sensors, defects in optical lenses, blur due to misfocus of camera, relative object camera motion, atmospheric turbulence, etc.

It tries to minimize some parameters of degradation and reconstructing an image that has been degraded based on known degradation (prior knowledge) models and mathematical or probabilistic models. Usually, iterative restoration techniques attempt to modeling degradation and then applying the inverse process to recover the original image.

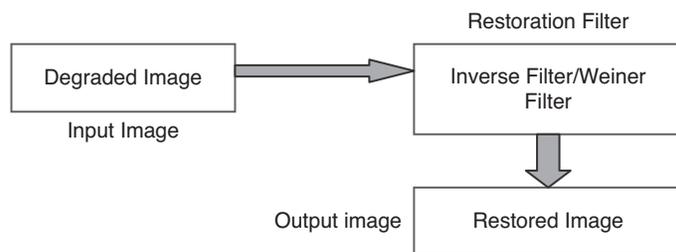
There are two subprocesses:

- i) By adding noise and blur to an image degrading the quality of an image.
- ii) Recovering the original image

In restoration application deblurring is very important because visually blurring is annoying. The different kind of filters and additive noise are used for blurring an image. Quality of image is degrading by adding Gaussian and salt pepper noise, as shown in Figure 6.5.



**Figure 6.5** Degradation model for blurring the image.



**Figure 6.6** Restoration model.

### 6.3.5 Restoration Model

This process estimates from degraded version using filter restoration blur and noise image factor is removed in order to obtained original image, as shown in Figure 6.6.

Ma. Guadalupe Sanchez et al. [1]. In the recent decade, several optimization methods are proposed depending on the type of noise. This paper explained the algorithm to remove Gaussian, speckle, and impulsive noise. NDF, PGFM, and PGFND methods were used for filtration purposes and compared obtained quality result in each case. If the Gaussian and speckle noise is present NDF method perform good to reduce the noise. If the impulsive noise (fixed) is appeared in an image then the best technique is PGFM and to deal with the combination of various noises PGFND techniques is able to reduce the noise more effectively.

A. Lakshmi and Subrata Rakshit [2] described object evaluation method were analyzed by comparing proposed and distortion measures with different restoration algorithm for the estimation of undistorted image which automates the process of restoration in real time without demanding any kind of knowledge about original image and it's derived without any assumption of image statistics and noise. The given measures have noise assessing terms and data fidelity term thus analyzing denoising as well as deblurring nature of image restoration method.

A.M. Raid [3] present image restoration based on morphological operation. There are two main morphological operations i.e, dilation and erosion. In dilation operation the object is expanded, thus small holes are filled and it connects to disjoint objects. The proposed methodology mainly focuses on two basic morphological algorithms (region filling and boundary extraction) and four morphological operations (opening and closing, dilation and erosion). It's implemented using the MATLAB

program with user interface which changing the SE parameters such as its type or size are simple but if the objects are near with the distance then it will be stuck together, thus it's need to solve this program by searching objects.

### 6.3.6 Image Analysis

Image analysis is an extraction of meaningful information from input image, with these information algorithms will able to identify the objects, the more feature we provide the better classification and identification we can achieve. In achieving high accuracies, the algorithm needs to be more intelligent and faster to respond, these can be achieved using deep learning, neural network, capsule network, and computation intelligence.

### 6.3.7 Image Segmentation

Image segmentation is one of the most significant steps in digital image processing, it is to separate foreground and background, which are treated as different objects in an image. The goal of segmentation is to classify each of the pixel as one of the classes and extracting region of interest (ROI). To achieve image segmentation effectively, the object must be different from one other, such as boundary, image intensity, texture, and shape etc. The aim of this stage may be either an outline or a mask i.e., outline may be a set of curves or parametric curve, like polygonal approximation of an object outline (shape), mask is to assign pixel value 1 to objects and treat back ground pixels as 0 or vice versa. Image segmentation is one of the most complicated tasks, we have several segmentation methods and they are more application specific. Segmentation process should stop when the region of interest has been isolated. An outline of the most widespread segmentation techniques as follows, shown in the Figure 6.7.

**Edge-based Segmentation:** Edge detection is a mathematical operation is an image processing, it detects boundaries of objects present in an image. It works with detecting sharp changes in intensity of the pixel that typically forms boarder between different object. Basic idea of edge detection is look for neighborhood pixel with strong sign of change. These pixels are easily detected by computer on basis of intensity differences. Mainly it's process of finding meaningful transaction in an image. Feature extraction, image morphology, and pattern recognition can be achieved by edge detection. It extracts the features such as corners, lines, and curves of an image. Therefore, it is very easy to recognize segmentation boundaries and objects. Edge

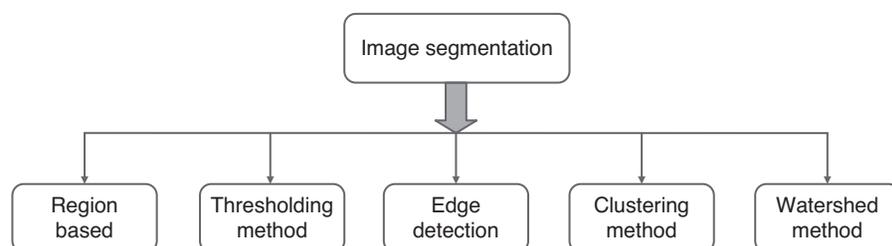


Figure 6.7 Different image segmentation.

detection steps consist smoothing, enhancement, detection and localization of an image. Commonly used edge detection types are step edge, ramp edge, ridge edge, and roof edge.

**Edge Detection Approaches:** Spatial domain and frequency domain are two classes of edge detection. Spatial domain includes operator-based approaches categorized into first order and second order method. First order methods are Prewitt, Sobel, and Robert. Canny and Laplacian are second order methods. Fourier transform method is used to convert the image into frequency domain. Using the low frequencies, the details were extracted from the image. High frequencies were used to obtain image edges, but frequencies having certain limitations.

**Gradient-based Edge Detection:** It is a first order derivative which computes gradient magnitude horizontally and vertically. Implementation of gradient-based edge detection method is very simple and capable of detecting edges and their directions. But edges are not located accurately because it is sensitive to noise.

**Sobel Edge Detection Operator:** This operator extracts all the edges without worrying about the directions. It computes gradient approximation of image intensity. It uses the  $3 \times 3$  kernel convolved with input image to compute vertical and horizontal approximation, respectively. It provides smoothing effect and time efficient computation. But it has certain limitations, it is highly sensitive to noise, not very accurate because it does not give appropriate result on thick and rough edges.

**Prewitt Operator:** Prewitt edge detection operator detects vertical and horizontal edges of an image. It uses kernels or masks. It is a best operator to detect magnitude and orientation of an image.

**Robert Edge Detection Operator:** It is used to compute the sum of square of difference between diagonally adjacent pixels in an image through discrete differentiation. In this operator orientation and detection of edges are very easy. It preserves diagonal direction point but it is very sensitive to noise therefore not accurate method for edge detection.

**Laplacian of Gaussian (LOG):** It is derivative operator that uses the Laplacian as a second derivative of an image. It is used to find sharp edges of all directions having a fixed characteristic and easily detects the edges.

**Canny Operator:** It is a Gaussian-based operator. Canny operator is most commonly used because it can extract features of an image without altering the features as well as it localizes the edge points and is less sensitive to noise.

**Thresholding Based Segmentation:** Thresholding is the simplest and most powerful technique in image segmentation. In this technique depending on intensity value the pixels are partitioned. Based on threshold value from the grey scale image it produces the binary image. It has advantages such as fast processing speed, smaller storage space, and ease in manipulation compared with grey level image. Therefore, thresholding technique is commonly used.

**Clustering:** A collection or arrangement of similar items is called clustering. The clustering method groups together a similar pattern and can produce a very good segmentation result. In clustering it is frequently important to change the information during preprocessing and demonstrate the parameters until the outcome accomplishes the desired properties. There are different clustering methods, K-means, fuzzy C-means, mixture of Gaussians, and ANN clustering.

- **K-means** clustering method uses unsupervised algorithm. The result is well separated. K-means is fast and robust but it has noisy data and a nonlinear dataset.
- **Fuzzy C-means** uses an assigning membership algorithm with a cluster center. But the result is overlapped and comparatively its better than K-means.
- **Mixture of Gaussian** algorithm is based on a priori “n” Gaussian. Where all data taken is the minimum and maximum from Gaussian centers. This method is best for real-world data but its complex in nature.
- **ANN clustering** is based on priori data. Whose result were well separated. An ANN is mainly working on noisy image but it has slow convergence rate.

### 6.3.8 Region-Based Segmentation

The region-based segmentation is used to classify a particular image into number of regions or classes. Therefore, we need to estimate and classify each pixel in the image. Methods of region-based segmentation are region growing, texture-based segmentation and edge-based snakes. Region growing is general technique of image segmentation, where image characteristics are used to group neighboring pixel together to form regions. Region based techniques look for consistency within a subregion based on a property like intensity, color, texture etc. Region based segmentation starts in the middle of an object and then grows slowly towards till it meets the object boundary.

### 6.3.9 Watershed Segmentation

Watershed segmentation is morphology segmentation, that use watershed transform, that belongs to a region-based segmentation technique. Watershed transform can get one-pixel wide connected closed, accurate positioning of the edge. This algorithm is automatic and doesn't require any parameters to determine the termination conditions.

Namata Mittal et al. [4] In this study, efficient edge detection approaches analyzed for image analysis. Proposed method is tested on normal and medical images and compared with all traditional edge detection algorithms. Developed method is capable to obtain better entropy value and edge continuity along with less noise proportion. It is not effective for blurry images and time consumption need to improve. The problem encountered in traditional edge detection technique i.e., connectivity and edge thickness can be solved by B-Edge, that uses multiple threshold approaches and for effective edge detection and better connectivity the proposed methodology uses the triple intensity threshold value. Finally, it was concluded that B-Edge obtained a better outcome than canny. Developed method is able to perform good connectivity with improved edge width uniformity and produces acceptable entropy value.

Yousif A Hamad et al. [5] notes a low contrast medical image edge detection based fuzzy C-mean clustering have been developed. A canny edge detection algorithm performs well among all edge detection techniques. A FCM clustering segmented the image. Algorithm and software will develop in order to provide image analysis to its primary stage. To solve urgent diagnosis problem more analysis and processing will be done for real-time clinical CT and MRI imagery.

Tessy Badriyah et al. [6] notes that stroke classification is conducted in this study. CT brain imagery consist of more noise. Mainly in thresholding the gray scale image is converted into binary image to segment the affected tissues from CT image. Here global threshold and Otsu threshold is used for classification of stroke i.e., ischemic stroke classes, no stroke (normal) and hemorrhagic stroke. The proposed methodology is experimented by analyzing three filters i.e., Gaussian filter, bilateral filter, and median filter to remove noise. Quality of image is improved using peak signal-to-noise ratio i.e., 69% and mean-square error i.e., 0.008% with bilateral filter. Otsu thresholding is used for stroke object segmentation by specifying lower threshold parameter  $\leq 170$ .

Alexander Zotin et al. [7] describes the proposed methods to detect the brain tumor from patients MRI scan image. In the first step, noise removal functions like median filter were used to improve features of medical images for reliability and enhancing balance contrast enhancement techniques (BCET). This image is segmented by a fuzzy C-means method and canny edge detector is applied to construct the edge map of brain tumor. In this paper they have compared sensitivity and accuracy parameters of different detection methods with proposed method. After comparing they have combined cany and fuzzy C-means together for better accuracy and sensitivity than the other single methods.

Cui, Xuemei et al. [8] has proposed algorithm based on an improved watershed transform method. Watershed transform has good response to the weak edges, but it is unable to obtain meaningful segmentation result directly. Therefore, they have made some improvements. Here they have briefly explained about image segmentation, watershed algorithm, and marker extraction. Watershed transform is the morphology segmentation method, mainly used for the study of the forms shape or structure of things. This method can suppress the noise and fine texture very accurately by avoiding over segmentation.

Abubakar et al. [9] has described about two categories of image segmentation. Here they have explained about sobel, canny and Robert cross field. Image segmentation is a segmentation of an image that is used in separating the object of an image from its background. From the experiment it was observed that canny edge detector better edge detection maps. And other image thresholding success fully separated the frequency from background.

Dubey et al. [10] gave a brief review about the image segmentation using different clustering methods. Clustering is the collection of an arrangement of articles such that items in a similar gathering called cluster. Here they have described about different clustering techniques that are K-means, fuzzy C-means, ANN clustering, and a mixture of Gaussians. By doing comparative study among these techniques by taking some important parameters such as data center, algorithm used, advantages and disadvantages, and final best result. After comparing they have concluded that fuzzy C-means is better than K-means. The mixture of Gaussian is used in real-world data.

Xu Gongwen et al. [11] describes wavelet transform base medical image segmentation as a broad term that encompasses a large range of applications. In this paper, analyzed frequency and time domain tool with some good features. It reduces noise and pointed the edges more precisely. The derived model solved all the problems that occur during traditional and classic algorithm. More analysis can be done

that will enable us to improve new algorithm for segmentation of medical images with very rapid, adaptable, and accurate results.

Deng Ping Fan et al. [12] notes in this paper, automatic COVID-19 infection segmentation were observed. Methodology is developed to identify the infected region using segmentation network named Inf-Net. Semi-Inf-Net and MC is used for the segmentation of Ground Glass Opacity (GGO) and consolidation infection, they are accurately segmented. This study research will focus on integration of segmentation, quantification, and detection of lung infection. Also, it will work on multi-class infection labeling for automatic AI diagnosis.

Qingsong Yao et al. [13] describes the focus of this study was to implement label free segmentation for COVID-19. We observed that normal net methodology is quite good compare to other UAD methods and NN-net using bright pixel CT imagery. It's able to segment the COVID-19 lesion without labeling the dataset. So, it's reduced the time and complexity in manual labeling. The proposed unsupervised methodology is good but still requires a lot of development. Thus, it can segment only small part lesion more accurately.

#### 6.3.10 Image Compression

Image compression is essential requirement in radiological imagery application. As the spatial and temporal resolution increase, the data generated is enormous, this led to a requirement of large bandwidth for communication and large data memory for storage of data arises, best alternate way is to use data compression algorithms to reduce the data size. More over lossless compression is used, this is preferred because of no loss of information while data compression, to achieve high compression ratio we need to exploit soft computing and computational intelligence algorithms.

Pradeep Kumar and Ashish Parmar [14] explain that this paper presents the lossless, lossy, and hybrid compression techniques for medical image compression and also it describes the various watermarking method and performance matrices. From literature it's concluded that hybrid techniques are more commonly used because it has a ability to compress both lossless and lossy in order to obtain the better compression. Performance parameters are computed based on their performance and efficiency and it's completely based on compression ratio.

Jing-Yu Cui et. al. [15] proposed example-based texture modeling for image compression, which is one of the current standard approaches. It uses fixed dictionary with texture samplers and vector quantizer. In past work, usually best predictor was selected based on its mean square error, but in addition to this framework it consists of the prediction residual and encoding rate. The compression quality is improved by selecting the accurate predictor. It's observed that proposed methodology performance good over JPEG and it has lower error than JPEG.

M. Moorthi and R. Amutha [16] explain that image compression mainly focuses on reducing image data, thus it's easy to store and transmit the data efficiently. Initially, segmentation is applied to obtain the two clusters i.e., region of interest and non-region of interest. Here, higher energy cluster uses the integer wavelet transform based compression and another cluster uses JPEG, which is one of the popular image formats. Finally, the designed model was able to preserve the edge information and maintain high compression ratio to provide reliable and faster compression technique.

T. G. Shrisat and V. K. Bairagi [17] note that medical images are very sensitive and it must have very clear information without any loss, it can be achieved from lossless compression. The performance enhancement in lossless compression combining predictive coding and integer transform. By looking toward the comparative analysis its predictive method gives precise compression compare to the plane wavelet-based image compression. There is very less possibility to lost a very less amount of data, by using predictive coding technique where we consider different (subtracting original image and reconstructed image) or prediction error. System performance was computed using scale entropy and entropy for compressed images with acceptable image quality.

Jiang et al. [18] explains that this paper introduces wavelet base image compression algorithm for radiological imagery, this is one the superior method for lossless image compression and improved vector quantization. The ultimate aim of proposed methodology is to maintain medical image at high compression ratio, which contains diagnostic related data. Initially wavelet transformation was applied. For low and high frequency a lossless compression method and novel vector quantization (VQ) with variable block size has been implemented respectively. Its analyzed that experimental result of optimized method can able to improve image compression performance and achieved proper balance between image visual quality and image compression ration with better performance. Proposed method was tested on liver and brain images also observed with compression ratio of 25 with different contrast ratio.

**Image synthesis** is the technique of generating new images from some form of image description. These images are synthesized typically like 3-dimension organ geometric shapes. Current trend requirement of medical image processing is to synthesize 3-dimension shapes. Deep neural network and capsule network with computational intelligence it is possible to synthesis any complex shapes.

**Image quantification** is assessing the degree of disease for a diagnosis, this is similar to computer assessing any disease without doctor interventions. This is one of the most powerful tool and future trend in radiological application, image quantification is a method to measure and classify objects as healthy or diseased. The advantage of computerized image quantification algorithm (CADE/CADx) is its objectivity and speed.

## 6.4 Fuzzy Logic

Fuzzy logic is a very interesting topic of AI. It allows membership value between 0 and 1, gray level and in linguistics form such a small tolerance. In traditional logic something can be represented by either having value of true, which is 1 or false, which is 0 and in fuzzy logic you can be anywhere and between 0 and 1. So you could have something that's true but only partially true and false with certain degree. Let's use tap water temperature as an example in traditional logic—you would have this represent either hot or cold representing 0 or 1, respectively. But using the fuzzy logic you could have something like this we have gradient from hot to cold so you could have something that is lukewarm very hot somewhat cold etc., instead of just cold or hot.

Fuzzy logic concept we encounter in our day-to-day life like the car is fast. The bag is heavy. Today is a hot day. Our exam was easy, and so on. None of the sentences have any metrics numbers or digits with them and yet we perfectly understand and

use them every day. We are doing all of this with outlet having precise information or mathematical model of the system we can use fuzzy logic to produce accurate results in presence of inaccuracies.

An example of the fuzzy logic concept for better understanding is learning to drive a car. When you are learning to drive for the first time you are much more cautious and you create a mental rule for yourself, for example, if you are driving first and distance between your car and the car in front of you is less than a certain value you should break immediately. So, the concept of driving fast is not a fixed rule or agreed value some people tend to drive faster and then others and some people are reckless when it comes to driving it means that the concept that the driving too fast can be driving above 70 mph for a new learner and someone with a couple of year of driving experience it could be over 90 mph and for some obviously driving above 135 mph or more regardless of each group of these people are driving.

If they sense that the distance between their car and the car in front of them is shorter than they will slow down immediately even the reckless ones. So, using fuzzy logic we can design and develop systems that could drive safely regardless of the type of the driver that uses them.

**Fuzzy Logic Working:** Fuzzy logic is an extension of Boolean logic based on the mathematical concept of fuzzy sets. Fuzzy logic contains different components, the block diagram of basic fuzzy system is as follows shown in the Figure 6.8.

- a) The fuzzifier is the part responsible for fuzzification. It's the process of converting crisp set data into fuzzy set data. It has the membership function for linguistic variable of fuzzy set.
- b) Fuzzy rule-based system is an extension of fuzzy logic concept. It consists the two main components:
  - Inference engine: This process maps the fuzzy output by combining the membership function with fuzzy control rules. Fuzzy inference is the processing unit based on fuzzy set theory concept each rule having a weight between 0 and 1 and then multiplying with the membership value that is assigned to the output vector. When the input is specified the fuzzy inference, process obtain the output from the fuzzy rules-based system.

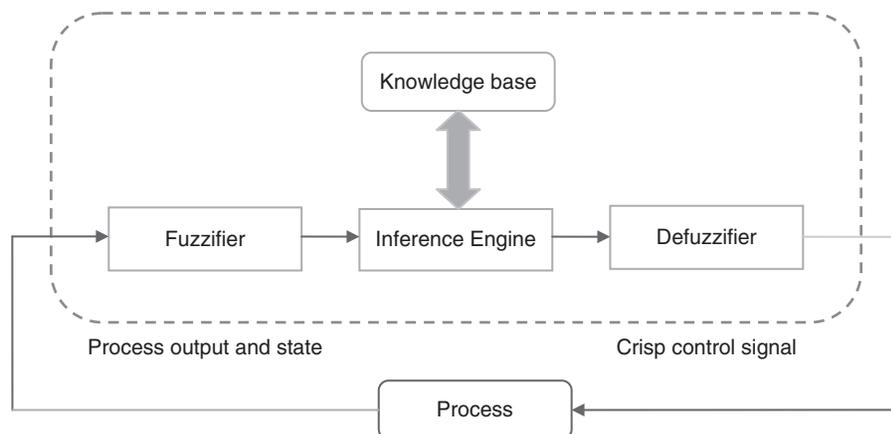


Figure 6.8 Fuzzy logic block diagram.

- Knowledge base: This is the third layer of a fuzzy system. It is the most important part of a fuzzy logic system. It is a combination of database and a rule base. It will store the knowledge available about the problem being solved in linguistic “IF-THEN” rules.

Knowledge base is constructed either by experts or self-learning algorithm.

- 1) The first way is for experts to construct a rule base. Experts is a system that describes if-then rules.
- 2) The second way is using self-learning to construct the rule base. In this method one part is used to train, while other part is to be solved by the system. These types of self-learning system are called neuro-fuzzy system.

For example: Knowledge-based system in medicine

In medical domain data is acquired from patient history, laboratory tests, physical examination, and clinical investigations. These obtained data have been converted into linguistic concept to idle medical knowledge level such as treatment recommendations, diseases description, and prognostic information.

- c) Defuzzifier is the process that maps fuzzy inference output into crisp logic based on corresponding membership degrees and fuzzy set. The decision-making algorithm selects bet crisp value.

J. Greeda et Al. [19] present application of the fuzzy expert system (FES) in medicine that has been discovered to support a practioner for decision making. Fuzzy set theory plays very important role in diagnostic decision. FES used in prediction of patients conditions, patients monitoring, handling of fuzzy queries, and prediction of aneurysm, fracture healing etc. Fuzzy logic is based on human thinking decision building that produces qualitative quantitative evaluation of medical facts.

Shruti Kambalimath and Paresh C. [20] describe how fuzzy models were developed in various hydrology and water resources. The fuzzy logic-based system deal with the problems that have uncertainty, approximation vagueness, and partial truth where the data are limited, but it is not suitable for mathematical imagery and solutions because of absence of mathematical explanation. This paper suggested that hybrid fuzzy modeling is more efficient where it will be combined with ANN fuzzy SVM model to obtain better accuracy than pure fuzzy model.

Novruz Allahverdi’s [21] paper describes application of FES in medical area such as determination of diseases risk and coronary heart diseases risk, periodontal dental disease, child anemia, etc. It’s concluded that fuzzy control and hybrid system will give effective outcome in upcoming future. The proposed fuzzy model has been trained and tested to get proper approximation between predicted value and measured value for precise outcome.

Jinsa Kuruvilla and K. Gunavathi [22] propose FIS and ANFIS models for classification of lung cancer using CT images. Morphological operations are used to segment the lung lob from CT images and classification is done by statistical and GLCM parameters. Cluster shade, dissimilarities, skewness, and difference variance are some parameters selected by principal component analysis that is used for feature selection purpose. Adaptive neuro fuzzy inference system uses the modified

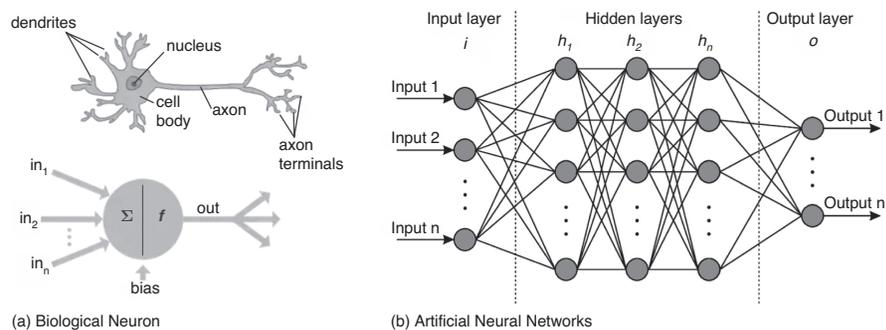
training algorithm and obtained 94% classification accuracy where FIS obtained 91.4% accuracy.

Maria Augusta et al. [23] presents a fuzzy inference system created to support medical diagnoses in real time. In this paper they have done some analysis on public and private health-care services. Which describes the problems in health-care sectors are like poor allocation of resources, social inequality, Inefficiency and absence of preventive medicine. This paper has used preventive medicine as the output of the intelligent system. Using fuzzy intelligent system, they have shown the feasibility of generating new channels for medical cost. They are working to improve hospital marketing, socially responsible, to minimize wait time, cost and marketing customer contented.

## 6.5 Artificial Neural Network

In 1943, ANN was first time proposed by Warren McCulloch and Walter Pitts. Neural networks are inspired by human brain biological neurons; ANN are built on assemblies of connected nodes or units know as artificial neurons. Individual connection identical to synapses in a biological brain, capable of transmitting information to other neurons. These artificial neurons once receive an information process and sends to next connected neurons, the results of individual neurons are calculated by nonlinear function of the sum of its inputs. Neurons have weights they alter the learning process, these weights changes based on certain threshold. A simple neural network mainly consists input, output, and hidden layers, the quantity of hidden layer depends on the requirements, shown in Figure 6.9. ANN, finds many applications in radiological imagery, starting from preprocessing to identification and classification. ANN are the best when the data dimensions are small but when the data is large, they don't perform good, due to this most of the current advanced application is radiological imaging used Deep Learning Deep Neural Networks.

ANN is a mathematical illustration of human neural architecture that reflects its “generalization” and “learning” abilities. Thus, it belongs to AI. ANN is broadly applied in research because they can model nonlinear structure where the variables relationship is unknown and very complex. ANN can have single or multiple layers. It consists of series of neurons or nodes that are interconnected in layer by using a set



**Figure 6.9** Biological and artificial neural networks.

of adjustable weights. Each neuron is connected with each and every neuron in the next organized layer. Generally, ANN consists of three layers i.e., input layer, hidden layer, and output layer. The input layer neurons receive the information and that will be passed to the next hidden layer via weight links. Here, one or more hidden layer processed the data mathematically and try to extract the pattern. Each neuron has weighted inputs, transfer function, and single output. Neuron is activated by weighted sum of inputs it receives and activation signal process through a transfer function to produce a single output. Ultimately, last layer neuron provides final network's output.

ANN classification is in Figure 6.10, shows the multiple types of neural networks. Based on the application most suitable neural network uses with their own specifications and levels of complexity, mainly two types of ANN.

a) Feed-forward neural network

It is used more commonly in which the information is unidirectional i.e., from input to output. No feedback loops are present in this type of ANN. It's used for recognition of pattern and it contains fixed input and output.

b) Feedback ANN

In this particular ANN, it allows feedback loops. It's used by internal system error connections and used in content addressable memories.

Al-Shayea [24] reports the proposed diagnosis ANN is a powerful tool that deals with the complex clinical data and help the doctor for proper treatment of diagnosis. In this paper we analyzed the two cases, first is acute nephritis and the second is heart disease. Feed-forward back propagation network with supervised learning [1] is used as classifier in both diseases where, it's able to classify infected or non-infected person in heart diseases by 95% correctly classified while in acute nephritis, network having the abilities to learn the pattern based upon selected symptoms and proposed network were capable to classify with 99% accuracy.

Shahid et al. [25] proposed study estimated that ANN can be applied to all level of health care organizational decision making. It's found that hybrid approaches are very effective to reducing challenges such as having insufficient data or new item is introducing to the system. The most successful purposes of ANN is observed in extraordinarily complex medical situations. It's found that ANN to be often used for prediction, classification, and clinical diagnosis in area of telemedicine, organizational behavior, and cardiovascular.

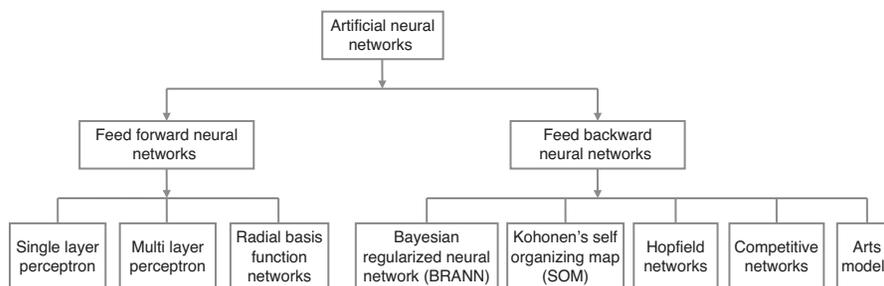


Figure 6.10 Framework for ANN classification.

Amato et al. [26] describes ANN is a powerful framework to assist physicians and other enforcement. ANN has proven suitable for various diseases and their use makes the diagnosis analysis more reliable and consequently increases patient satisfaction. This paper was describing the workflow of ANN analysis, which include, the major steps such as feature selection, database building, preprocessing, training, testing and verification for rapid and correct diagnosis prediction of various diseases.

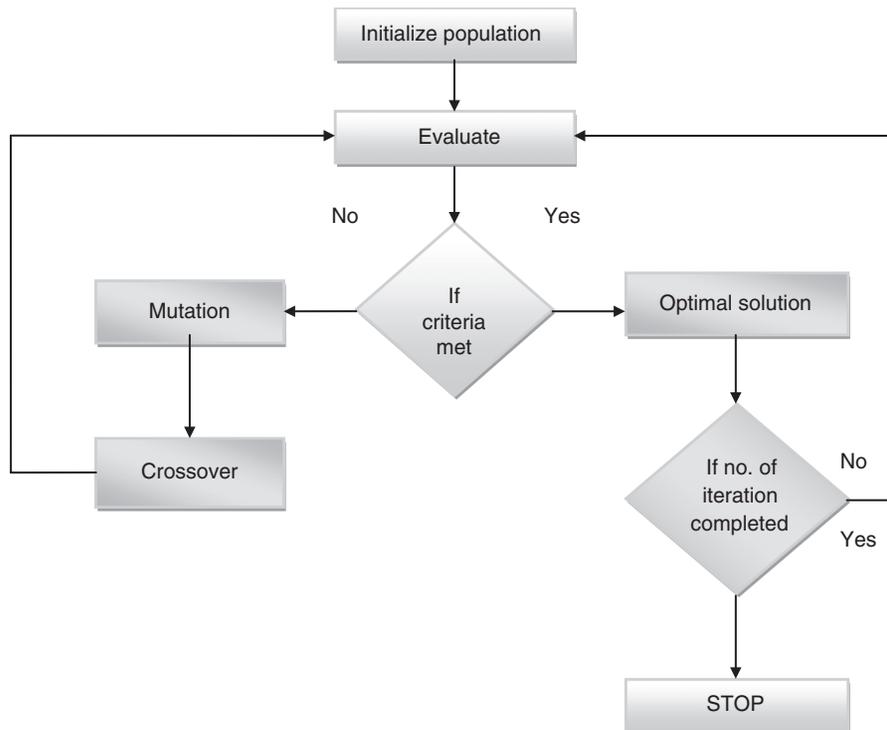
Abiodun et al. [27] survey was present the application of neural network in real-world scenario. It's concluded that ANN can apply to any areas of industries, bio-medical, and profession fields. Based on data analysis factors it's observed that ANN is more effective, successful, and efficient. Therefore, it has ability to solve complex and non-complex real life problems. Finally result can be summarized on various fields of ANN applications regarding pattern recognition, prediction, and classification.

Mossalam and Mohamad Arafa [28] the proposed model uses the databases of 48 projects. The study aim is to identify the variables and enterprises databases that define project criticality also, the related information to build strong neural network model. The four major steps are implements to develop and test the proposed ANN model i.e., data preparation, training, testing, and sensitivity analysis. This research uses three configuration models of nets to develop intelligent model rather than existed manual selection process. Result has been observed by comparative analysis of PN method, Multi-layer feed forward network (MLFN) and best net search. Best net search generated best predictions result for the data.

## 6.6 Evolutionary Computation

These algorithms are very much preferred in the area where mathematical are incompatible to solve the broader range of problems and usually in the application of DNA analysis and scheduling problems, example is shown in Figure 6.11. One of the prominent evolutionary algorithms is Genetic algorithm. Below shows the procedure of genetic algorithm is these evolutionary algorithms aim in bringing out novel artificial evolutionary techniques exploiting the strength of the natural evolution and are most probably engaged in the search optimization problems that requires an optimal result.

Pena-Reyes and Moshe Sipper [29] note that the paper focused mainly on evolutionary computation (EC) and its medical application and observed the effectiveness of various evolutionary algorithms in medicine. EC makes the use of metaphor of natural evolution. EC family introduced powerful techniques that are used to search complex spaces. There are mainly three tasks which are demonstrated by EC i.e., data mining; signal processing and medical imaging; and scheduling and planning. In data mining EC work as a parameters filter. It has the ability to discover the necessary knowledge for interpretation of accumulated information. The prognosis is used frequently because of its predictive nature. EC used to performance improvement in signal processing algorithms such as compressor and filters and also from welter of data the required clinical data are extracted by taking the help of EC. It plays a very important role in planning and scheduling. Specifically, for



**Figure 6.11** Evolutionary computation.

3-dimensional radiography, different medical procedures, and many more. EC applied in medicine in order to perform several tasks in diagnosis, especially for decision support.

Mahesh and J. Arokia Renjit [30] the actual intention of this survey paper was to review and study the segmentation and evolutionary intelligence that include various classification techniques. This review article very nicely present segmentation and classification-based approaches for the recognition of brain tumor from MRI imagery. Here, 50 research papers were studied and analysis was done accordingly, which was mainly emphasis toward the utilized image datasets, feature extraction techniques, image modality, evolution measures, implementation tools, and final achieved results. It's concluded that performance of all proposed techniques were good with respect to different modalities and its requirements, but still lots of improvement is necessary to get desire outcome. Compared to all the other existed classification-based techniques hybrid techniques gave good classification accuracy. Here, nonlinear classification and 3-dimensional evolution is complex. It has been seen that a greater number of researchers focused on classification techniques for recognition of tumor.

Nakane et al. [31], this literature review paper briefly summarized computer vision applications using evolutionary algorithms (EAs) and Swarm algorithm (SAs) and observed characteristics and differences. The proposed study concentrated on four

algorithms i.e., differential evolution (DE) and genetic algorithm (GA), that belongs to EAs and colony optimization (CO) and particle swarm optimization (PSO) are belongs to SAs. Among all of the four representative algorithms of EAs and SAs, the GA and PSO are more commonly adopted in computer vision application because of its improved efficiency, parameter tuning and practical applications. Combination of the EAs/SAs and also deep neural networks such as neural architecture search is one of the popular fields of research. Ultimate aim of computer vision is to understand meaningful information and extract the features from videos and images, it's concluded that evolutionary algorithms and swarm algorithm have a potential to solve the various complex problem very precisely.

Holmes [32] evolutionary computation is a more popular approach that could be used alone or with machine learning. Proposed approach of evolutionary computation was divided as genetics based and non-genetic based algorithm. It's model free and also has a capability to provide meta-heuristic structure, where there is no need of any perfect data and prior assumptions. Thus, it can solve the wide range of problem. Genetic algorithm can be used to identify mRNA targets, also it identifies lesion on mammogram and mining temporal workflow data etc.

Slowik and Halina Kwasnicka [33] present on application of evolutionary family for real-life problems. A complete family of evolutionary optimization algorithm is considered as evolutionary computation. The paper describes the main properties of various evolutionary computation algorithms. For the easy implementation pseudo-code form is presented for each technique of EC. The described literature review gives the overview of all EC methods, which was suitable for many industrial and engineering problem, but there were some little gaps between practical and theoretical aspects. Currently EAs are modifying for hybridization of more algorithms in order to obtain better performance result.

## 6.7 Challenges

Tremendous improvements in image acquisition sensors has revolutionized the radiological imagery applications, over the past two decades image quality and information obtained is very large and it is helping radiologist at the same time for proper and accurate assessment of disease. Now big challenges are to develop hardware architectures that can process these data at high speed at affordable cost, there is a need to improve the processing speed.

## 6.8 Conclusion

This chapter provided an overview of computational intelligence application to radiological imagery. It introduced the fundamental principles of digital image processing, steps involved in image computation, and covered computational intelligence paradigms based on fuzzy logic, ANNs, and EC. Finally, the chapter described a few applications of these paradigms and emphasized how algorithm could be made more intelligent and process at high speed with better accuracy.

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## Chapter

# Overview of Primary Cell Culture Models in Preclinical Research of Prostate and Bladder Cancer

*Kalyani Killekar, Sridevi I. Puranik, Aimen Akbar A.,  
Shridhar C. Ghagane, Rajendra B. Nerli  
and Murigendra B. Hiremath*

## Abstract

The number of patients diagnosed with prostate and bladder cancer is increasing worldwide and one of the most important challenges remains the development of effective, safe and economically viable antitumor drugs. Clinical approval for drugs tested in preclinical studies enabling them to enter phase I clinical trials is essential. Cell lines are *in vitro* model systems that are widely used in different fields of medical research, especially basic cancer research and drug discovery. Their usefulness is primarily linked to their ability to provide an indefinite source of biological material for experimental purposes. Under the right conditions and with appropriate controls, authenticated cancer cell lines retain most of the genetic properties of the cancer of origin. Studies conducted during the initial development of drugs such as toxicity, corrosion and drug activity were carried out on animals; however, in the past two decades, alternatives have been sought due to the fact that animals do not effectively model to human *in vivo* conditions and unexpected responses are observed in the studies. Also, more than 100 million animals were used and billion dollars were spent for animal toxicity experiments. Cell culture studies made positive contributions to the initial development of drugs and is highly desirable, as it provides systems for ready, direct access and evaluation of tissues. Contrary to animal studies, less cost and the need for low drug and a short response time are the characteristics for *in vitro* cell culture methods. *In vitro* tumor models are a necessary tool, in not only the search for new substances showing antitumor activity but additionally for assessing their effectiveness. This chapter reviews the main features of primary cancer cell cultures, provides an overview of the different methods for their selection and management, and summarizes the wide range of studies that can be performed with them to improve the understanding of prostate and bladder cancer preclinical treatment processes.

**Keywords:** Primary cell culture, preclinical studies, prostate and bladder cancer, *in vitro* model

## 1. Introduction

Cancer is the one of the major death cause worldwide and accounted nearly 10 million deaths in 2020 [1]. The rate of incidence in prostate cancer and bladder cancer are increasing worldwide too. According to GLOBOCON 2018, prostate cancer is the second most frequent cancer and in men, it is fifth leading cause of death. Bladder cancer is also common in men ranking on sixth position and ninth leading cause of cancer death [2]. There are so many treatments available like radiotherapy, chemotherapy, hormonal therapy but these treatments are associated with adverse side effects and poor quality of post treatment life. Hence there is need in development of effective, safe and economically viable antitumor drugs.

Prostate cancer and bladder cancer are heterogeneous diseases where many molecular, environmental and genetic factors are involved in its progression and understanding the mechanism of this progression is difficult [3]. In recent years the cancer research has made significant progress, but many challenges remain as it is [4]. Currently, only 7% of potential anticancer drugs are gaining approval which is much lower than drugs for other diseases [5]. Hence, to improve this percentage, it is essential to clinically approve drugs which are tested in preclinical studies and enabling them to enter phase I clinical trials [6].

Experimental models are important tools in the cancer research. The model should be reproducible, able to successfully reflect disease stage that is being studied and mimic the disease; how it behaves in humans [4]. Cell lines are *in vitro* model systems, a necessary tool, in not only the search for new substances showing antitumor activity but additionally for assessing their effectiveness. They are widely used in different fields of medical research and pharmaceutical companies. Presently pharmaceutical industries mostly rely on *in vitro* models like two dimensional (2D), three dimensional (3D), boyden's chamber (to study chemotaxis and assessment of cell motility) [7], micro fluidic systems (It is small devices that can provide a specific fluid flow, constant temperature, fresh medium, flow pressure and chemical gradients which is same as *in vivo* systems to study migration and invasion [8], 3D bioprinting (mimics the processes that occurs in tumor micro environment) [9, 10]. Main reason for accepting *in vitro* model is it's physiological relevance, it helps in improving the understanding of prognosis and treatment, it provides accuracy and it is also a low cost screening tool for researchers [11]. The usefulness of *in vitro* models is primarily linked to their ability to provide an indefinite source of biological material for experimental purposes. The *in vivo* model involves animals which provide valuable information to understand many aspects in development of disease and initial development of drugs such as toxicity, corrosion and drug activity [12]. But from past two decades, alternatives have been sought due to the fact that animals do not effectively model humans in *in vivo* conditions, as it shows unexpected responses like anatomical variation and also difficulty in extracting quantitative mechanistic data in the studies. Mathematical models are also used in the cancer research to analyze tumor growth and progression, and helps in predicting the effects of some therapies [13]. Different clinical setting, cancer resistance and switching to another treatment, existence of unknown biological details these issues can affect the mathematical models [14–16]. Computer simulation is another model in the cancer research, helps to test complex multi scale cancer progresses, it also accounts for drug pharmacokinetics and pharmacodynamics, but has drawback in less common cancers because of less data, therefore it lacks perspective validation and accuracy [17].

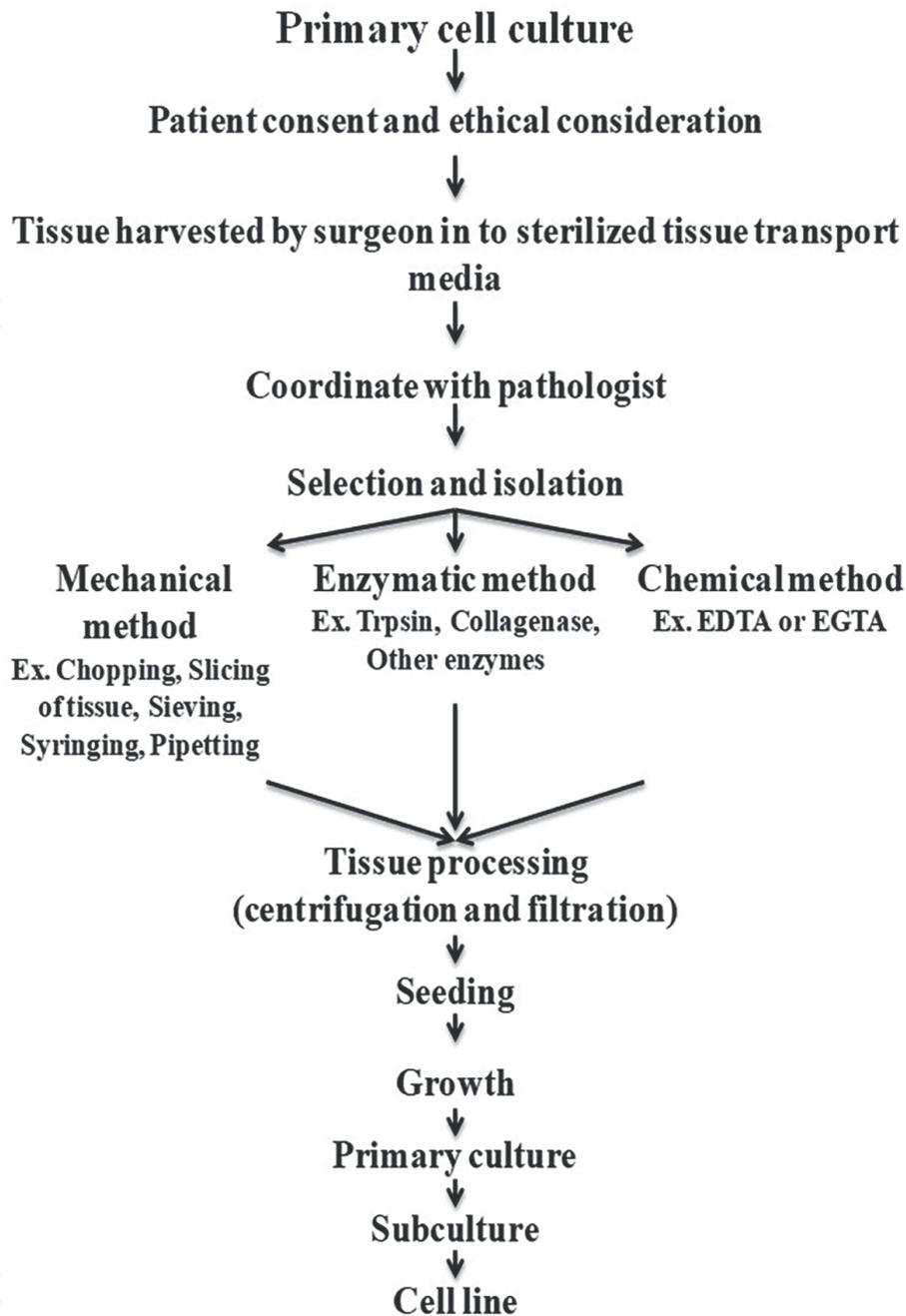
All models involved in the cancer research have pros and cons hence the cost duration, experimental design and data analysis in developing the anticancer drug should be considered for the selection of the model. It is necessary to choose more effective pre-clinical platforms to screen the antitumor compounds [18]. Practically *in-vitro* models of tumors will not only give primary screening of potential antitumor drugs but it also prevents drugs with insufficient antitumor activity from entering into preclinical animal testing [19]. This chapter reviews the main features of primary cancer cell cultures, provides an overview of the different methods for their selection and management, and summarizes the wide range of studies that can be performed with them to improve the understanding of prostate and bladder cancer preclinical treatment processes.

## 2. Primary cell culture

Primary cell culture is a gold standard testing platform for *in-vitro* research in oncology as they reflect the tumor state more accurately compare to most commonly employed cell lines [20]. It is a powerful tool commonly used by scientists to study cellular properties and mechanisms of isolated cells in a controlled environment [21]. Cell culture studies have made positive contributions to the initial development of drugs. Contrary to animal studies *in vitro* method requires low drug dose and short response time, which is characteristic feature of *in vitro* cell culture methods [22]. Primary cell culture is also called as *ex-vivo*. Because primary cells are directly taken from tissue origin and cultured under favorable conditions hence it is more similar to the *in-vivo* state and exhibit normal physiology. It maintains the cross talk between malignant and healthy components [23]. This is the main reason why primary cell culture is called as excellent model system to carry studies in metabolic, aging, signaling studies and effects of drugs, toxic compounds in the cell.

Primary cells are non-immortalized and non-transformable as they imitate the appearance of living model and hence these can help to model 3D tissues. In this culture, cells will grow in 3D aggregates and presents interesting application [24]. It helps for detection, isolation, growth and developmental stages of viruses and helps to analyze the mode of infection. Drug candidate and its toxicity screening rely on results of early-stage *in vitro* cell based assays. Particularly in pharmaceutical industry primary cell culture is used to synthesize variety of biomolecules in high scale, various research project on cell-based product are developed. It is alternative for animal model to test effect of drugs and cosmetics [25]. There are few technical hurdles associate with primary cell culture. For instance, culturing might be difficult if the quality of the surgical material is poor. Also, due to early onset of cell senescence, difficulty arises to maintain sufficient number of cell passages but researchers have made many attempts to resolve this problem [26, 27].

Primary cell culture has been subdivided in to adherent cell culture and suspension cell culture. In the adherent cell culture, cells are arranged in monolayer and attach to the surface of the culture flask. Adherent cells are usually derived from tissues of organs. Growth is limited to surface area and it needs to be detached from the surface before cells get sub-cultured. Viral vaccine, gene therapy and cell therapies depend only on adherent cell culture. Suspension cells are derived from the peripheral blood and do not require any attachment for growth. They do not get attached the surface area of the cultural flask. The cells are free floating and growth is limited to the concentration of cells. The steps involved in the primary cell culture are represented in (Figure 1).



**Figure 1.**  
Flowchart showing the process of primary cell culture technique.

### 3. Isolation of cells

Before going to any further tissue processes, it is important to keep in mind that all tissue processing has to be carried out in a biosafety cabinet and all the sterilization protocols has to be maintained properly [28]. Now moving towards cell isolation, it is a process where one or more specific cells are isolated from heterogenous cell mixture. Isolation of primary cells from cancer cells is an important phenomenon of cell culture biology as they are more reliable sources to understand the human cell. There are many standard protocols available for culturing the normal andneoplastic cells [28]. Human prostate and bladder are composed of many cell types which can be isolated and cultured. Hierarchy of the epithelium has been reviewed most [29, 30].

There are 3 main epithelial lineages namely neuroendocrine, basal and luminal. Prostatic homeostasis is mainly depends upon the epithelial cells and stromal cells; stromal cells guides to the epithelium cell for their dedifferentiation, proliferation and also progression of carcinogenesis [31].

Now, how to understand which cell is cancerous and which cell is non- cancerous because cell does not contain tags on it. There are specific cell markers (Antigen) which will identify the difference between cancerous and non-cancerous for ex. ARA70 (Androgen receptor-associated protein 70) is a cell marker which was noted to be expressed at high levels in normal primary cultures compared with prostate cancer cell lines [32]. Many cell markers are available depending upon cell type which is listed in **Table 1**. Also in bladder cancer depending upon cell type there are different CD (Cluster of Differentiation) cell markers which are depicted in **Table 2** [38]. Identification of stem cell marker has uncovered a cellular hierarchy of epithelium during development and in response to injury [39]. Cell markers (Antigens) have specific antibodies and these have to be evaluated histochemically. These reactions are evaluated by specific kits which are available in market (**Table 3**). For isolation, first tissues will be collected from prostate cancer patients and bladder cancer patients who are undergoing biopsy. This collection of tissues needs to be well coordinated between urology, pathology and the investigator and it has to proceed for primary culture within 2 hours after collection of tissues [33–37, 39–41]. After collection, tissue should be placed in sterile container which has HBSS (Hanks’ balanced salt

Cell marker	Cell type
Cytokeratin 5 [33]	Basal cell
CD59 [34]	Basal cell
c-Met [35]	Basal cell
CD95 [34]	Basal cell
Cytokeratin 8 [36]	luminal cell
CD9 [37]	luminal cell
15-LOX-2 [36]	luminal cell
CD24 [34]	luminal cell

**Table 1.**  
 Biomarkers for Prostate cell culture.

Cell marker	Cell type
CD9 [38]	Urothelial
CD104+ [38]	Basal
CD13+ [38]	Stromal cells of the lamina propria
CK5 [37]	Basal
p63 [37]	Basal
CK8 [37]	Luminal

**Table 2.**  
 Biomarkers for bladder cell culture.

Antigen	Antibodies	Cell type
Cytokeratin 8/18 (Prostate)	Mouse IgG1	Luminal cells and intermediate cells
High molecular weight cytokeratin (Prostate)	Mouse IgG1	Intermediate cells
Trop2-APC (Prostate)	Mouse IgG2a	Epithelial cells
CD49f-PE(Prostate)	Rat IgG2a	Epithelial cells
CD + 9 (Bladder)	antibody clone M-L13	Urothelial
CD104 (Bladder)	clone 439-9B	Basal

**Table 3.**  
Primary antibodies for prostate and bladder epithelial cultures [38, 40].

Method	Mechanism	Advantages	Disadvantages
Chemical Method	By using EDTA or EGTA it binds with cations and disrupt the intracellular bonds [42]	Easy and cost saving	It does not adequately dissociate all types of tissue
Mechanical Method	Cutting, scratching, the tissues in to small pieces in order to separate the cells and wash it with gentle agitation [42]	It is a rapid technique works best for loosely associated tissue. Correct temperature should be maintained for enzyme.	Decreases in the surviving capacity of the cell, incision of scissor, scalpel for cutting, scratching can damage the cell.
Enzymatic Method	Enzymes to cut or digest tissue pieces in free cells. Combination of enzyme also can be used Ex.- Collagenase, Trypsin, Hyaluronidase [43].	It has great specificity with specific enzymes	Enzyme dissociation can modify proteins on cell surface

**Table 4.**  
Mechanisms for isolation of cells.

solution) with HEPES (Hydroxyethyl piperazineethanesulfonic acid) and store at 4°C for 2 hours to increase cell viability. To assess tumor cells in the dissected material Hematoxylin and Eosin (H&E) stain is used in the histopathology lab. To get a single cell suspension from tissue dissociation obtained after surgery, there are three mechanisms available for isolation: Chemical, Mechanical and Enzymatic method (Table 4).

Although this is first step in primary culture, there is still no standardized protocol for this. There is a variety of options available. Tissue has to be mechanically minced from autoclaved scalpel or scissor; if tissue is measuring from 1 to 20 grams semi-automated dissociator can be used. Manual method has to be done in ice cold PBS (Phosphate-buffered saline). Commercially available formulation showed 10% increased viability compare to collagenase I, II, IV. (Table 5) [33]. In another study mechanical and enzymatic method has been used. In mechanical method, they used lacerate and scalpels and in enzymatic method collagenase type I and hyaluronidase type I enzymes with medium agitation at 37°C for 18 hours was used [34]. EDTA

Sl. No.	Components	Function
1	Buffering systems 1. Natural buffer system 2. Chemical buffers system	<ul style="list-style-type: none"> <li>• CO<sub>2</sub> balances the pH, 5 to 10% CO<sub>2</sub> incubation, non-toxic and cost effective [44]</li> <li>• HEPES, buffering capacity 7.2–7.4, in high concentration it is toxic, costly [45, 46]</li> </ul>
2	Inorganic salt	Maintains osmotic balance and membrane potential by providing sodium, potassium, and calcium ions [47]
3	Amino acids	Require for proliferation of cells and provides nitrogen. Ex. L-glutamine provides NAD, NADPH and serve as secondary source of energy in metabolism [48].
4	Carbohydrates	Carbohydrates are major source of energy, most of the media use glucose and Galactose.
5	Proteins and peptides	Major proteins and peptides in media are albumin, fibronectin and transferrin. Albumin helps to remove toxic substances from cell culture media
6	Fatty acids and lipids	Particularly added when serum free media is used [44].
7	Vitamins	Important for cell growth and proliferation as cells cannot produce sufficient amount, need to provide through culture media [44].
8	Trace elements	Copper, Zinc, Selenium required in trace amount for proper growth and many biological process
9	Antibiotics	Controls growth of bacteria and fungi. ex. Penicillin, Streptomycin, fluconazole [49].
10	Serum in media	Serum is a complex mixture provides all above elements. Ex. Fetal and Calf bovine serum [44].

**Table 5.**  
*Basic components of media and their functions.*

(Ethylenediaminetetraacetic acid)/Trypsin mixture used with 5 minutes of incubation in 37°C degree for prostate tissue [35]. Both the mechanisms, mechanical disaggregation with disposable disaggregator and enzymatic by collagenase and trypsin used for prostate tissue [36, 37]. In some cases, trypsin/EDTA 1:5 solution and incubation for 15 minutes for bladder tissue was used. In some studies for dissociation of bladder tissue 1:1 collagenase II and dispase enzymes are used at 37°C for 12 hours [40–43]. Also there is a need to monitor tissue digestion process for every 2 hours by gently shaking the digestion mixture by checking the viability of cells under the microscope [50–53].

#### 4. Tissue processing

After digestion, cells are strained by strainer to separate the debris from it. Then, cells micro clumps are washed with PBS or HBSS twice or thrice followed by centrifugation [54]. Cell pellet collected from centrifugation is suspended in 2 ml of culture media. Count the viable cell by hemocytometer or by tryptophan dye exclusion method [55]. Cell viability also can be measured by the intracellular adenosine triphosphate levels which are commercially available kit [56]. Immunohistochemistry

and immunofluorescence techniques used to localize, identify and quantitate the cells based on cell surface marker [57].

## 5. Culture media

Cell pellets collected from centrifugation has to be placed in micro well plate or flask that contains culture media. It provides artificial environment for cell to grow. Basic requirement of culture media are controlled temperature, substrate to attach cell, growth medium and incubator to maintain pH [45]. Main step in culture is to choose culture media. It generally composed of amino acid, vitamins, inorganic salts, glucose, hormones, growth factor, and attachment factor which provides energy and helps to complete the cell cycle. Commercially available cell media for primary epithelialcancer cells are less effective compare to tissue specific primary cell media prepared in lab (**Table 6**) [46–49].

Choice of culture media is very important to get significant result in experiment. Selection of media completely depends upon type of cell, purpose and resource [62].

SL No.	Cell type	Components of media
1.	Fibroblast cell culture [28]	DMEM media with 7.2 pH + Fetal calf serum (FCS) + 100 U/ml penicillin, 100 µg/ml streptomycin + 1% amphotericin B added in culture media. culture plate incubated at 37°C a humidified chamber of 95% air and 5% CO <sub>2</sub>
2.	Prostate cancer (Bone metastatic variant) [29]	DMEM Glutamax + 4.5 g/L D-Glucose with pyruvate + 10% FCS + 1% penicillin-streptomycin + 37°C with 5% CO <sub>2</sub>
3.	Bladder cancer (Epithelial cells) [58]	EMEM (ATCC) + 10% FCS + 1% penicillin + streptomycin + humidified incubator at 37°C with 5% CO <sub>2</sub>
4.	Prostate cancer (Epithelial cells) [59]	KSFM medium + 25 mM HEPES + 1% penicillin + streptomycin + 0.5 mg/mL fungizone + 100 mg/mL gentamicin + 37°C, 5% CO <sub>2</sub> humidified incubation.
5.	Epithelial cells [40]	serum-free RPMI 1640 without phenol red + penicillin 100 IU/mL + streptomycin 100 µg/mL + metronidazole 1 µg/mL + amphotericin B 2.5 µg/mL + gentamicin 20 µg/mL + 37°C and 5% CO <sub>2</sub> for 6 days.
6.	Bladder cancer (Urothelial cells) [50]	Glutamine + insulin + Phosphoethanolamine + ethanolamine + hydrocortisone + transferrin + EGF + BPHE + 5% FBS + 5% CO <sub>2</sub> at 37°C
7.	Prostate cancer (Epithelial cells) [60]	DMEM + Glucose + 100 U/ml penicillin + 100 mg/ml streptomycin sulfate + 0.29 mg/ml glutamine + Euroclone
8.	Prostate cancer (Epithelial cells) [61]	DEME /Ham's (1:1) + BSA (0.01%) + FAS (2%) + Epidermal growth factor (10 ng/mL) + (insulin-transferring-selenium-1%) + hydrocortison (0.5 µg/mL) + Tryiodotyronone (1 nM) + phosphoethanolamine (0.1 mM) + cholera toxin (50 ng/mL) + fibronectin (100 ng/mL) + putine (20 µg/mL) + penicillin/streptomycin (100 U/mL, 100 µg/mL) + R1881 (0.1 nM).

**Table 6.**  
Components of media from different studies.

Sl.No.	Name of media	Supplier
1.	Human Endothelial-SFM	Life Technologies
2.	Endothelial Basal Media	Sigma Aldrich
3.	EndoGRO-LS Complete Media Kit	MilliporeSigma
4.	HUVEC Basal Medium CB HUVEC	AllCells
5.	Endothelial Cell Medium	ScienCell
6.	Epithelial cell medium	ScienCell
7.	EpiGRO primary epithelial cells	MilliporeSigma
8.	RPMI 1640	Sigma Aldrich
9.	$\alpha$ MEM	ThermoFischer
10.	k- SFM	ThermoFischer

**Table 7.**  
 Commercially available media for epithelial cells [44, 63].

As primary culture provides valuable research data, preparation of quality culture media is required, or to avoid limitation (cell number) of primary cell culture, commercially produced medias are available (**Table 7**) [58–61].

It is very important to maintain cell viability after isolation process which is totally depends on skillful handling and culture conditions. The culture condition will differ depending on the cell type. Cell growth has to be observed till 11 or 12 days. Additional extra media, Fetal Bovine Serum (FBS) and antibiotics need to be provided to avoid contamination. Culture media has to be changed between 2 and 3 days [60]. Initially apoptosis is 5% from 0 to 1 day but as days will pass apoptosis rate will increases from 7 to 14 days. But functional validity of benign and prostate cancer cells was 5 days after confirming it with histochemically, biochemical and by immunohistochemical assay [63]. Use of serum free culture media with low calcium condition increases the longevity of the cell. Cryopreservation (Preservation of structurally intact cells) can be achieved by adding 10% FBS (Fetal bovine serum) and 10% DMSO (Dimethyl sulfoxide) in 80% confluence primary cell culture [64].

Each day morphological changes have to benoted. Normal cells get counted every day and cancer cells get counted every 2 days [65]. Cell viability is determined by trypsin blue dye, equal volume of PBS and trypsin blue dye allowed to sit on cells for few minutes then to count the cells samples are loaded on hemocytometer, cells scored as leaving or dead based on uptake of tryptophan blue dye [66]. Once confluence reaches to 80 to 90% it has to get counted by Neubauer camera at 1:2 dilution with tryptophan dye exclusion, MTT assay (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide) can be used to determine cell viability [67]. Cell growth curve can be plotted from the graph to check the time when the cell viability increases in the culture. Once cell get cultured properly depending upon need of investigator, cells can be passaged and characterization of the cells can be done.

## 6. Cancer cell lines

Most established prostate cancer cell lines namely PC-3, DU145 (Duke University 145) and LNCaP (Lymph Node Carcinoma of the Prostate) developed in the 1970s and 1980s are in the majority of the published studies [68–70]. T24 cells (cell line

from transitional cell carcinoma of the bladder) are exemplified for bladder cancer research [71]. These immortalized cancer cell lines are not always predictive of the real cancer behavior for the preclinical studies as these cells are adapted to 2D monolayer culture conditions [72, 73].

## 7. Cell culture models

Traditionally animal models were commonly employed for carrying out study of different types of cancer for the past three decades [74]. These animal studies have many drawbacks including lack of high-throughput drug screening, longer time consumption to conduct tests and ethical controversies concerning animal testing. Cell culture is the most widely used alternative to animal studies and cell culture techniques can broadly be classified into 2D and 3D methods [75]. The potentialities of primary cancer cell models' cultures in preclinical studies for cancer research and drug discovery has amplified over the past few years. Primary cell cultures provide a good model system to understand normal and malignant biological activities. Carcinogenesis-related behavior such as apoptosis, proliferation, adhesion, differentiation, migration, senescence, invasion, angiogenesis, and other metabolic pathways have been studied in recent years. One of the major advantages is that the heterogeneity of cell populations composing a primary culture mimics the tumor microenvironment, crosstalk, and interactions between malignant and healthy cells, neither of which is possible with cell lines [76].

Most studies have shown that the cellular responses to drug treatments in 3D cell culture are significant and more similar to that of *in vivo* architecture when compared to 2D cell culture. One of the most improved successful assays using 3D culture for cell-based screening in the early phase of drug discovery is cancer cell viability assessment. This assay is particularly useful to test the cytotoxic effects of compounds that may lead to cell death. It plays an essential role in checking how many cells are viable at the end of each experiment. Cell viability assay is closely followed by cell proliferation, cell migration and then cell signaling assays [77–79].

Currently a number of anticancer drugs belonging to different classes chemically are available. To be used as a potential anticancer agent, the testing compounds need to inhibit the growth and proliferation of cancer cell lines. This will further inhibit the signaling pathways by knocking in or knocking out a candidate gene thereby stopping the progression of tumor to fatal stages. For instance, antiproliferative investigations were performed on prostate cancer cell line DU-145 *in vitro* and *in vivo* using salvia miltiorrhizabunge [80]. Another example to justify this concept will be a study performed on PC-3 cell line. Generally, cancer cells express higher amount of Transferrin Receptors (TfR) for an increased uptake of iron in relative to normal cells. This higher amount of intracellular free iron is required for the growth and proliferation of cancer cells. Anhydrodihydroartemisinin (ADHA) was used to inhibit PC-3 cell lines through caspase-dependent pathway [81].

## 8. Applications: cell culture in drug discovery and screening

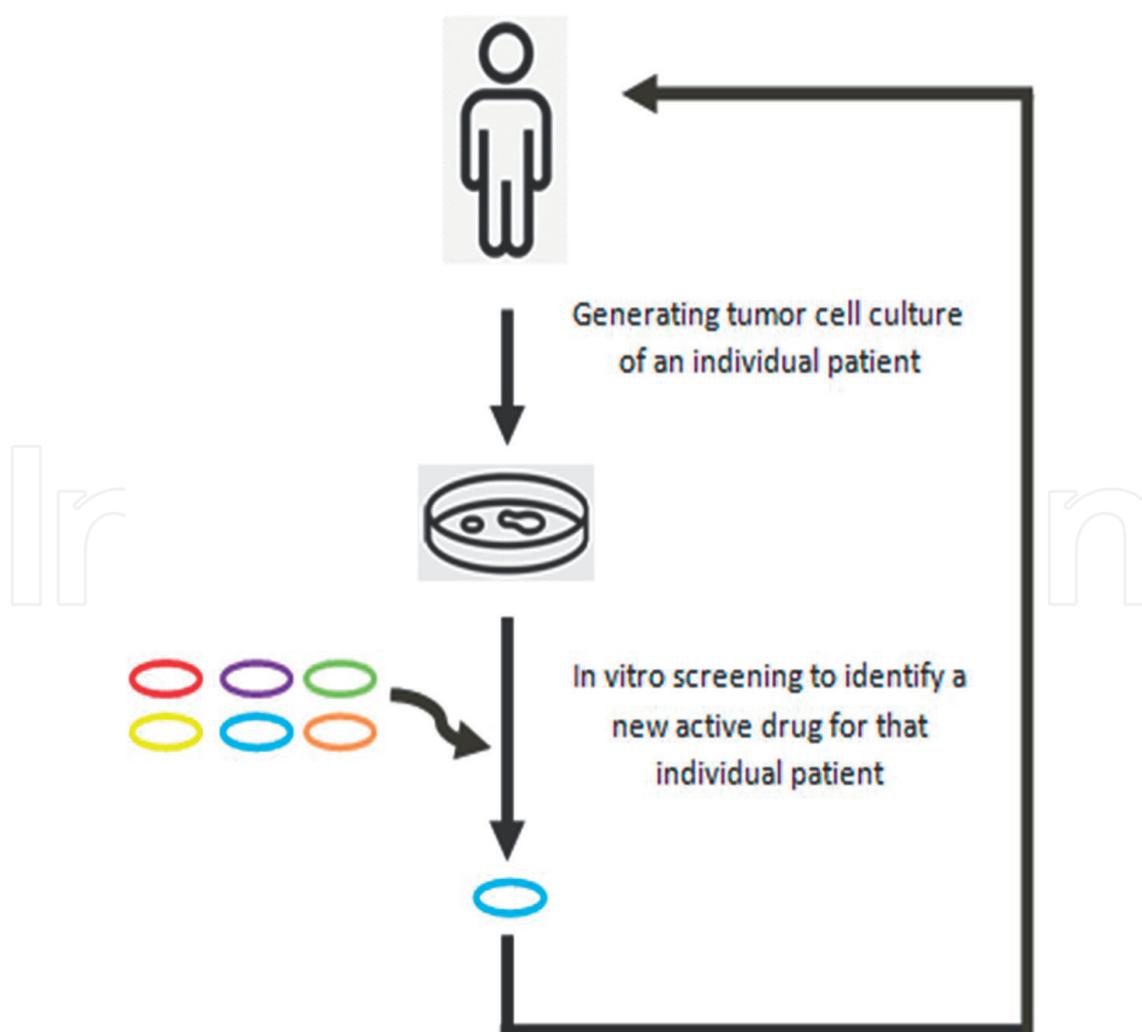
### 8.1 Drug candidate identification

Often the rate-limiting step in preclinical drug discovery is the target identification and validation step. 3D cell cultures have the potential to discover the

molecular perturbations governing carcinogenesis and to accelerate target identification and validation, given that the gene expression patterns found in 3D models are relative to *in vivo*, when compared to 2D monolayer models [81]. For instance, a study reported that CXCR7 (C-X-C chemokine receptor type 7) and CXCR4 (C-X-C chemokine receptor type 4) were co-expressed in LNCaP, DU145 and PC3 cell lines in 2D culture. A marked up-regulation of both receptors was observed in PC3 cells when cultured in 3D using Matrigel suggesting that inhibition of CXCR7/CXCR4 may assist in controlling prostate tumor growth and subsequent progression [82].

## 8.2 Toxicity profiling

Cultured cancer cells are powerful in assessing drug-induced toxicity and to determine suitable drugs and methods for selectively destroying different types of cancer. It is useful to investigate effects of drug responses on metabolic signaling pathways or candidate genes conceding drug screening practices with impressive progress in the last decade. A study investigated features such as vascularization and perfusion of antineoplastic drugs on human T24 bladder cancer [83]. It allowed in the understanding of basic paracrine signaling mechanisms that regulates tissue homeostasis, development of new methods for urinary bladder reconstruction and tissue



**Figure 2.**  
*Assay-guided treatment choosing the best active drug for an individual patient.*

engineering, and generation of models of malignant and benign diseases. This study suggested that the use of 3D urinary bladder cultures could be a possible approach in clinical practice to select for the best antineoplastic drug for each patient and to investigate the effect of drug combinations or new antineoplastic drugs [84, 85]. The below (**Figure 2**) suggests how assay-guided treatment can be useful in choosing the best active drug for an individual patient.

### 8.3 Testing anticancer activities

By far the most useful *in vitro* model which is used to analyze the anticancer activity is Cell culture. Treatments including radiotherapy, chemotherapy, hormone therapy, novel and experimental therapies can be evaluated. Extracts of plants can also be utilized to check for anti-cancer behaviors such anti-inflammatory, destabilized membranes through which invasion and migration can occur. For instance, leaf extracts of *Leea indica* were used to study *in-vitro* antioxidant and anticancer activity on DU-145 and PC-3 human prostate cancer cell lines [86]. An example of drug combination is the synergistic effect of cisplatin and sunitinib malate – based chemotherapy on T24, 5637, and HT1376 human urinary bladder cancer cell lines [87].

## 9. Conclusion

Primary cell cultures have its application in various fields like toxicology, virology, drug screening, genetic engineering, gene therapy, genetic counseling, cancer research but main important application is model system. It provides best model system for studying basic cell biology and biochemistry, effects of disease-causing agent and cell, effect of drugs on cell, process which triggers aging and apoptosis. Primary cell culture represents excellent model for transitional preclinical experiments to understand cancer in *in-vitro* system. Primary cell culture acts as gold standard for cell line experiments because it provides broader spectrum of cell types from greater number of patients to be studied without any induction of artificial genetic mutation and it also maintains same phenotype throughout the culture. It involves both, clinician and researcher in the culture, it helps in understanding the drawback of treatments and lack in laboratory methodology and hence it is possible to overcome from it.

There are many models in cancer research; each model has different potentialities and inadequacy. In primary cell culture, complexity arises due to poor tissue quality, collection and inappropriate culturing may decrease the cell viability. Hence management of primary cell culture is difficult. But to overcome from these difficulties proper collection with the help of pathologist and selection of proper isolation method and culture media based on tissue type can help to increase the cell viability. Considering the current clinical system towards precision medicine, patient derived cancer models are powerful epitome in cancer research. Nowadays 3D model system is emerging system. Primary cell culture can help to model 3D culture, in future technological perspectives like 3D culture can replace the *in vivo* model system. In conclusion, this chapter reviews several aspects of primary cell culture, provides overview on selection of tissues, different methods of isolation, culturing media and management of cells after culture. It summarizes the wide range of studies to improve the understanding of prostate and bladder cancer preclinical treatment processes.

## Author's contributions

KK & SIP: Worked on collection of data and drafted the chapter, AAA: Worked on the draft of cell lines images and edited, SCG: Developed the study designed and edited the chapter, RBN & MBH: Collected the literature and guided throughout the study. All the authors reviewed and approved the chapter.

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## Conflict of interest

The authors declare conflict of interest as none.

## Abbreviations

ADHA	Anhydrodihydroartemisinin
BPHE	Brazed Plate Heat Exchangers
BSA	Bovine Serum Albumin
CD cell markers	Cluster of Differentiation cell markers
DMEM	Dulbecco's Modified Eagle Medium
DMSO	Dimethyl sulfoxide
DU145	Duke University 145
EDTA	Ethylenediaminetetraacetic acid
EGTA	Ethylene glycol tetraacetic acid
EMEM	Eagle's Minimum Essential Medium
FBS	Fetal Bovine Serum
FCS	Fetal Calf Serum
FGF	Fibroblast Growth Factors
HBBS	Hanks' balanced salt solution
HEPES	Hydroxyethylpiperazineethanesulfonic acid
IgMI	Imunoglobuline M Imunostain
KSFM	Keratinocyte Serum Free Medium
LNCaP	Lymph Node Carcinoma of the Prostate
PBS	Phosphate buffer saline
RPMI 1640	Roswell Park Memorial Institute ( <i>RPMI</i> ) <i>media</i>
TfR	Transferrin Receptors

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# Machine Intelligence and Soft Computing

Proceedings of ICMISC 2021

# Coronavirus (COVID-19) Detection and Classification Using High Resolution Computed Tomography (HR-CT) Imageries



Anil B. Gavade, Rajendra B. Nerli, Ashwin Patil, and Shridhar Ghagane

**Abstract** In assessing the Covid-19 patient's severity an abdominal High Resolution (HR) Computed Tomography (CT) plays a significant role; this assessment is crucial for treatment planning of Coronavirus patient. Convolutional Neural Network (CNN/ConNet) is one of the popular deep neural networks; do find applications in image classification and recognition. This paper proposes comparative analysis of HR-CT COVID-19 image classification using 4 different pretrained CNN models namely VGG-19, AlexNet, DensNet-201, ResNet-50, and Support Vector Machine (SVM), performance analysis is done using Sensitivity, Specificity, and Accuracy. It is observed that CNN performs better than SVM but they require large number of datasets and high-performance computing machine. These algorithms definitely support radiologists to speed up the screening of CT scan images and act as secondary accessors for result verification.

**Keywords** Feature extraction · Convolutional neural network (CNN) · Classification · Support vector machine (SVM) · Gray level co-occurrence matrix (GLCM) · Rectified linear unit (ReLU)

## 1 Introduction

The image classification accepts the given input image, depending on relevant features, produces classification of image results for identifying whether the disease is present or not. During the pandemic situation the AI, ML, and DL played a significant role to support medical staff to access the significance of variation of infections in CT. Deep Learning (DL) invented during 2000 by Igor Aizenberg, which is subset of Machine Learning (ML), was invented by Arthur Samuel during 1959 and ML

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is subset of Artificial Intelligence (AI) invented by Jhon McCarthy during 1956. The desire of human being is to discover an algorithm more and more meaningful, day by day as the information captured for every second by artificial sensors need to premeditated and classified for many applications. AI and its allied areas are the key players, they are helping humans to make system more intelligent, reliable, and accurate to deal with data and make meaning out of this captured data. AI makes a provision for machine to mimic human behavior, ML learn by experience and DL algorithm are inspired by structure and function of human brain and learn and improve on available data to make any decision. Normally when the data dimensions are small machine learning is preferred and DL is best choice when the data is very large. Machine learning is a model that determines unknown patterns in a data by learning and optimization methods. Deep learning models are large neural networks, which is improved model that determine unknown patterns in data by experiences.

### **Contributions**

The involvements of this paper are three fold. First, we provide implementation of SVM classification algorithm, with small database, good performance is observed. Second, we propose four different CNN and comparison is carried out and is observed that performance of ResNet-50 CNN is outstanding. Third, we compare and contrast the performance of HR CT image classification using CNN and SVM.

### **Related Works**

The major contributions of research related to Covid-19 during the past 1 year are summarized below.

Dangis et al. [1], published during early days of pandemic that considered two different testing mechanisms for COVID-19, they are CT scan and RT-PCR of patient carried. CT scans were assessed by two radiologists blinded to the RT-PCR test; conclusion of this paper was assessment of the disease is much faster with CT scan than RT-PCR test in comparison to time.

Bai et al. [2], have considered 219 patients from USA and china for screening to differentiate COVID-19 from viral pneumonia using CT scans, in this work initially RT-PCR tests were carried out and if the results are infected same patient will go through chest CT scanning. Comparisons of CT findings are carried out from both contents and accuracy of assessment was compared, it was moderate to high.

Yang et al. [3], proposed publicly available collection of CT scan for AI-based diagnostic model in which they collected 349 COVID-19 CT scans from 216 patients and 463 non COVID-19 CT scan from 55 members. This model is tested for with DenseNet-169 and ResNet-50 and performance is compared with parameter such as accuracy, F1, and area under the curve (AUC). In this model performance assessment DenseNet-169 out performed.

Xu et al. [4], have emphasized on digitization of radiological imagery application with support of deep learning model to support physicians in assessing the disease more precisely as an assisting tool. This tool assesses the CT scan images as influenza-A viral pneumonia (IAVP), COVID-19, and healthy, the overall classification accuracy of 86.7% is achieved. Algorithm is tested for 618 CT sample

images. CT imagery screen patients can improve the early detection of COVID-19, and simplicity of the work load on laboratory nucleic acid testing.

Shan et al. [5], implemented Lung Infection Quantification of COVID-19 in CT scan images using deep learning VB-Net segmentation, it's customized 3D-CNN that merges V-Net with bottle-neck configuration. In this implementation it is observed as they increased the dataset the segmentation accuracy also increased and highest segmentation accuracy achieved was 91.6% to compute they have considered 300 CT scan images of COVID-19 infected patients, algorithm assessment was compared to 2 expert radiologist assessment.

A low contrast medical image edge detection based Fuzzy-c mean clustering has been developed [6]. Canny edge detection algorithm performs well among all edge detection techniques. FCM clustering segmented the image. Algorithm and software will develop in order to provide image analysis to its primary stage. To solve urgent diagnosis problem. More analysis and processing will have done for real time clinical CT and MRI imagery.

In this paper automatic Covid-19 infection segmentation was observed. Methodology is developed to identify the infected region using segmentation network named Inf-Net. Both GGO and consolidation infections are accurately segmented by Semi-Inf-Net and MC [7]. This study research will focus on integration of segmentation, quantification and detection of lung infection. Also, it will work on multi-class infection labeling for automatic AI diagnosis.

The focus of this study was to implement label free segmentation for Covid-19 [8]. We observed that Normal Net methodology is quite good compared to other UAD methods and NNN-net using bright pixel CT imagery. It's able to segment the Covid-19 lesion without labeling the dataset. So, it reduced the time and complexity in manual labeling. The proposed unsupervised methodology is good but still requires a lot of development. Thus it can segment only small part of lesion more accurately.

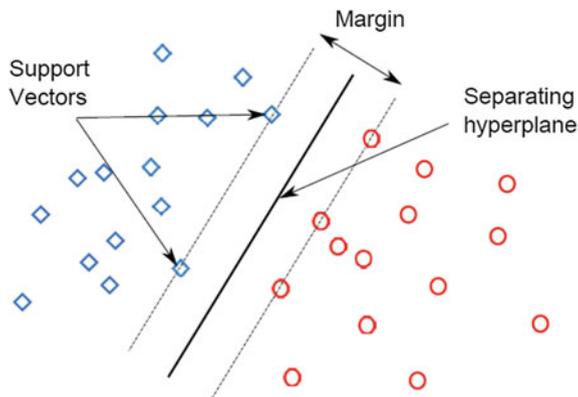
This paper shows that Covid-19 detection using AI based methodology. By combining UNET++ AND ResNet 50 model which gives 90.7% sensitivity and 92.2% specificity for better analysis [8]. It would be desirable to develop a self-supervised learning and collect more patient data to get more samples to improve efficiency and accuracy with advance application of AI. The proposed worked should focus on impact of Ciraf net, Alex net and Google net [9]. CNN architecture on a different training dataset and analyzed LN and ILD classification problem with 86% sensitivity. In future, research can be done on CAD problem where limited training dataset will be available.

## 2 Methods

### A. Support Vector Machines (SVM)

Support vector machines (SVM) is one of the best binary classification algorithm used in image classification. SVM uses a method called kernel (filter) to transform the image data and then based on these transformations it finds an optimal boundary

**Fig. 1** Illustration of the SVM approach



between the probable results. SVM algorithm is preferred to reduce the complication involved in the biomedical image segmentation process and improves the performance. SVM process input image by mapping image to a high dimensional feature space, so that image points can be classified, even when the data are not otherwise linearly separable. A separator between the categories is found, then the data are transformed in such a way that the separator could be drawn as a hyperplane. SVM model sets of labeled training data for each category, they're able to categorize new text. Furthermore, to improve the accuracy and quality rate of the support vector machine (SVM) based classifier, relevant features are extracted. SVM creates and maintains the pattern for future use, Fig. 1 and Algorithm 1.

### Algorithm 1

#### HR—CT SVM Classification

Input: HR-CT Image

Output: Patient HR-CT image infected (+Ve)/Patient HR-CT image not infected (-Ve)

- Step 1** Import patient HR-CT image database.
- Step 2** Split HR-CT image database as Covid-19 infected (+Ve) and not infected (-Ve).
- Step 3** Develop SVM classifier with Gray Level Co-occurrence Matrix (GLCM) GLCM feature.
- Step 4** Train and Test SVM classifier with Covid-19 infected (+Ve) and not infected (-Ve) and also validate.
- Step 5** Import test HR-CT image of patient for checking the algorithm result—fed to the SVM algorithm.
- Step 6** Result: HR-CT image infected (+Ve)/Patient HR-CT image not infected (-Ve).
- Step 7** Repeat **steps 5** for any number of test HR-CT images.
- Step 8** Access the results using accuracy, Sensitivity and Specificity.

### B. Convolutional Neural Network (CNN)

Convolutional Neural Network (CNN) is also identified as ConNet, is essentially a deep neural network model that consists of several layers of architecture, which are improved versions of artificial neural networks (ANN). CNN is developed by the inspiration of biological visual cortex; these have small cells which are sensitive to explicit areas of the visual field. Each neuron in the human brain retort to diverse features and this is the source behind CNN. CNN is popular because of their capabilities to extract features from large objects variation image and performance is excellent in numerous applications, they are widely used in radiological image processing and computer vision application ranging from resolution enhancement, segmentation, classification, and identification. CNN made computer vision so simple by extracting local feature from input image at higher layers and combines them into more complex features at the lower layers. However, due to its multi-layered architecture, it is computationally excessive and training such networks on a large image dataset. CNN models are designed and developed to adaptively and automatically learn spatial hierarchies of features through backpropagation by using multiple building blocks, such as convolution layers, pooling layers, and fully connected layers, HR-CT CNN image classification block diagram shown in Fig. 2. A CNN algorithm consists of these stages such as Convolution Layer, Activation function (ReLU—layer), Pooling, flattening and last layer is full connection. In this architecture the convolution layer and pooling layers accomplish feature extraction, and final stage fully connected layer maps the extracted features into final result, such as image classification.

**Convolution Layer:** Convolution layer on of the most significant section in the CNN architecture and this is a linear mathematical operation, convolution of two-dimensional information i.e., with a specific dimension kernel is convolved with entire image, which makes CNN extremely efficient for imagery applications, since a feature may occur anywhere in the image and it is represented as

$$(f * g)(t) \stackrel{\text{def}}{=} \int_{-\infty}^{\infty} f(\tau)g(t - \tau)d\tau \tag{1}$$

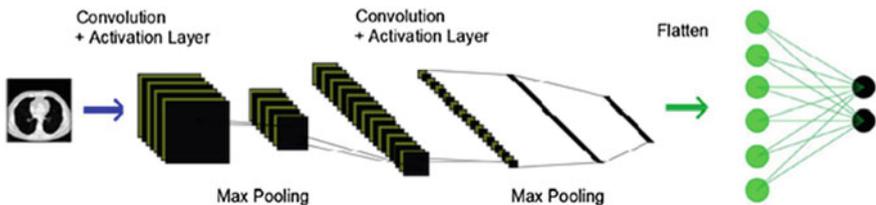


Fig. 2 Convolutional neural network architecture for CT-HR classification

While convolution process results output matrix with feature maps and this is sensitive to a specific area and hence the selection filter/kernel need to be selected judiciously.

**Activation Function (Rectified Linear Unit (ReLU)):** Once convolution of input image (sliding process) and kernel is performed the next stage activation function. Activation function receives information from convolution layer and converts it into some format which is suitable to process to the next stages, this is nonlinear transformation, it is carried out for inputs that is received before sending them to next layer/neuron, basically this is transfer function.

**Pooling:** The pooling processing in CNN architecture reduces the dimension of matrix which is input from the ReLU, the purpose is to minimize the over fitting and computation in images. Pooling layer perceive corners, edges etc., in image, it can be used to detect any infection in radiological image applications by means of multiple kernels; it is similar to filtering feature map, we obtain feature maps from convolution process, pooling is applied to kernel. Commonly preferred dimension of kernel is of dimension  $2 \times 2$ , this refers to feature maps get compact by factor of 2, this leads to reduction of feature map to one quarter. There are two types of pooling, Average pooling and Max pooling, the Average pooling returns the average of all the values from the part of the image covered by the filter, Max Pooling returns the maximum value from the part of the image covered by the filter.

**Flattening:** After the pooling layer, the next layer is flattening layer, which maps 2-dimensional feature vectors into single dimension feature vector. Flattening layer is which convert and 2-dimensional matrix into single dimension i.e., into a column matrix, in this process all row matrix is placed into single column matrix. Once the 2-dimension matrix is converted into single column it is simple to feed to neural network for additional processing.

**Fully Connected Layer/Full Connection:** In CNN architecture the bottom layer is fully connected layer in this layer each individual pixel is considered as separate neuron similar to neural network. The last fully connected layer will include lots of neurons as the amount of classes to be predicted. Fully connected layer receives the inputs from flattening layer in which the image is mapped into single column vector, i.e., flattened results are fed to the feed forward NN and back propagation is applied to each iteration of training. Over a sequence of epochs, the model can differentiate between dominating and specific low-level features in images and classify image objects. Fully connected layer assigns arbitrary weights to the inputs and determines an appropriate label.

Apart from these layers, few more blocks are utilized in the CNN architecture models involving the outputs of the labels found for the classification and assign a class to the dataset; other 2 significant blocks are Softmax and Dropout. The Softmax converts the output of final layer in NN into what is basically a probability allocation, this is generally used to standardize NN result to lie between '0' and '1', this presents the confidence "probability" in the network result. Dropout's main purpose is to keep away from overfitting, most common regularization technique is

used in NN, and dropout improves the accuracy. While training time at individual iteration a neuron is momentarily dropped/ disabled with probability  $p$ , temporarily all input and out neuron will be disabled at the existing iteration. The dropped out neurons are resampled with probability  $p$  at every training stage, so a dropped out neuron at one step can be active at the next one. The hyperparameter  $p$  is called the dropout rate and it's typically a number around 0.5, corresponding to 50% of the neurons being dropped out.

**Pre-trained CNN Model:** Pretrained CNN model is developed by somebody else to solve a similar problem, rather than building new model from base to resolve a similar type of problem, use these pretrained models could be utilized for any image classification application. This paper proposes 4 different pretrained CNN architectures for performance analysis comparisons for HR-CT classification, those are **DensNet-201**, **ResNet-50**, **VGG-19**, and **AlexNet**. Algorithm 2, shows the steps involved in CNN HR-CT classification.

### Algorithm 2

HR—CT CNN Classification

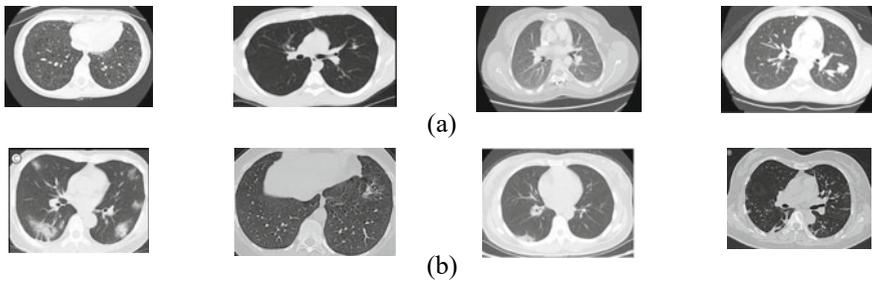
Input: HR-CT Image

Output: Patient HR-CT image infected (+Ve)/Patient HR-CT image not infected (−Ve)

- Step 1** Import patient HR-CT image database.
- Step 2** Split HR-CT image database as Covid-19 infected (+Ve) and not infected (−Ve).
- Step 3** Select pretrained CNN model (DensNet-201, ResNet-50, VGG-19 and AlexNet.)
- Step 4** Train and Test pretrained CNN model classifier with Covid-19 infected (+Ve) and not infected (−Ve) datasets and also validate.
- Step 5** Import test HR-CT image of patient for checking the algorithm result – fed to the CNN algorithm.
- Step 6** Result: HR-CT image infected (+Ve)/Patient HR-CT image not infected (−Ve).
- Step 7** Repeat **steps 5** for any number of test HR-CT images.
- Step 8** Access the results using accuracy, Sensitivity and Specificity.

## 3 Experimental Results

The Coronavirus (COVID-19) disease shows a number of unique characteristics, infection of patients could have been visualized using radiological imageries primarily using X-ray, but HR-CT gives detailed understanding of lung infections, Fig. 3 shows a sample of HR-CT sample images of Coronavirus patients infected and not infected. Ground Glass Opacification (opacity (GGO)) is an expressive term



**Fig. 3** Input HR—CT image samples to the algorithm. **a** Negative HR-CT. **b** Positive HR-CT

indicating an area of enlarged attenuation in lung of CT with bronchial and vascular markings.

### Results Analysis

The selection of pretrained CNN model plays a significant role for specific application, in our implementation we have considered four (4) pretrained CNN; these are trained and tested with training and testing ratio of dataset as **70:30**. Open access datasets are used for the experimentation, a total of more than 800 negative and 800 positive Covid-19 patients CT images are utilized [9–11]. Experimentation is carried out with different training and test ratios, but we have obtained efficient performance when training and testing ratio as **70:30**. The proposed model is implemented using Math Work Matlab 2019b software and Deep Learning toolbox on computer with i7 core, 8 GB RAM and GEFORCE Nvidia Graphics Processing Unit (GPU) (Table 1).

**Table 1** Comparative analysis of 4—CNN model

Parameters (training, validation and other information)	Pretrained CNN model for HR-CT image classification			
	AlexNet	VGG-19	DenseNet-201	ResNet-50
Results				
Validation accuracy (%)	88.60	90	95.0	96.67
<i>Training time</i>				
Elapsed time	3 m 15 s	29 m 25 s	24 m 23 s	11 m 56 s
<i>Training Cycle</i>				
Epoch	30	10	10	10
Iteration	30	80	80	70
Iteration per epoch	1	8	8	7
Maximum iteration	30	80	80	70
<i>Validation</i>				
Frequency	N/A	3 iteration	3 iteration	3 iteration
<i>Other information</i>				
Learning rate	0.0001	0.0003	0.0003	0.0003

**Table 2** Comparative discussion

Metrics	SVM	DensNet	VGG-19	AlexNet	ResNet-50
Accuracy	0.926	0.951	0.932	0.948	0.966
Sensitivity	0.909	0.921	0.941	0.935	0.961
Specificity	0.951	0.950	0.938	0.942	0.958

## Results Analysis by Pretrained CNN

### Comparative Analysis

#### Evaluation Metrics

The performance of the implementation is computed by means of three parameters accuracy, sensitivity, and measures. Table 2 describes the comparative analysis of all classification techniques, where  $TP$  is True Positive,  $TN$  is True Negative,  $FP$  and  $FN$  denotes false positive and false negative.

$$A = \frac{(TP + TN)}{(TP + FP + FN + TN)} \quad (2)$$

$$TPR = \frac{TP}{(TP + FN)} \quad (3)$$

$$FPR = \frac{FP}{(FP + TN)} \quad (4)$$

## 4 Conclusion

This paper makes an attempt to identify and classify Coronavirus (COVID-19) disease using high resolution CT images, around 1600 total images out of these 800 images are grouped into negative and positive patients. Total 5 classification algorithms are implemented and result is measured with parameters such as accuracy, sensitivity and specificity. As outcome of the implementation, it is observed in SVM algorithm we have achieved a classification accuracy of 92.6%, sensitivity is 90.9%, and specificity 95.1%. Among 4 CNN models ResNet-50 outperformed over other pretrained CNN models with classification accuracy of 96.6%, sensitivity is 96.1%, and specificity 95.8% by dividing datasets into two parts as training (70%) and testing (30%). It is observed that CNN performs better than SVM but they require large number of datasets and high-performance computing machines. Still the performance could be improved by combining CNN and SVM and definitely this will improve the result, which could be the future scope of the proposed work.

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# Reproductive Toxicology: An Update

*Makhadumsab Toragall, Shridhar C. Ghagane,  
Rajendra B. Nerli and Murigendra B. Hiremath*

## Abstract

Human reproduction and development is a succession of symbiotic events. Nearly, at every point of this phenomenon found to be the principle target of one or more reproductive toxicants. Chemical agents, physical factors, as well as biological intruders can pose antagonistic effects on reproductive potential of an organism. The pathways are different *viz.*, either damaging embryo and sometimes fetus or inducing mutation in a parent's germ cell. The outcomes are declined fertility to impulsive abortion, functional discrepancies, developmental retardation, structural anomalies, etc. It is a now essential to establishing proper databases for reproductive and developmental toxicity chemicals, physical and biological factors including appropriate awareness among the society. Although many *in vitro* and *in vivo* toxicology studies are in pipeline which are independent studies but combination with other hazardous studies could give us an accurate numbers.

**Keywords:** reproduction, toxicity, fertility, infertility, mutagens

## 1. Introduction

Reproduction (procreation; conception) is one of the most essential requirements of all organisms where producing a transcript, helps in the survival and perpetuation of the species [1]. Parenthood is one of the most comprehensively preferred priorities of mankind and which happens at ease, when couples are vigorous and normal. According to earlier archaic studies of anthropologists and evolutionary biologists, *Homo sapiens* displayed a better cognitive development about 2,00,000 years ago and hence, had a “reproductive consciousness” [2]. Ancient mythologies and civilizations respected and worshipped fertility Gods and Goddesses like, Egyptian goddess *Maat* [3], Mesopotamian's *Erua* [4], Babylonian's *Ishtar*, Persian's *Anaitis*, Greek's *Actemia* [2], and also they had a deep desire for conception, and a strong perception of fertility, which can be correlated with human sustainability and existence.

The reproductive cycle of a mammalian individual involves of a sequence of several phases and unified events. According to ICH guideline [5]:

- A. Pre-mating to birth (mature male and female conceptive ability, growth and maturation of gametes, reproductive nature, and conception).
- B. Conception to implantation (mature female conceptive ability, pre-implantation development, cleavage, morula, blastula, and implantation).

- C. Implantation and organogenesis (mature female conceptive ability, development of embryo, and foremost organ development).
- D. Fetal development (until the end of gestation, mature female conceptive ability, fetal development and growth, and growth and development of organs).
- E. Birth and pre-weaning development (mature female conceptive ability, parturition, lactation, neonate adaptation to extrauterine life, pre-weaning development, and growth).
- F. Post-weaning development up to sexual maturity (growth, adulthood, adaptation to independent life, and achievement to full sexual function).

According to World Health Organization (WHO) info, at present globally 50–80 million people are facing infertility [6]. Significant studies have reported that female infertility occurs 50%, infertility because of male factors is 20–30%, and rest is shared by both genders [7]. These findings are considerably broader than previously reported.

## 2. Reproductive toxicity

Since a decade, human reproductive disruption by various factors including xenobiotics such as drugs, occupational, and environmental exposures leading to reproductive toxicity which is has become a growing concern. Reproductive toxicity defined as: “the antagonistic effects of a substance on any characteristics of the male or female sexual reproductive cycle, together with an impairment of reproductive function, and the induction of adverse effects in the embryo, such as growth retardation, malformations, and death which would interfere with the production and development of normal offspring that could be reared to sexual maturity, capable in turn of reproducing the species” [8].

The first essential introduction in reproductive toxicology was given by Wilson and Warkany in 1965 [9]. The first test guideline was published by the Food and Drug Administration (FDA) in 1966 [10], followed by the Committee on Safety of Medicines [11], Ministry of Health and Welfare (MHW) of Japan [12], and rest of the other nations. It was provisionally terminated by International Federation of Teratology Societies (IFTS), pharmaceutical industry and the health authorities of EEC, Japan, and USA with the aid of ICH Harmonized Tripartite Guideline “Detection of Toxicity to Reproduction for Medicinal Products” in June 1993 [13, 14].

Reproductive toxicity is categorized as follows:

### 2.1 Reproductive toxicity

Reproductive toxicity has been defined as “any effect of chemicals that would interfere with reproductive ability or potential,” with consequent effects on lactation and the development of the progenies [15]. It includes, variations in the reproductive system of men and women, adverse impacts on the beginning of adolescence, normal reproductive cycle, production and transport of healthy gametes, sexual activities, fertility, parturition, early conceptive senescence, and alterations in any other activities which are reliant on the integrity of the reproductive systems [16]. Reproductive toxicity effects could be via lactation too but such classes are treated separately [17]. This is because it is desirable to be able to classify chemicals

specifically for adverse effect on lactation so that a specific hazard warning about this effect can be provided for lactating mothers.

Classes of reproductive toxicity include:

- Male fertility
- Female fertility
- Parturition
- Lactation.

## 2.2 Developmental toxicity

According to Globally Harmonized System the developmental toxicity is defined as, “adverse effects induced during pregnancy, or as a result of parental exposure,” which “can be manifested at any point in the life span of the organism” [15]. The exposure to specific exogenous substances prior to conception in either of the parent, exposure during gestation, or exposure during prenatal or postnatal development from birth to sexual maturation may result in developmental toxicity. Developmental toxicity has varied end points such as impulsive abortions, stillbirths, deformities, and early postnatal mortality, reduced birth weight leading to structural anomaly, altered growth, functionally deficit, and death of the developing organism [18].

Classes of developmental toxicity include:

- Mortality
- Dymorphogenesis (structural abnormalities)
- Alterations to growth
- Functional impairment.

Due to the fact that, male and female reproductive anatomy and biologic mechanisms are differing, they have a speckled result for reproductive toxicants. It is therefore essential to recognize reproductive toxins and their mechanisms and sites of action and to learn about species (especially human) vulnerability to them. Reproductive toxicants or reprotoxicant are chemical, biohazardous (e.g., viruses), or physical (e.g., radiation), agents that can impair the reproductive capabilities in men and/or women. Developmental toxicants interfere with proper growth or health of the child acting at any point from conception to puberty. The chemical agents which elevate the occurrence mutations above natural level by damaging the genetic material of an individual are known as mutagens. Incidences of defective cells or cancerous cells found when these mutations are inherited. As the name suggests, embryotoxins are lethal to embryos, where they may exterminate, distort, impede the growth and development of embryo, and may cause postnatal problems. The compounds like, mercury, lead, other heavy metals, and organic compounds *viz.*, formamide are some of the well-known examples of embryotoxins. Additionally, agents which can interrupt or leads to deformity in the development of an embryo or fetus are called as teratogens, which have the potential to miscarriage or cause children with birth defects.

The fundamental biological mechanisms of reproductive toxicity are multifaceted and involve absorption, distribution, metabolism (toxification, and/or detoxification), excretion, and repair [19]. The mechanism of reproductive toxicants disturbs the flow of matter, energy, or information that are necessary for normal functioning of cells, organs, or organisms. Later, toxicant will distribute to the target organ (gonad, hypothalamus, pituitary, uterus, epididymis, liver, etc.) where it employs its antagonistic effect before it is metabolized. The action of reproductive toxicant is either direct by the virtue of structural similarity to an endogenous compound (*viz.*, hormone, vitamin, or nutrient) or because of chemical reactivity (i.e., alkylating agent, denaturant, and chelator) or indirect (requiring metabolism before exerting a toxic effect) on reproductive system [19].

Formerly debated male fertility decline is no longer controversial. Several substantiating reports have confirmed a fall in sperm counts and semen quality in men over the last several decades globally [20]. The causative factors are not only obesity, illicit substance use, smoking rates, and alcohol abuse, but also due to chronic reproductive toxin exposures of the modern age. The spermatozoa with abnormal genetic material, which supports irregular spermatogenesis, abortions, progenies with genetic defect and diseases, etc., are some of the adverse effect of causative factors on male fertility. The investigation of male reproductive function begins with measurement of testis size, semen analysis, accessory gland functionality, reproductive hormone estimation, impotence or reduced libido, and fertility [21].

Many studies have been reporting weakening of female reproductive capacity over the past half century, which could be because of cultural change (e.g., delayed childbearing and increased contraception in women), but environmental exposures to the fetus, mother, or father may also contribute [22]. The women's health practitioners, obstetricians, and gynecologists have been advised to increase communication with their patients about the potentially detrimental effects of reproductive toxicants on reproductive health [23]. Among women of US and Danish the conception rate have declined to 44% since 1960 [24] and hormone-related diseases such as disorders of pubertal development, polycystic ovary syndrome (PCOS), endometriosis, and uterine fibroids have become common.

Reproductive difficulties and developmental abnormalities constitute a significant medical problem and greatly contribute to human suffering. The following provides a summary of the Globally Harmonized System (GHS) system as it relates to classification of health hazards [15]. The GHS system defines developmental toxicity with reproductive toxicity, but later classifies them separately. While classification, the GHS system define reproductive toxicity as, antagonistic effects on sexual activity and fertility amongst adult men and women comprising its adverse effect on sexual deeds, parturition, pregnancy outcomes [15].

These are the following categories of reproductive and developmental toxicants:

### 2.2.1 Category I: satisfactory reports with human evidence

The toxicants which are found to be human reproductive and/or developmental hazards are considered as category-I agents. The research reports which assist the above hypothesis with satisfactory epidemiologic confirmations or studies involving humans along with solid subsidiary animal study for at least one adverse reproductive effect. Though, the research data with human study is limited to support this classification, at present there are agents which fall under this category. The list includes biological, physical along with chemical hazards which pose potential reproductive effects, are the resultant of studies included humans and animals (**Table 1**).

<b>Chemical</b>	<b>Reported adverse effects</b>
Aniline	Female subfertility, natural abortion, growth impedance, and developmental disorders
Bulsulfan, methotrexate, cyclophosphamide	Male and female infertility, natural abortion, genetic defects, and growth retardation
Carbon disulfide	Lower male sex libido, infertility, abortion, abnormal growth, menstrual disorders, and breast milk contamination
Carbon monoxide	Female infertility, spontaneous abortion, growth retardation, and functional deficit
Dibromochloropropane (DBCP)	Infertility in men, genetic defects, and altered sex ratios
Dinitrotoluene (DNT)	Spontaneous abortion, male infertility, growth retardation, and developmental disorders
Ethyl alcohol	Male infertility, developmental disorders, birth defects, low birth weight, or premature births
Lead	Infertility, miscarriage, growth retardation, functional deficit, and breast milk contamination
Mercury	Male infertility, birth defects, growth retardation, and breast milk contamination
Phenol	Altered sex ratio, spontaneous abortions, and impotence
Polychlorinated biphenyls (PCBs)	Infertility, spontaneous abortion, growth retardation, and breast milk contamination.
Warfarin	Birth defects, developmental disorders, and spontaneous abortions
Toluene (methyl benzene)	Low birth weight, developmental disorders, birth defects, menstrual disorders, and male and female infertility
Bio-hazardous material	
Cytomegalovirus	Spontaneous abortion, birth defects, growth retardation, and developmental disorders
Hepatitis B virus	Growth retardation, liver disease in infected offspring, and breast milk contamination
HIV	Functional deficit and childhood cancer
Rubella virus (German measles)	Birth defects, growth retardation, and developmental disorders
Varicella-zoster virus (chicken pox and shingles)	Birth defects and growth retardation
Physical hazard	
Excessive heat	Male infertility
Heavy physical exertion	Spontaneous abortion and growth retardation
Ionizing radiation	Male and female infertility, spontaneous abortion, birth defects, growth retardation, developmental disorders, and childhood cancer

**Table 1.**  
 Category I: Satisfactory reports with human evidence [15].

### 2.2.2 Category II: satisfactory reports with animal evidence/limited human evidence

The toxicants which are likely found to be or possible human reproductive hazards are considered as category-II agents. In order to support this category, studies which include experimental animals and/or limited human trails can be considered.

<b>Chemical</b>	<b>Reported adverse effects</b>
Acetaldehyde	Growth retardation and developmental disorders
Acetone	Female infertility, birth defects, and menstrual disorders
Aluminum	Birth defects
Ammonia	Premature birth
Anesthetic agents	Male infertility, spontaneous abortion, birth defects, growth retardation, and breast milk contamination
Antimony	Spontaneous abortion, and breast milk contamination
Arsenic	Birth defects and spontaneous abortion
Benzene	Female infertility, spontaneous abortion, birth defects, growth retardation, and menstrual disorders
Boric acid, borates	Reduced male sex drive, male infertility, and female infertility
Bromine	Male infertility, decreased libido, impotence, and breast milk contamination
Cadmium	Infertility, birth defects, growth retardation, developmental disorders, and breast milk contamination
Carbamide (urea)	Spontaneous abortion
Carbaryl	Male and female infertility and genetic defects
Carbon tetrachloride	Male and female infertility
Chloroform	Spontaneous abortion and birth defects
Copper	Spontaneous abortion and birth defects
Dimethoate	Birth defects, spontaneous abortion, and male infertility
Dimethylformamide, N, N (DMF)	Spontaneous abortion, stillbirths, birth defects, and female infertility
Ethylene glycol monomethyl ether (EGME)	Male infertility, birth defects, and developmental disorders
Ethylene oxide	Male and female infertility, spontaneous abortion, birth defects, and growth retardation
Formaldehyde	Female infertility and spontaneous abortion
Gasoline	Female infertility, birth defects, and menstrual disorders
Lithium	Birth defects and male infertility among patients taking lithium
Manganese	Reduced male sex drive, male infertility, and breast milk contamination
Nitrous oxide	Male and female infertility, spontaneous abortion, and developmental defects
Oral contraceptives	Reduced male sex drive, female infertility, and birth defects
Paints	Spontaneous abortion and developmental disorders
Polyvinyl chloride (PVC resin)	Female infertility, spontaneous abortion, and stillbirths
Solvents	Birth defects, developmental disorders, spontaneous abortion, impotence, female infertility, menstrual disorders, and breast milk contamination
Sulfur dioxide	Spontaneous abortions, female infertility, low fetal weights, and birth defects
Styrene (vinyl benzene)	Male and female infertility, spontaneous abortion, and breast milk contamination

Chemical	Reported adverse effects
Tetrachloroethylene (perchloroethylene)	Female infertility, spontaneous abortion, developmental disorders, birth defects, menstrual disorders, and breast milk contamination
Trichloroethylene	Male and female infertility, spontaneous abortion, and birth defects
Trinitrotoluene	Male infertility
Vinyl chloride monomer	Reduced male sex drive, spontaneous abortion, birth defects, and childhood cancer
Xylene	Female infertility, birth defects, menstrual disorders, and breast milk contamination
Physical hazard	
Low atmospheric pressure (hypobaric)	Male infertility and growth retardation
High atmospheric pressure (hyperbaric)	Male infertility and birth defects

**Table 2.**  
 Category II: Satisfactory reports with animal evidence/limited human evidence [15].

Chemical	Reported adverse effects
Acrylamide	Male and female infertility, birth defects, and developmental disorders
Carbon dioxide	Birth defects and male infertility
Carbon tetrachloride	Male and female infertility, developmental disorders, and birth defects
Chromium	Birth defects and infertility
Dimethyl phthalate	Birth defects and developmental disorders
Dimethyl sulfoxide (DMSO)	Developmental disorders
Epichlorohydrin	Male infertility
Ethylene thiourea	Birth defects
Halothane	Developmental disorders and birth defects
Methyl alcohol	Developmental disorders
Methyl ethyl ketone (MEK)	Developmental disorders
Methylformamide, N	Birth defects
Methylpyrrolidone	Birth defects
Nickel	Birth defects
Polybrominated biphenyls (PBBs)	Birth defects and developmental disorders
Ribavirin (virazole)	Birth defects and spontaneous abortion
Toxaphene (camphechlor)	Developmental disorders, infertility, and breast milk contamination
1,1,1-Trichloroethane	Low fetal weight, birth defects, and developmental disorders

**Table 3.**  
 Category III: Suspect/insufficient reports with animal evidence but not humans [15].

To support this class, minimum criteria is a single, systematic experiment on one animal species for one adverse reproductive effect. Below **Table 2**, enlisted the toxic effects of potential reproductive toxicants based on the observation of studies comprised animals and humans.

### 2.2.3 Category III: suspect/insufficient reports with animal evidence but not humans

This category consists of agents with probable or indeterminate reproductive hazards. Though they possess adverse effect on reproductive health but data are inadequate. Present details in **Table 3**, is only of studies with animal experiments with no human trials.

## 3. Chemical factors

Chemicals are omnipresent elements with both positive and negative effects found in workplaces across the globe. Several environmental chemicals together with other agents (e.g., radiation and bacteria), chemicals may also destructively affect the reproductive systems of male and female workers (**Table 4**). Exposure to toxicants before and after conception can affect parents, fetuses, and newborns. In most of the working environments, huge numbers of workers are exposed to the substances which are potentially toxic to reproductive health even after knowing. Exposure to industrial chemicals can alter reproductive functions in females. The ovary of a female is vulnerable in most of the cases therefore, have a significant effect on fertility, menstrual (estrous) cyclicity, and the timing of puberty and menopause [26]. Many toxic chemical agents, active metabolites from mother may reach the womb by different routes of mechanisms causing unfavorable environment to its development. This toxicity could reach to the deepest point, where it may not only obstructs the transport of male and female gametes to the site of fertilization but also stops fertilized egg moving to the site of implantation and development in the uterus. It is also found that, abnormal hormonal control during pregnancy is influenced by toxicants resulting in potential adverse effects on the fetus. The primary manifestations of developmental toxicity are embryo/fetal death, malformations (birth defects), growth retardation, and developmental delay. Adverse fetal outcomes may also include preterm delivery, altered sex ratio, and childhood cancer. The human tests is the house of high rates of proliferation, differentiation, as well as a metabolic activity associated with the production of large quantities of mature sperm which makes it more vulnerable to chemicals. The toxicants will target the Leydig cells (LC), sertoli, and germ cells of a testis which are the site of spermatogenesis, leading to germ-cell apoptosis and spermatogenic failure. Examples of chemicals toxic to the male reproductive system are presented in **Table 5**.

### 3.1 Heavy metals

Metals exert an extensive diversity of hazardous effects on reproduction and development including influence on fertility, intrauterine growth retardation, abortions, malformations, birth defects, and developmental effects, mainly those on the nervous system [21]. More recent, important mechanisms of action are those related to endocrine disruption and oxidative stress. Endocrine disruptors (EDs) have been defined as “exogenous chemical substances or mixtures able to alter the structure or function of the endocrine system and to cause adverse effects on organisms or their progeny” [28].

It is believed that, partial exposure to certain chemicals will decreases the puberty, causes abnormal semen quality and quantity, impairment of sex ratio, occurrence of hypospadias, testicular cancer, infertility, miscarriages, and genetic defects. In an *in vitro* study, concentration over 1 mmol of copper significantly

Agent	Industry or occupational group	Reported effects of female exposure	Reported effects of male exposure
Organic solvents in general	Painting, degreasing, shoemaking, printing, dry cleaning, metal industry, and several other fields of industry	Reduced fertility, menstrual disorders, fetal loss, birth defects, preterm birth, neurobehavioral effects, and childhood leukemia	Delayed conception, reduced semen quality, fetal loss, and birth defects
Benzene	Petrochemical industry and laboratory personnel	Fetal loss, reduced fertility, and low birth weight	
Carbon disulfide	Viscose rayon industry	Menstrual disorders	Decreased libido and potency
Some ethylene glycol ethers and their acetates	Electronics industry, silk screen printing, photography and dyeing, shipyard painting, metal casting, chemical industry, and other industries	Reduced fertility, fetal loss, birth defects, and menstrual disorders	Reduced semen quality
Tetrachloroethylene	Dry cleaning and degreasing	Reduced fertility and fetal loss	
Toluene	Shoe industry, painting, and laboratory work	Reduced fertility and fetal loss	
<b>Metals</b>			
Lead	Battery industry, lead smelting, foundries, pottery industry, ammunition industry, and some other metal industries	Reduced fertility, fetal loss, preterm birth, low birth weight, birth defects, and impaired cognitive development	Reduced semen quality, reduced fertility, fetal loss, and birth defects
Inorganic mercury	Lamp industry, chloralkali industry, and dental personnel	Reduced fertility, menstrual disorders, and fetal loss	Fetal loss
Pesticides <sup>a</sup>	Agriculture, gardening, and greenhouse work	Reduced fertility, fetal loss, birth defects, preterm birth, reduced fetal growth, neurodevelopmental effects, and childhood leukemia	Reduced sperm quality, reduced fertility, fetal loss, birth defects, and childhood cancer
<b>Pharmaceuticals</b>			
Anesthetic gases	Operating rooms, delivery wards, and dental offices	Fetal loss, reduced birth weight, preterm birth, birth defects, and reduced fertility	
Nitrous oxide	Operating rooms, delivery wards, and dental offices	Fetal loss, reduced birth weight, and reduced fertility	

Agent	Industry or occupational group	Reported effects of female exposure	Reported effects of male exposure
Antineoplastic agents	Hospital workers, pharmaceutical industry	Menstrual dysfunction, reduced fertility, fetal loss, premature birth, low birth weight, and birth defects	
Carbon monoxide	Iron and steel foundries, welding, food industry, car repair, and service stations	Preterm birth and intrauterine death	

<sup>a</sup>Examples of pesticides with adverse effects in men include dibromochloropropane (DBCP), 2,4-dichlorophenoxyacetic acid (2,4-D), ethylene dibromide, chlordane, carbaryl, alachlor, atrazine, and diazinon.

**Table 4.**

Adverse reproductive effects of some chemical agents that have been reported in human studies (Source: [25]).

reduced the human sperm motility, where sperm motility is considered as one of the prime attribute of a male gamete to reach oocyte [29]. Cadmium, for example, may affect steroidogenesis by mimicking or inhibiting the actions of endogenous estrogens [30]. Several metals such as, iron, copper, cobalt, and lead will lead to oxidative stress by increasing the production of reactive oxygen species, decrease the levels of glutathione and other antioxidants. Lead interrupts the hypothalamic-pituitary axis and has been reported to alter hormone levels [31, 32], alter the onset of puberty, and decrease overall fertility [31]. The industrial discharges and emissions, batteries and most of the thermometers are the primary sources of mercury. Currently, mercury concentrations can be found in food chain especially in tainted seafood, leading to bioaccumulation amongst humans who are consumers of such foods which leads to reproductive toxicity [31] by disrupting normal spermatogenesis and fetal development [32]. Amongst heavy metals, boron is widely employed in the production of soap and cement including in leather industries, which is found to disrupt the HPG axis like lead [32]. Cadmium is another metal which is reported to cause testicular necrosis in mice and notable libido activity and infertility (Table 5) [33].

### 3.2 Insecticides

Insecticides are described as “chemicals used to control insects by killing them or preventing them from engaging in undesirable or destructive behaviors” by United States Environmental Protection Agency [34]. Considering the chemical structure, insecticides could be divided into five groups: (i) organochlorines, (ii) organophosphates, (iii) carbamates, (iv) pyrethrins/pyrethroids, and (v) nicotine/neonicotinoids. Insecticides could be characterized as “endocrine disrupters” due to their adverse effects on reproductive hormone pathway [35]. Exposure to permethrin, fenvalerate, and cypermethrin showed drastic drop in serum testosterone levels and elevated follicle stimulating hormone (FSH) and luteinizing hormone (LH) levels. It is understandable that, decrease in testosterone levels provides a negative feedback to HPG axis, helping FS and LH to rise. Impairment of spermatogenesis, anti-androgenic effects, and alterations in reproductive enzyme pathways, decreased sperm quality and motility are key elements in insecticide-induced male infertility [36]. Organophosphates could alter the spermatozoon chromatin structure, DNA, acrosome, motility and, have toxic effects on HPG axis

Chemical hazards	Species effect observed (h = humans, a = animals)	Examples of occupations where hazards may occur
Alcohol	h	Social threat
Alkylating agents	h, a	Chemical and drug industrial
Anesthetic gases nitrous oxide	a, h	Medical, dental, and veterinary employees
Cadmium	h, a	Storage batteries and smelter workers
Carbon disulfide	h, a	Viscose rayon manufacture and soil treaters
Carbon tetrachloride	a	Chemical laboratories and dry cleaners
Diethylstilbestrol (DES)	a, h	DES producers
Chloroprene	h, a	Rubber labors
Ethylene oxide	a, h	Health-care workers (disinfectants) and users of epoxy resins
Hair dyes	a	Cosmetic manufacturers, hairdressers, and barbers
Lead	h, a	Storage batteries, policeman, and smelter workers
Manganese	h	Welders, ore smelters, and roasters
Nickel	a	Smelters and welders
Organic mercury compounds	a	Pesticide workers
Tris (flame retardants)	a, h	Clothing and textile work
Pesticides	a, h	Farmworkers and pesticide manufacturers
Dibromochloropropane	—	Exterminators
Vinyl chloride	h	Polyvinylchloride manufacture and processing
Elevated carbon dioxide	a	Brewery workers and chemical manufacture
Elevated temperature	h, a	Bakers, glassblowers, foundry, and oven workers
Microwaves	h, a	Radar operators, flight crew or pilots, and transmitter operators
X-irradiation	h, a	Health workers and radiation workers

**Table 5.**  
*Examples of agents toxic to the male reproductive system [27].*

including reduced levels of testosterone [37]. Organochlorines such as dichloro-diphenyltrichloroethane (DDT), methoxychlor, chlordane, heptachlor, aldrin, endrin, and lindane are reported to cause oxidative stress within epididymis by decreasing antioxidant defense [38]. Endosulfan was found to cause irregular sperm maturation amongst farmers who employed this chemical into their fields. These insecticides not only hazard to male but also to female reproductive system (**Table 6**). They disrupt endocrine system and ovarian physiology in females via HPG axis leading to follicular maturation anomaly, disordered ovarian cycle, prolonged pregnancy, stillbirth, and subfertility also DNA damage and apoptosis amongst cells [39]. Endosulfan, an organochlorine, triggered apoptosis via

Hazard	Outcome
Anesthetic gases	Miscarriage and neonatal deaths
Hepatitis B	Newborn hepatitis and liver cancer
Organic mercury	Cerebral palsy and brain malformation
Lead	Abortions and premature birth (polychlorinated biphenyls)
Radiation	Miscarriage, brain defects, and skeletal defects [suspected reproductive hazards (based on human studies)]
Carbon monoxide	Slowed growth
Cytotoxic drugs	Abortions
Ethylene oxide	Abortions
Hexachlorophene	Birth defects
Organic solvents	Cleft palate, miscarriage, newborn infection, childhood cancer, physical stress (including heat), and prematurity
Vinyl chloride	Brain defects

**Table 6.**  
Examples of reproductive hazards to humans.

oxidative stress induction in the follicle cells. Moreover, it induced the expressions of steroidogenic acute regulatory protein (StAR), CYP19A1a and aromatase, causing improper ovarian maturation organochlorines (**Table 7**) [38].

### 3.3 Genital tract infection

The male accessory gland infection and genital tract infections, by numerous bacteria, viruses, and fungi have an adverse effect on male fertility aptitude by infecting semen, inducing oxidative stress, which damages testicles, colonizing genital tract leading to obstruction, and directly disturbing sperm function, morphology [40]. The sexually transmitted pathogens and uro-pathogens such as, *Chlamydia trachomatis*, *Escherichia coli*, *Staphylococcus epidermidis*, *Klebsiella*

Insecticides	Effects on endocrine system
Aldicarb	17 beta-estradiol and progesterone inhibition
Aldrin	Androgen receptor binding
Carbofuran	Estradiol and progesterone increase; testosterone decrease (chlordane)
Deltamethrin	Estrogenic activity
Dieldrin	Androgen receptor binding, inducing estrogen receptor production in the cell (endosulfan)
Lindane	Luteal progesterone decrease, androgen, estrogen, and progesterone receptor binding
Methoxychlor	Estrogenic effect, pregnane X cellular receptor binding (parathion)
Parathion	Gonadotrophic hormone synthesis inhibition
Fenoxycarb	Testosterone metabolism disruption
Endosulfan	Androgen receptor binding, inducing estrogen receptor production in the cell
Chlordane	Androgen receptor binding, estrogenic pathway inhibition

**Table 7.**  
Selected insecticides and their effects on endocrine system.

spp., *Proteus* spp., *Ureaplasma urealyticum*, *mycoplasmas*, *Trichomonas vaginalis*, *Staphylococcus saprophyticus*, *Neisseria gonorrhoeae*, and chronic viral sperm contagions *viz.* *human immunodeficiency virus*, *hepatitis B*, and *hepatitis C viruses* [41] are some of the prominent pathogens which infect the male accessory glands and also the genital tract leading to male infertility which is accounted for 15–20% of total infertility [42]. The testicular tenderness, urethral expulsion, epididymal inflammation, and throbbing ejaculation are some of the notable symptoms of genital infection [43]. Microbial infection triggers the immune inflammatory mechanism, by which white blood cells and pro-inflammatory cytokines such as IL-1, IL-6, IL-8, macrophages, and polymorphonuclear neutrophils will be released into the infection site, which have been found to show negative effect on sperm functionality and fertilizing ability [44]. In females, genital tract infection can lead to adverse health outcomes such as infertility, ectopic pregnancy and increased vulnerability to transmission of the human immunodeficiency virus. It is also associated with adverse pregnancy outcomes. Vaginitis and cervicitis are common lower genital tract infections usually found in females which enable uncharacteristic vaginal discharge, genital discomfort, itching, and burning sensation while urination. Generally infection occurs at soft tissue and perineal of female genital tract. The infections which are common *viz.*, bacterial vaginosis, Bartholin gland abscess, endometritis, *pyometra*, *salpingitis*, pelvic inflammatory disease, intrauterine contraceptive device-associated infection, postsurgical obstetric, and gynecologic infections.

### 3.4 Obesity

A medical ailment linked with excessive accumulation of white adipose tissue within the body, distressing normal health and a person with BMI 25–30 kg/m<sup>2</sup> can be overweight, whereas BMI  $\geq 30$  kg/m<sup>2</sup> is said to be obese [45]. Current evidences have shown the destructive impact of obesity on the reproductive aptitude of men by subduing spermatogenesis, causing abnormal sperm morphology, sperm DNA fragmentation, erectile dysfunction, and reduced libido [46]. Increased deposition of fat in the upper thighs, scrotum, and suprapubic area causes rise in scrotal temperature and oxidative stress, which ruins normal spermatogenesis, sperm motility, and also interferes with sperm-oocyte interaction [47]. Prevalence of menstrual dysfunction, subfertility, abortion rates, pregnancy hitches, and anovulation are commonly seen in overweighed women and they are at high risk for reproductive health. In obese women, gonadotropin secretion is affected because of the increased peripheral aromatization of androgens to estrogens. When neuro-regulation of HPG axis declines abnormal ovulatory activities can be seen [48], which is generally because of decreased sex hormone-binding globulin (SHBG), growth hormone (GH), and insulin-like growth factor binding proteins (IGFBP) leading to elevated leptin levels [49].

### 3.5 Tobacco consumption and smoking

Chewing tobacco and smoking are the injurious addictions [50], which contains >30 mutagenic substances, numerous toxic chemicals along with nicotine and familiar carcinogens [51], have been reported for adversely affecting semen quality and eventually male infertility [52]. The cytotoxic effect of tobacco chewing and/or smoking decreases sperm count, motility, viability and morphological mutations along with damaging testes, accessory glands/ducts leading to low semen volume, seminal leukocytes, abnormal hormonal levels, impaired spermatogenesis, sperm DNA damage, oxidative stress, cytogenetic abnormalities, spontaneous abortions, and congenital anomalies [53]. For women, smoking cigarettes can lead to reproductive

damage, reduced fertility, and difficulty conceiving. Research shows smoking may affect hormone production, making it difficult to become pregnant [54]. Several studies have indicated the adverse effects of maternal smoking during pregnancy on abnormal fetus development, newborn deaths, and problems associated with pregnancy resulting in premature conception.

### 3.6 Alcohol ingestion

Chronic and excessive alcohol consumption hamper the normal functioning of the HPG axis, resulting abnormal secretion of gonadotropin-releasing hormone (GnRH), FSH, LH, and testosterone that alters LCs and sertoli cell functions, and impairs spermatogenesis [55]. Furthermore, prolonged alcohol addiction causes testicular damage and shrinkage [56], abridged semen quality [57], lower semen volume [58], partial or complete spermatogenic seizure [59], and delayed seminal fluid liquefaction [60]. Eventually, decline in sex hormone levels causes loss of secondary sexual distinctiveness, Sertoli cell-only syndrome, impotence, diminished libido [61], erectile dysfunction, and ejaculation problems [62]. Heavy alcohol use may diminish ovarian reserve and fecundability in women. Detrimental effects of mild to moderate alcohol consumption may interfere with normal menstrual cycle, disturb puberty, damage reproductive capacity, and cause hormonal abnormality amongst women [63]. As alcohol easily pass through placenta, accumulates in amniotic fluid leading to decreased fetal metabolic enzyme activity [64].

### 3.7 Drugs

Drugs of abuse and chronic medication may have adverse effect on the fertility potential of men by disturbing HPG axis, gonadotoxic activity, or by upsetting sexual performances (ejaculation, erection, and libido) [65]. Prolonged treatment with immunosuppressive drugs (sirolimus and ciclosporine), corticosteroids, immunomodulators (mAbs and TNF $\alpha$  inhibitors), thyrosine kinases inhibitors, opiates (morphine and cocaine), hormonal agents (anabolic steroids and testosterone), antiandrogenic drugs (cyproterone acetate and flutamide), antibiotics (erythromycine and tetracyclines), antimicrobial drugs (metronidazole and chloroquine), antidepressant (imipramine and buspirone), antipsychotic (phenothiazines and butyrophenones), etc., will present a drastic drop in sperm count, motility and morphology [66], inhibition or low level of testosterone [67], hindering acrosomal reaction and shrinking fertility potential of spermatozoa [68], toxic effect on gonads [69], drop in testicular size, weight and volume, inhibiting dopamine synthesis [70] thereby causing erectile dysfunction [71], decreased libido [72], sedation [73] and delayed ejaculation [74], anejaculation/retrograde ejaculation [75] which will result in impotency or male infertility (Tables 8 and 9) [65].

### 3.8 Testicular hyperthermia

The normal spermatogenesis in humans and most mammals require testicular temperature 2–4°C below body temperature [77]. The rise in the scrotal temperature and its duration upsets semen quality resulting spermatogenesis seizure [78], producing more morphologically abnormal sperm, reduced sperm movement [79], destruction of mitochondria and DNA [80], declined sperm concentration [81], and death of germ cells [82], sooner or later into male infertility. The relentless exposure to several external factors such as stance/posture, outfit/clothing, lifestyle, and seasons may negotiate the ability of the scrotum to thermo-regulate leading to adverse effects on male fertility [83]. Apart from these factors, occupational exposure to

<b>Medication</b>	<b>Effect on reproductive function</b>
Anabolic steroids	Impairment of spermatogenesis (up to 1 year recovery); may cause hypogonadism through pituitary-gonadal axis
	Reversible
Antiandrogens	Impairment of spermatogenesis; erectile dysfunction
Cyproterone acetate, danazol, finasteride, ketoconazole, and spironolactone	Reversible
Antibiotics	Impairment of spermatogenesis
Ampicillin, cephalotin, cotrimoxazole, gentamycin, neomycin, nitrofurantoin, Penicillin G, and spiramycin	Reversible
Antibiotics	Impairment of sperm motility
Cotrimoxazole, dicloxacillin, erythromycin, lincomycin, neomycin, nitrofurantoin, quinolones, tetracycline, and tylosin	Reversible
Antiepileptics	Impairment of sperm motility
Phenytoin	Reversible
Antihypertensives	Fertilization failure
Antipsychotics	Impairment of spermatogenesis and sperm motility
Butyrophenones	Reversible
H2 blockers: cimetidine, ranitidine	Increase prolactin concentrations that can lead to impairment of luteal function, loss of libido, and erectile dysfunction

**Table 8.**  
*Medications and their respective effects on both male and female reproductive function [76].*

<b>Chemical</b>	<b>Possible reproductive effects</b>
BPA	Inhibits binding to androgen receptor, decreased semen quality, erectile dysfunction, chromosomal abnormalities in oocyte, and recurrent miscarriage
Disinfection by-products	
Organochemicals and pesticides e.g., DDT, DDE, methoxychlor	Change in hormone levels, irregular menstruation, decreased fertility, decreased semen quality, chromosomal abnormalities in sperm, altered histology of testes, decreased libido, fetal loss, and miscarriage
Dioxins	Changes in hormone levels, altered puberty, altered start of menarche, endometriosis, decreased fertility, and fetal loss
Phthalates	Decreased semen quality, oligozoospermia, earlier menarche, altered menstrual cycle, and infertility
Solvents	Change in hormone levels, decreased semen quality, irregular menstruation, decreased fertility, miscarriage, and fetal loss

**Table 9.**  
*Chemicals and their respective effects on both male and female reproductive function [76].*

extreme temperature, for example, workers at welding factories, ceramics companies, furnace workers, mechanics, and drivers are the chief victims of this risk factor facing fertility problems [47].

## 4. Conclusion

The male or female reproductive structure or function disturbed by any factors leading to the delivery of abnormal offspring, which has interfered with the continuation of generation is basically a reproductive or developmental toxicity. Presently, several reproductive or developmental toxicants are under routine by the people without their awareness, which obviously have negative impact on their health. In most of the working environments, due to the lack of knowledge and information many workers are occupationally exposed to such hazards and they are at the edge of reproductive toxicity. To understand the pathway of this toxicity needs a deeper research but due complexity of the mammalian reproductive cycle *in vitro* studies are quite lagging but one can slice this series of cycle and work on it independently. Currently, advancement in the field of reproductive toxicity testing has come-up with useful and promising *in vitro* models but their potential and accuracy are yet to be finalize. Though, individual tests are helping to identify certain aspects of toxicity but study can be only completed with combination of detailed toxicology reports.

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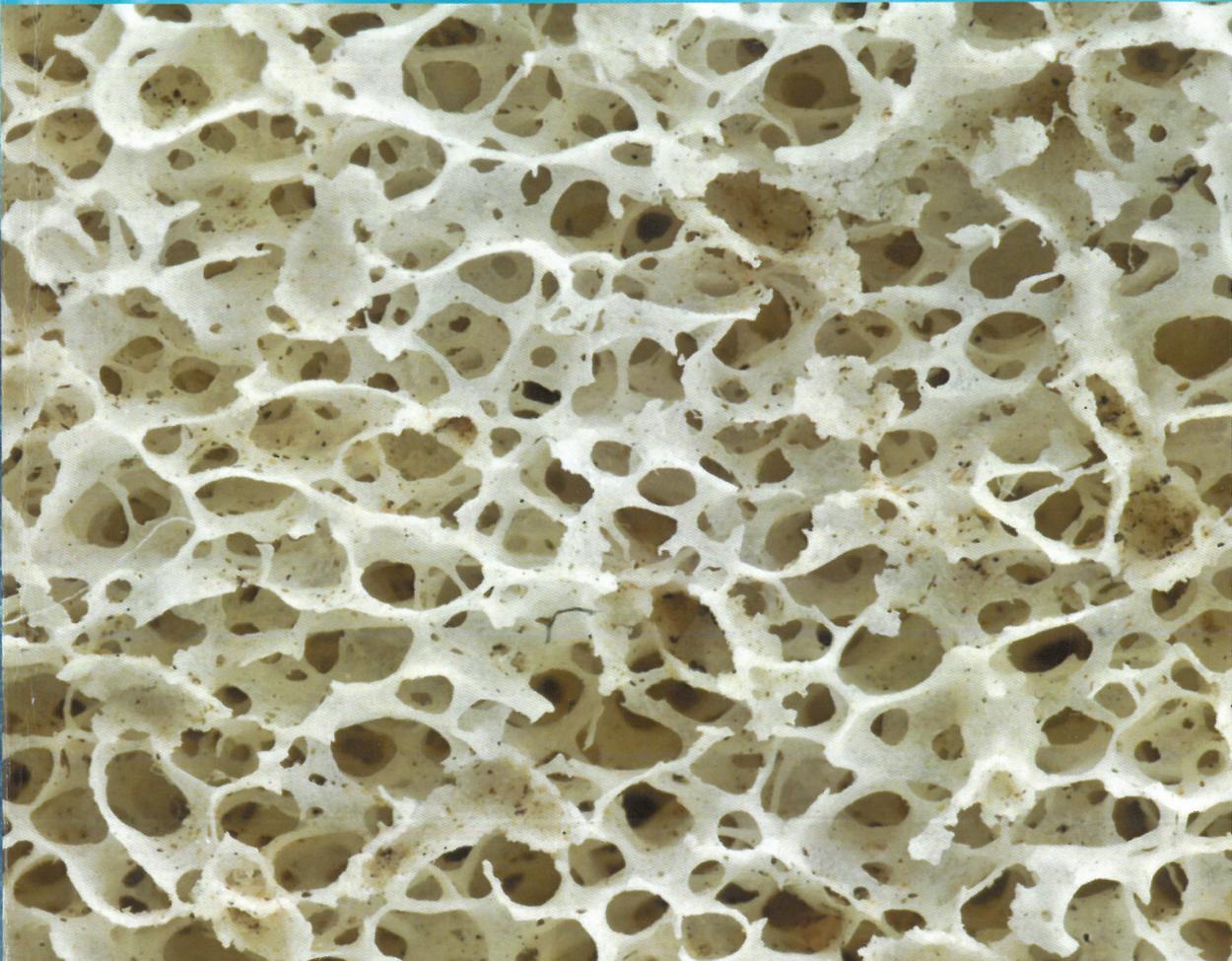
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# OSTEOPOROSIS

“Weak Bone Disease”

PROF. DR. R.B. UPPIN



**RED FLOWER**  
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To  
Department of Orthopaedics  
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KLES Dr. Prabhakar Kore Hospital &

MRC, Belagavi.

# OSTEOPOROSIS

WEAK BONE DISEASE

(1<sup>st</sup> Edition)

MRC, Belgavi  
KLES Dr. Prabhakar Kore Hospital &  
KMC Reg. No. 19577  
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## **OSTEOPOROSIS A WEAK BONE DISEASE**

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**Dedicated To**  
**My Parents, My wife, Dr. Geeta**  
**My Children**  
**Dr. Chaitanya and Chandan**  
**&**  
**To All My Patients**

## FOREWORD



Osteoporosis is considered as a major growing global health care problem, especially with increasing life survival the aging society is at risk. In US, Osteoporosis is a major health problem affecting more than 10 million adults, estimating to more than 50% cost involved in annual fractures by 2025. It is known that Osteoporosis related mortality and morbidity is huge, amounting to almost 17 billion USD in 2005 itself. Similar observations were made in Australian Population with life time risk of osteoporotic fractures for women and men more than 60 years of age being 60% & 30% respectively.

Till recently, osteoporosis was considered a disease mainly of the developed countries. But now it is becoming a major problem even in the developing countries. It is predicted that the Asian countries alone would contribute to majority of the hip fractures when compared to rest of the world. More than 4.5 million women above the age of 60 years suffered fracture spine and more than 250,000 people had suffered from hip fracture per year due to osteoporosis. This causes severe compromise on quality of life. The life time risk of any osteoporosis fracture is 40% - 50% for women and 13% to 22% men. Hence it is a common disease affecting both older women and significant number of older men. In India, the magnitude of the problem is huge, affecting a large population, to the tune of about 50 million individuals. Today, in India the impact of this disease is comparable to if not more than cardiovascular disease or malignancy and thus needs to be addressed to urgently. Osteoporosis is a hidden public health concern requiring the attention of treating physicians, the health care system and the government for having a policy for early identification and management.

Osteoporosis is a disease of loss of bone mass. Early detection is important. But sadly, it is diagnosed only when fractures occur, similar to diagnosing hypertension after a myocardial infarction or stroke. There is a need to have good screening techniques such as use of Bone Mass Density or Dual Energy X-ray absorptiometry (DXA) etc. There is a need also to understand associated risk factors and to look at preventive measures such as early

calcium supplementation, diet etc, to develop a health care policy to address this problem.

I am extremely, glad that this book on "Osteoporosis: A Weak Bone Disease" authored by Dr. R B Uppin and Co-authored by Orthopedic Resident Dr. DondetiUday Kumar is being published. This book will definitely throw light on all aspects of osteoporosis such as early diagnosis, prevention and management of the complexities involved in orthopedic problems especially with fractures of patients which will enable complete rehabilitation of the patients. this book will not only be of immense help to orthopedicians, but also to all medical practitioners involved in patient care.

I congratulate Dr. R B Uppin and Dr. DondetiUday Kumar for bringing out this book

**Prof.(Dr) NS Mahantshetty M.D (Pediatrics)**  
**Principal, KAHER JN Medical College, Belagavi**

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## Preface

Osteoporosis is a major global health problem that is increasing dramatically as the population ages. In the last few years, Growth has been seen in the knowledge of the pathological mechanism of the disease. Modern technologies have added significant information in bone mineral density measurements and furthermore mechanical and geometrical properties of bone. Novel bone indices have been formulated from hormonal and biochemical measurements for the investigation of bone metabolism. Osteoporosis is one of the critical disease faced by the aging population and along with heart diseases, stroke, diabetes and cancer, It is one of the most important disorder encountered in clinical practice. In the United States there are 1.5 million fractures attributable to osteoporosis annually. This includes roughly 7,00,000 vertebral fracture 2,50,000 hip fractures 2,50,000 distal forearm fractures and 3,00,00 fractures of other limb sites. The lifetime risk of a fracture of spine, hip and distal radius is 40%. World wide fractures from osteoporosis occurring each year are projected to increase to 6.3 million in 2050 from 1.7 million in 1990 which was reported. It is evident that drugs are crucial part of the therapy, however beyond medication there are other interventions in the management of the disease. Prevention of this disease begins at young age and goes on with the process of aging for the purpose of prevention of fractures related to the impaired quality of life, mortality, physical decline and high cost for health system. India, a developing country has high incidence of osteoporosis and an important finding that we come across in most studies is that the incidence of osteoporosis particularly in women occurs in younger age group than in developed world. The reason for this prompted me to undertake this study several years ago. This included clinical studies on fractures of femoral neck between adults and children. Various methods of bone densinometry, using roentgenographic techniques available in sixties and seventies. Lastly a modern method of assessment of bone density using CT scan and MRI with collaboration of other specialists in the field of DEXA scan, QCT and ultrasonography has been done. A chapter including focus on future trends (agents) in the horizon of Osteoporosis and tailoring therapy to specific patient population. I have also included real patient cases from our hospital and emphasized teaching points for each cases.

A handwritten signature in black ink, appearing to be 'R. B. Uppin'.

**Prof Dr. R.B. Uppin**

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First, the editors would like to thank each one of the authors for their valuable contributions. Our sincere gratitude goes to the chapters authors who contributed their time and research expertise to this book.

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**Prof. R.B. Uppin**

M.S.Ortho, FAOI

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## Postpartum ENT Emergencies

# 9

Serdar Ferit Toprak, Müzeyyen Yıldırım Baylan,  
and Nitin R. Ankle

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### 9.1 Introduction

Many ear, nose and throat (ENT) emergencies occur during postpartum period. Most of these emergencies are benign; however, there are certain ENT disorders that are critical and require immediate intervention. Several studies have been published that have improved the knowledge of the pathophysiology of these conditions and helped us define appropriate investigations and management for these conditions.

---

### 9.2 Postpartum Thyroiditis

Dysfunction of the thyroid gland in a previously euthyroid female diagnosed 12 months after pregnancy is termed as postpartum thyroiditis. Some of these cases have been reported to occur after miscarriage, but majority occur after a period of pregnancy. The natural history of postpartum thyroiditis is triphasic. The three phases which include initial thyrotoxic phase followed by a hypothyroid phase and then a euthyroid phase all these occur within 12 months [1]. 25–40% of these patients have the three classic phases, while 20–30% have only the thyrotoxic

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phase and 40% have only hypothyroid phase [1–3]. The initial thyrotoxic phase starts within 2–6 months after delivery, the median time of onset is around 13 weeks, and this phase is mostly asymptomatic. The duration of this is 2–3 months. Some symptoms like fatigue, intolerance to heat, palpitations and nervousness are common in the thyrotoxic phase [4]. The second phase, the hypothyroid phase, starts 3–12 months after delivery; the median onset time was found to be 19 weeks and is usually symptomatic with patients complaining of intolerance to cold, dryness of the skin, easy fatiguability and difficulty concentrating [4]. On examination, most of the women in this phase have small and painless enlargement of the thyroid gland. Some studies have also explored the role of this postpartum thyroiditis in the development of postpartum depression. The treatment for this condition is similar to disorders like silent thyroiditis, but there is a need for extra precautions when treating breastfeeding women. During the thyrotoxic phase, beta-blockers are used to relieve symptoms, but mild symptoms require no treatment. L-T4 can be used if necessary to treat symptoms in the hypothyroid phase. TSH levels should be checked at regular intervals, at every 1–2 months for a duration of 12 months postpartum [4]. Postpartum thyroiditis often tends to end up in hypothyroidism for long durations of time, especially in high-risk groups of women. In these cases, the patient will have to be continued on L-T4 even if they are breastfeeding. The decision to discontinue L-T4 needs to be discussed with the patient taking into consideration personal situations like women who are considering a second pregnancy within a year, in which case hypothyroidism can be detrimental to the continuation of pregnancy as well as to foetal development. Prevention of postpartum thyroiditis using supplements has been studied by performing controlled trials that were randomised. Two of these trials tried the administration of iodine or L-T4 either during or after pregnancy in women who had anti-TPO antibodies; these failed to cause a decrease in the risk of development of postpartum thyroiditis [5, 6]. Another trial attempted to administer selenium to women who had anti-TPO antibodies during and after pregnancy, and was successful in reducing the rate of development of thyroiditis; 50% of women on the placebo developed thyroiditis, whereas only 29% of those treated with selenium developed thyroiditis [7]. They also noted a decrease in the rate of development of permanent hypothyroidism in the long term from 20% to just 12% after administration of selenium. Even so, the new ATA guidelines do not recommend the prescription of selenium in high-risk women until there are more studies with regard to its efficacy and safety [4]. A high recurrence rate of about 70% in subsequent pregnancies was noted in anti-TPO-positive women recovering from postpartum thyroiditis [1, 4]. Persistence of a hypothyroid phase was seen in about 15–50% of these women in the long term [8, 9]. Thirty-eight percent of 700 women in a study conducted 12 years ago had hypothyroidism [8]. The risk for the development of permanent hypothyroidism is seen to be higher in women with certain parameters such as high anti-TPO antibody titres, hypoechogenicity on ultrasound and high TSH levels in the sixth month after delivery [8, 9]. Keeping these in mind, it is important that TSH levels be checked yearly for all women with a history of postpartum thyroiditis, and continued indefinitely [4].

---

### 9.3 Epistaxis

At least 60% of the general population have had a history of nasal bleed [10]. Some of these people will have recurrent or habitual history of nasal bleeding. These individuals have been found to have an increased risk of impaired haemostasis [11–15], and therefore obtaining the history of episodes of nasal bleed can help identify patients with an increased risk of intraoperative bleeding [16, 17]. Obstetricians believe that pregnant women are at a higher risk of developing epistaxis, and this has been attributed to increased incidence of rhinitis in patients due to vascular occlusion and development of mucosal oedema during pregnancy as a result of high oestrogen during pregnancy [18]. This theory has not been proven by research as of yet. The exact prevalence of epistaxis in pregnancy is also not known.

---

### 9.4 Hereditary Angioedema

This disorder is characterised by recurrent episodes of non-pitting oedema. This oedema tends to be localised and well-defined, but can affect any region of the human body. Sometimes, it can cause pain, especially in regions like extremities, face, torso, throat and internal organs of the abdomen. A high mortality rate is seen in cases with laryngeal involvement [19, 20]. Patients with hereditary angioedema also have urinary tract infections, spontaneous abortions and preterm labour. Heartburn and rheumatic symptoms are also noted more commonly [21].

The role of oestrogen in HAE has been discussed. It has been reported that increased attacks during menstruation with oral contraceptives cause more frequent and severe attacks. Both CI-inhibitory activity and mean values of antigen titres were significantly reduced in normal women using oral contraceptives compared to those who did not. Angioedema attacks not due to a lack of C1 inhibitor and that are oestrogen induced and familial have also been described [22, 23]. The treatment of HAE can be divided into prophylactic treatment, either short or long term, and the treatment of an acute attack. There is no role or benefit in treatment with adrenaline, antihistamine agents or corticosteroids in patients with HAE. Replacement therapy is the main treatment of an acute episode and has also been used to treat other protein deficiencies like haemophilia and hypogammaglobulinaemia. Fresh-frozen plasma infusion has also been shown to improve the disease even though theoretically it could worsen the attack. It has also been shown that the C1 inhibitor concentrate is safe and effective in resolving acute episodes. Intravenously administered in doses of 500–1000 units, oedema starts to recover within 2 h, and within 24 h complete remission is noted [22, 23].

---

### 9.5 Vertigo

Postpartum women often complain of dizziness and imbalance [24, 25]. Delivery seems to cause superior semicircular canal-like symptoms. At the time of normal vaginal delivery, there is a rise in the intracranial pressure. This rise in intracranial

pressure can compress an exposed semicircular canal labyrinth due to a thin or dehiscent bone covering it.

Minor [26] reported a series of surgical repairs for a series of semicircular canal dehiscence from 1995 to 2004, in 20 patients a craniotomy into the middle cranial fossa and SSCD repair were performed, and 9 of these were occluded and 11 reappeared [26].

In 89% of the patients, vestibular symptoms resolved completely, after duct obstruction, whereas in 64% of the patients, the symptoms resolved after resurfacing [26].

Mikulec et al. [27] presented ten patients with separation obstruction, and one patient had reclosure. There was no improvement in the symptoms of the patient who underwent reroofing, but this patient also had bilateral opening [27].

Vestibular symptoms were improved in all ten patients with obstruction, and postoperatively hearing improved in four out of five patients with conductive hearing loss preoperatively.

Minor et al. [26] also reported a patient who had postoperative improvement of 20 dB in air conduction threshold after resurfacing a dissected superior duct.

---

## 9.6 Laryngeal Oedema

A caesarean section is often an emergency procedure and frequently requires general anaesthesia, women who undergo emergency caesarean section have a high risk for airway complications, and it is important to pay attention towards airway management.

There needs to be a recognition of the risk of pulmonary aspiration in these patients, and hence proper airway management is essential [28].

There are several national surveys about airway complications during anaesthesia like confidential Investigations on Maternal Death in the United Kingdom [29].

Cormack and Lehane have established an optimal laryngoscopy method for tracheal intubation [30] and also gave the first algorithm for management of difficult airway [31].

In order to prevent pulmonary aspiration and to minimise the administration of drugs required for anaesthesia to the foetus during emergency caesarean sections done under general anaesthesia, it is vital to intubate the patient immediately after the induction of anaesthesia.

The effects of the injected drugs should be short, so that in case tracheal intubation fails, it is possible to awaken the patient.

It is indicated to also have rapid initiation of anaesthesia; in the 1950s and 1960s, the method of anaesthesia included preoxygenation, application of pressure over the cricoid cartilage and usage of thiamylal or thiopentone for induction of general anaesthesia. The airway is first protected using a cuffed endotracheal tube prior to initiation of manual ventilation. This traditional method has remained unchanged, but it has evolved since the mid-1980s; however, the fundamental protocol of

minimising the duration of airway protection from aspiration and allowing for rapid awakening in the case of failure of tracheal intubation.

---

## 9.7 Bell's Palsy

The seventh cranial nerve, or the facial nerve, is primarily a motor nerve that additionally contains a small sensory component known as Wrisberg's nervus intermedius. The facial nerve can suffer various injuries and insults as it exits from the pons and passes through the facial canal which extends till the stylo-mastoid foramen, from where the nerve innervates the facial muscles. Trauma secondary to surgery, vascular pathologies, infections and autoimmune causes are considered the possible mechanisms of Bell's palsy. No association was observed between the female menstrual cycle and the occurrence of Bell's palsy [32], but in pregnant women the rise in steroid hormones has been considered as the cause of Bell's palsy [33].

Other aetiological factors include herpes simplex virus infection noted in 79% of patients with Bell's palsy. Interestingly, Herpes zoster virus is said to play an aetiological role in peripheral facial paralysis ('zoster sine herpette') even without skin rashes. In pregnant women, immunosuppression is considered the aetiology of viral reactivation. Herpes simplex or herpes zoster virus reactivated from cranial ganglia required treatment with acyclovir and prednisone [34].

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# MONOGRAPH ON CLEFT LIP / PALATE



*Editor*  
Ajay K. Kulkarni, MD, FRCS

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**UNIT- 6 of 6**  
**CRANIOFACIAL SYNDROMES ASSOCIATED WITH**  
**CLEFT LIP AND PALATE**

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**Photos - Courtesy**

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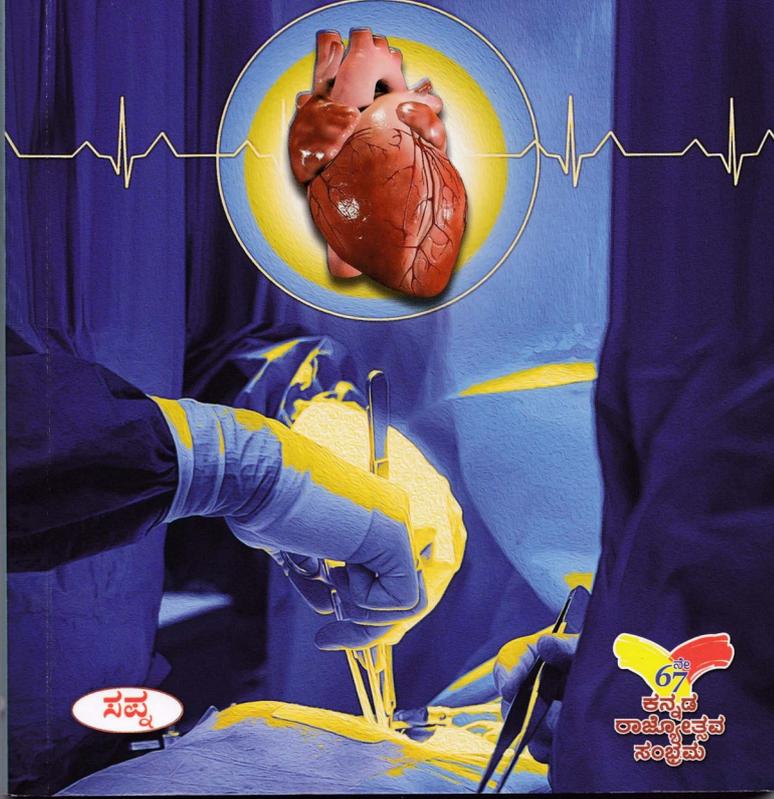
Recognition of the associated syndromes and craniofacial anomalies with the oral cleft is essential to assess the problem and risk faced by the child and for counselling the parents. Proper knowledge and details of anomalies associated with OFC will help to provide necessary treatment for these children. More than 300 syndromes can have a cleft lip and or palate as one of the features. Some of the conditions which may involve a cleft are and which are described in this Unit-6 of Chapter-II:

- Pierre Robin sequence
- Stickler syndrome
- Velocardiofacial syndrome (VCF)
- Treacher Collins syndrome
- Oculo-auriculo-vertebral spectrum (OAV) / Goldenhar syndrome / hemifacial microsomia
- Van der Woude syndrome

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# Effects of Various Dentofacial Orthopedic and Orthognathic Treatment Modalities on Pharyngeal Airway

*Tejashri Pradhan and Aarti Sethia*

## Abstract

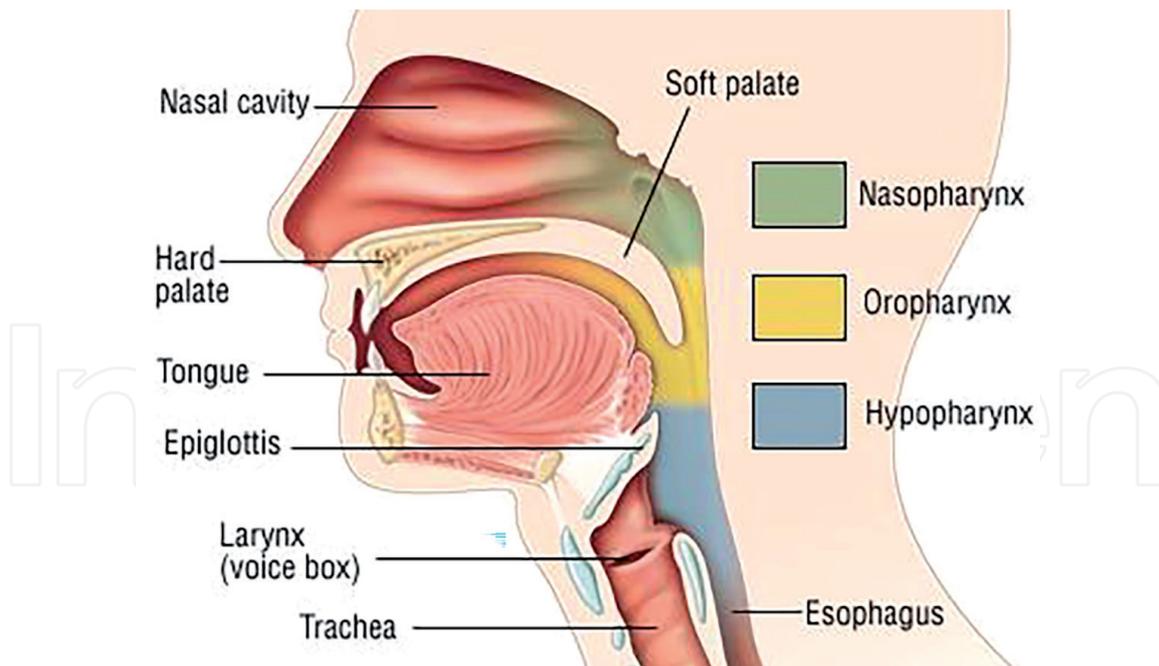
The function of respiration is highly relevant to orthodontic diagnosis and treatment planning. Significant relationships between pharyngeal, craniofacial as well as dentofacial structures have been reported in several studies. Many authors have emphasized that mouth breathing is concomitantly associated with constricted airway causing obstructive sleep apnoea. Associated symptoms can be cured with correction of either skeletal or dental problems or both. Therefore it would be very intriguing to understand and interpret the airway during diagnosis and treatment planning for a clear view of changes in the airway dimensions during the course of orthodontic treatment using various treatment modalities. Therefore a complete understanding of the concept of airway should be considered as an important one. This chapter gives us an insight to the intricate detailing on how the various orthodontic and dentofacial orthopedic treatment signifies the changes in the dimensions of pharyngeal airway.

**Keywords:** pharyngeal airway, skeletal changes, dental changes, functional appliances, Orthognathic surgeries, expansion

## 1. Introduction

Orthodontia being one of its kind specialty has always aimed at correcting the dento-facial esthetics which involves achievement of: ideal jaw relationship, normal oral function, proximal and occlusal contact of teeth. But the core aspect of function and performance has been taken up by the function of respiration or breathing which in fact is the top most important function for humans. The synchrony of ideal health and facial development is based on accurate posture of tongue and nasal breathing. Therefore the recent protocols be it Preventive, interceptive or corrective orthodontics, factoring the dire need of pharyngeal airway space improvement in addition to improvement in smile and facial appearance [1].

Today Orthodontists play a very crucial and integral role in the interdisciplinary team management of airway and sleep related disorders. Commencement of Sleep Medicine as a speciality has brought about a very clear understanding of transformative or developmental biology, medicine; the jaw size and its spatial orientation has surfaced as the important factor of optimizing upper airway physiology. Airway



**Figure 1.**  
*Anatomy of the pharyngeal airway space.*

passage, type of breathing and craniofacial formation are so interconnected during growth and development that form follows the function and function follows the form [2]. So the specialty of orthodontics, is well balanced to treat ideally form and function both in children and adults so that the function is optimized for life. The conventional treatment in orthodontics has always prioritised primarily on teeth esthetics. This method, seldom addresses symptoms and as a result the airway is ignored. Therefore it is necessary to focus more at physiologic adaptations and its muscle to resolve sleep disordered breathing [3].

The nasal airway analysis requires adequate anatomical dimensions for the overall pharyngeal airway space [4]. Oral breathing in relation to nasal obstruction is a well known entity among orthodontic patients [5]. Obstruction of nasopharyngeal pathway is associated with various craniofacial features, such as backward and upward growth of condyle, backward and downward rotation of mandible, divergent gonial angle, anterior open bite and spacing w.r.t mandibular anteriors [6]. The eradication of respiratory obstruction and acquiring adequate functional nasal breathing with precise patterns of swallowing boosts the stability and functional balance of orthodontic treatment (**Figure 1**) [7, 8].

## 2. Anatomy of airway

The airway, or respiratory tract, describes its organs that allow airflow during ventilation. They pass through the nares and buccal opening till the blind end of the alveolar sacs. This respiratory tract is subdivided into different regions and various organs and tissues to perform specific functions. The airway passage is subdivided into the upper and lower airway, each of which has numerous compartments. The pharynx is the mucosal lined portion of the airway that is situated between the base of the skull and the esophagus. It is subdivided as follows:

- Nasopharynx [rhino-pharynx], is the muscular tubular structure from the nares, including the posterior nasal cavity, that divides from the oropharynx by the palate and lining the skull base superiorly.

- Oro-pharynx is the region that joins the nasopharynx and hypopharynx. It is the region situated between the palate and the hyoid bone, which anteriorly gets divided from the oral cavity by the tonsillar arch.
- Hypopharynx is the region which connects the oropharynx to the esophagus and the larynx, the region of pharynx below the hyoid bone.

Boundary between nasopharynx and oropharynx is known as soft palate, similarly the boundary between the oropharynx and laryngopharynx is the epiglottis. The soft palate is dangled at the posterior corner of the hard palate, and its top and bottom are comprises of the mucosal tissues. The centre portion of the soft palate includes muscles, aponeurosis, blood vessels, nerves, lymph and mucosal tissues. During the process of deglutition and injestion, the soft palate develops postero-superiorly and separates the nasopharynx and oropharynx. The mandible is interconnected to the hyoid bone, tongue, and soft palate by the strong musculature. Therefore, the location of the mandible can affect the size of the pharyngeal airway space.

### 3. Pharyngeal airway space (PAS)

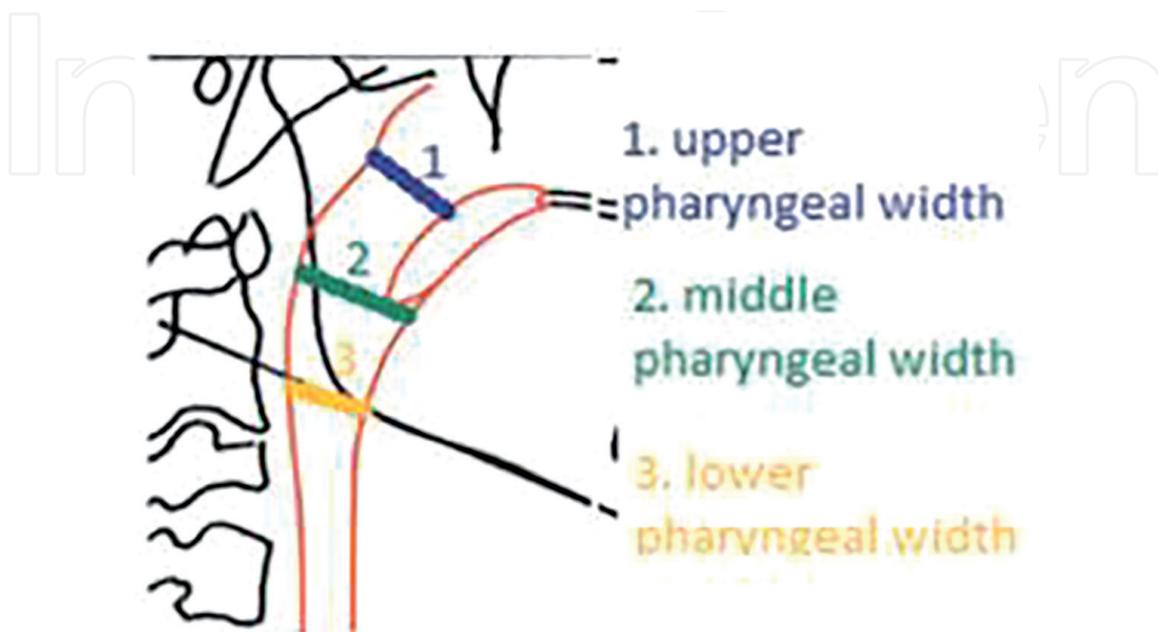
Pharyngeal airway space is divided into three compartments: (**Figure 2**).

*Upper pharyngeal width (UPW)*: Its is the smallest distance between the posterior border of the soft palate to the nearest point on the posterior pharyngeal wall.

*Middle pharyngeal width (MPW)*: It is the smallest distance between the posterior borders of the tongue to the nearest point on the posterior pharyngeal wall, through the tip of the soft palate.

*Lower pharyngeal width (LPW)*: It is the smallest distance from the intersection of posterior border of tongue and inferior border of the mandible to the closest point on the posterior pharyngeal wall.

Normal upper pharyngeal airway space is 15–20 mm while middle and lower pharyngeal airway (LPA) space is 11–14 mm [9].



**Figure 2.**  
*Various compartments of the pharyngeal airway space [9].*

Literature supports the hypothesis that mandibular deficiency is analogous to a narrower PAS. It is generally observed that a retrognathic mandible and reduced space between the cranial column and the corpus of the mandible often leads to a posteriorly placed tongue and soft palate, which in turn increases the chances of impaired respiratory function and possibly causing nocturnal breathing problems. Alterations in PAS have been described with various sleeping disorders such as obstructive sleep apnea. Advancement and setback surgeries are standard procedures for the correction of mandibular position whether its retrognathism and prognathism, respectively. Operation for the mandibular deformity changes hard and soft tissue components, including the PAS [10].

#### **4. Diagnosis**

Malocclusion can be perceived in several ways which more likely includes patients with enlarged adenoids, obstructive sleep apnoea (OSA), snoring and clefts. The relation between respiratory pattern and form of malocclusion is still disputed. Patients with craniofacial disorders including a short cranial base, reduction in the cranial base angle, bimaxillary retrusion, and retrognathic mandibles show common finding of narrow airways [11].

#### **5. Various methods for assessment**

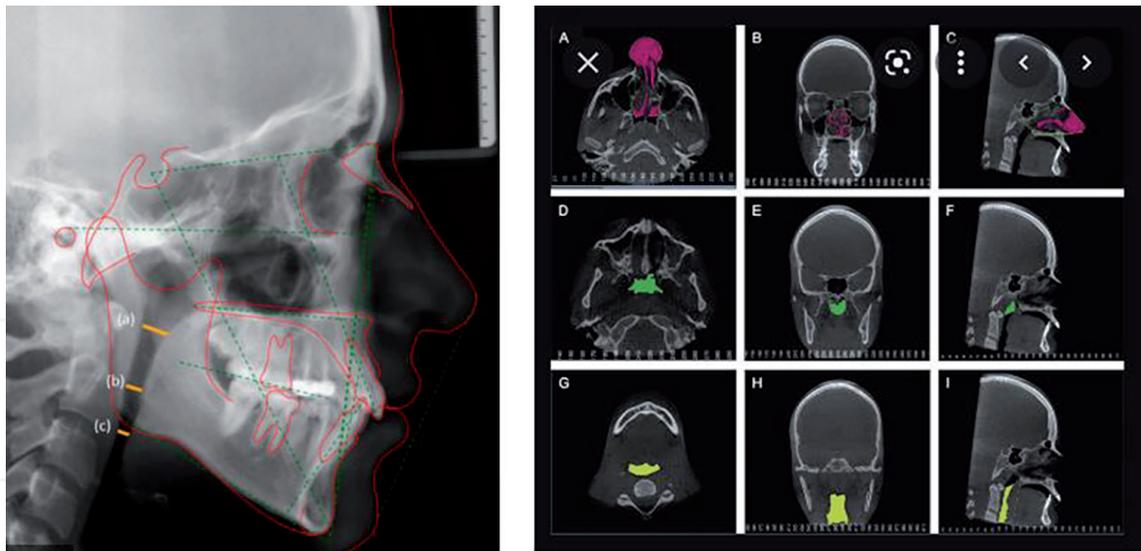
The methods described to assess the airway include: nasal endoscopy, rhinomanometry, acoustic rhinomanometry, cephalometry, computed tomography (CT), magnetic resonance imaging (MRI) and cone-beam computed tomography (CBCT).

#### **6. Two dimensional versus three dimensional imaging**

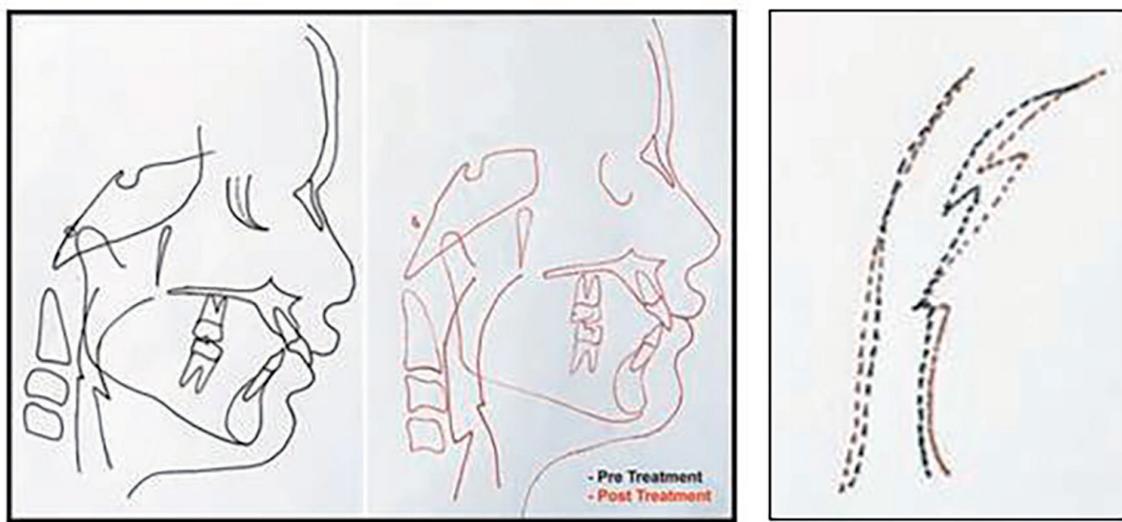
Lateral cephalograms can provide us with useful, credible and replicable airway measurements while minimizing patient costs and radiation exposure. Studies have shown that while cephalometric measurements provide two-dimensional data, cephalometry is a reliable method for airway assessment and adenoid size estimation [12]. Another comparative study to assess the linear measurements with lateral cephalograms and CBCT was carried out and the conclusions drawn: that airway linear measurements are reliable, with both lateral cephalograms and CBCT reconstruction, as there is a positive correlation with the respective area measurements on axial slices [13].

#### **7. Changes in pharyngeal airway space using functional appliance therapy**

In 1934, Pierre Robin proposed that use of an intraoral appliance helps in bringing the lower jaw forward in newborns with mandibular deficiency. This helps in preventing the posterior relocation of the tongue during sleep and the occurrence of oropharyngeal collapse [14]. This concept is now often used in adult obstructive sleep apnea (OSA) patients to avoid an upper airway collapse during sleep with the help of various myofunctional appliances [15]. Moreover, the idea to relocate the mandible anteriorly is applied in dentofacial orthopedics by the use of various myofunctional appliances which helps in stimulating mandibular growth in skeletal Class II growing



**Figure 3.**  
*Two dimensional lateral cephalometric evaluation versus three dimensional CBCT evaluation.*



**Figure 4.**  
*Changes in the dimension of pharyngeal airway width using functional appliance therapy [9].*

patients with mandibular deficiency [16]. Several authors have hypothesized that the functional orthopedic treatment of growing patients with short mandibles may lead to increased oropharyngeal airway dimensions, and some have suggested a possible reduction in the risk of future respiratory problems (**Figures 3 and 4**) [17–20].

## 8. Effect of various functional appliances on pharyngeal airway

Twin block is considered to be one of the most patient compliant myofunctional appliance. Therefore prominent results can be drawn with this appliance [21]. According to Jena et al. [21] when twin block was compared with Mandibular protraction appliance MPA, the improvement of oropharynx dimension by twin-block appliance was significantly more. Another study showed significant increase in the dimensions of nasopharynx, oropharynx and hypopharynx following twin-block treatment [22]. Although the growth itself had very minor contribution in the improvement of oropharyngeal dimension, but the advancement of mandible through myofunctional orthopedic correction was evidently beneficial.

The anterior relocation of mandible by the functional appliances places the tongue more forward and thus increases the overall dimension of oropharynx [23]. The improvement in the dimension of oropharynx was more with removable functional appliance (twin block) compared to fixed functional appliance [21, 24]. An increase in oropharyngeal volume was found after functional appliance treatment in Class II patients, leading to an increase in final volume of the upper airway.

Forsus Fatigue Resistance Device (FFRD) brought about improvement in the oropharyngeal airway significantly when compared the untreated subjects. Post treatment, the mean values of Superior Pharyngeal Space and Middle Pharyngeal Space increased by 1.06 mm and 1.28 mm respectively in the FFRD group. Aksu et al. [25] measured the airway space equivalent to the depth of hypopharynx and concluded that there was no significant improvement in the width of hypopharynx. Bavbek et al. [26] measured CV3 projection in FFRD group and control group and found that FFRD did not increase the hypopharyngeal width. Whereas the other three studies had not measured the hypopharyngeal airway dimension.

The following were the conclusions drawn from the systematic review [27]:

*Functional appliances help in improving the pharyngeal airway dimensions in Class II malocclusion subjects with retrognathic mandibles. But it is also evident that minimum effect on nasopharyngeal airway passage and the minor improvement is mainly due to growth. Improvement of oropharyngeal airway passage dimensions is a very prominent effects of functional appliance treatment. Removable functional appliance prove to be more efficient than fixed functional appliance in the improvement of positive airway pressure (PAP) dimension.*

## **9. Hyoid bone and tongue position with changes in pharyngeal airway space**

The results obtained by treatment with functional appliances are mainly dento-alveolar in nature, there is however a significant modification of the oropharyngeal airway dimension is observed in most of the studies. Hypothesis could be presumed that, the dentoalveolar modifications occurring after functional appliance treatment, guides the tongue to a more forward position, enlarging the posterior airway space (PAS). Therefore, it can be said that forward positioning of the tongue is part of a planned surgical strategy when treatment of sleep disordered breathing is needed. Changes observed in the hyoid bone distance are more prominent horizontally than that in the vertical direction [27].

The conclusions drawn with respect to hyoid bone position are as follows:

Hyoid bone is found to be posteriorly and superiorly placed in patients with Class II skeletal malocclusion when compared to Class III and Class I skeletal cases. The hyoid bone position in males is found to be more inferiorly and anteriorly when compared to females. Also the anterior cranial base is very strongly related to the nasal fossa length and a moderately related to positive correlation with the hyoid bone vertical position and lower airway width. The hyoid bone vertical position had a strong positive correlation with the length of the nasal fossa [4].

## **10. Changes in pharyngeal airway space with various surgical procedures**

Orthognathic surgery is a common method to treat dentofacial deformities. It changes the position of facial skeletal structures and also affects the morphology of

the pharynx drastically. Structures such as soft palate, tongue, hyoid bone and some surrounding tissues are attached directly or indirectly to the maxilla and mandible, therefore any desired movement of the jaws by orthognathic surgery affects these tissues, causing changes in the dimensions of the pharyngeal area [28].

## **11. Mandibular set back surgery**

In a thesis by Jain et al. [29], statistically significant increase in the nasopoharyngeal airway dimension was observed. This finding has also been reported by Kitagawara et al. [30] and has been explained as a biological adaptation against postoperative swelling and edema, and for airway maintenance. It is a compensatory mechanism after the hypopharyngeal airway collapses. According to Susarla et al. [31], the upper airway length (UAL) contributes to resistance to airflow. Longer airways have more resistance to airflow than shorter airways [31].

## **12. Bimaxillary surgeries**

Chen et al. [32] found that patients undergoing bimaxillary surgery had changes at the three levels, with increase at the nasopharynx and decreases at the oropharynx and hypopharynx. Bimaxillary operations mostly decrease the narrowing effect of the mandibular setback operations [33]. This indicates that Upper Airway Length increases along with narrowing of the airway, in patients who undergo bimaxillary surgery.

## **13. Mandibular advancement**

Statistically significant increase in the oropharyngeal and hypopharyngeal airway dimension was observed according to Jain et al. [29] and Turnbull et al. [34].

## **14. Pharyngeal airway in cleft lip and palate patients**

Cleft patient presents more frequently with large adenoids than do the non-cleft population. This has been regarded as a compensatory phenomenon to decrease the pharyngeal depth and make velopharyngeal competence possible. After palatal operation, soft tissue is sometime short and scarred and frequently the uvula is missing, tissue deficit results in incompetence to velopharyngeal sphincter mechanism.

Gohilot et al. [35] in a study noted that adenoidal tissue size was larger in the juvenile and adolescent cleft group as compared to the adolescent cleft group and airway passage was decreased in juvenile subjects. The thickness of adenoidal tissues decreases with age in both subjects with and without CLP. Conversely, the upper airway dimensions increase in those with and without CLP.

## **15. Effect of expansion on pharyngeal airway**

Iwasaki et al. [36] evaluated the effect of rapid maxillary expansion (RME) on nasal airway ventilation condition, tongue posture, and pharyngeal airway volume. They found that RME enlarges the pharyngeal airway bothways with and without

improvement in nasal obstruction. Another study by Malkoç et al. [37] derived that expansion does not cause any significant change in the dimension of pharyngeal airway.

## **16. Cervical spine posture**

Various researchers have been taking prime interest in finding the correlation between the cervical spine posture, head position and pharyngeal airway space, but significant evidence still needs to be procured through proper research.

## **17. Effect of different growth patterns on pharyngeal airway**

A study by Kocakara et al. [38] showed that, the pharyngeal airway dimensions and hyoid bone position are similar in individuals in the sagittal direction. The vertical airway length is significantly shorter in Class III patients with hypodivergent patterns. Another study by Ucar et al. [39] concluded that the nasopharyngeal airway space and upper pharyngeal airway space in Class I subjects is larger in low angle cases than in high angle cases.

## **18. Conclusions**

Impactful evaluation of orthodontic treatment on the pharyngeal airway dimensions is considered one of the prime aspects of orthodontic diagnosis and treatment planning. The protocol helps in emboldening the impersonation of what the nature had planned i.e. by fitting all the teeth early enough through various habit breaking appliances, expansion appliances, and functional jaw orthopedics. Although maxillo-mandibular advancement surgeries are very well known to improve the airway dimensions along with improvement in dento-facial esthetics. But the hypothetical percentage of cases undergoing this beneficial modality is far less due to its invasive nature. Although Orthodontia at the present juncture, recognizes the importance of evaluating and treating airway, sleep disorders, there are yet tremendous scope untouched.

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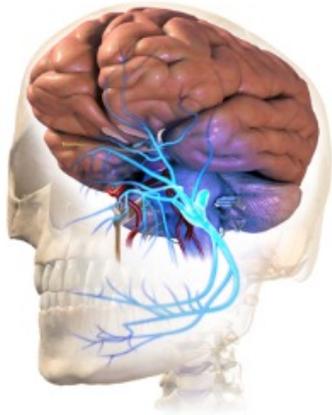
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# PANORAMA OF OROFACIAL PAIN

Dr Sounyala Rayannavar  
Dr Bhumika shaha



# **Panorama of Orofacial Pain**

First Edition

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Dr. Sounyala Rayannavar

Dr. Bhumika Suresh Shaha



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*Dedicated*

*To*



*Our Parents*

*And*

*Teachers*

## **Preface**

This book is for the knowledge of orofacial pain which is made simple to understand by the dental students.

There are very few books written on orofacial pain. Here i have tried my best to compile and include things, which is made comprehensive and integrated which is necessary to understand Orofacial pain for the dental students, which is a separate branch of speciality in dentistry in the west.

I did my fellowship in orofacial pain, TMD & Dental sleep medicine from Roseman university, USA. This made me to go in depth of the subject and made me to write this book.

I immensely thank Dr Bhumika Shaha .

## **Acknowledgement**

No endeavor can start, continue and complete without the blessings of **Lord Ganesha**. We thank Him for blessing us with the strength and patience to complete the task entrusted.

I gladly utilize this opportunity to express my deep sense of gratitude and indebtedness to all my Teachers, Colleagues, Friends And My Family.

I extend my heartfelt gratitude to my dearest friends, juniors and seniors for their constant support and encouragement.

I would not have completed this book without the unconditional support of my family who have always been there for me whenever I needed them, with encouragement and unconditional love to empower me all the time.

***Dr. Sounyala Rayannavar***

I owe everything of what I am to my grandparents Late Shri. **Laxmidas Shah** and **Smt. Damayantiben Shah**, my parents, **Mr. Suresh Shah** and **Mrs. Santok Shah**, my dearest brother **Dr. Mandar Shaha** and sister-in-law **Dr. Bhagyashri Shaha** who gave form to all my dreams and aspirations.

I owe every success to them and I humbly acknowledge that everything I am today is because they loved me.  
Thank you, one and all.

***Dr. Bhumika Suresh Shaha***

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# Chapter 1

## Introduction

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Pain is one of the most commonly experienced symptoms that compels patients to seek medical and dental therapy. It is often spoken of as protective mechanism, since it is usually manifested when an environmental change occurs that cause injury to responsive tissue.

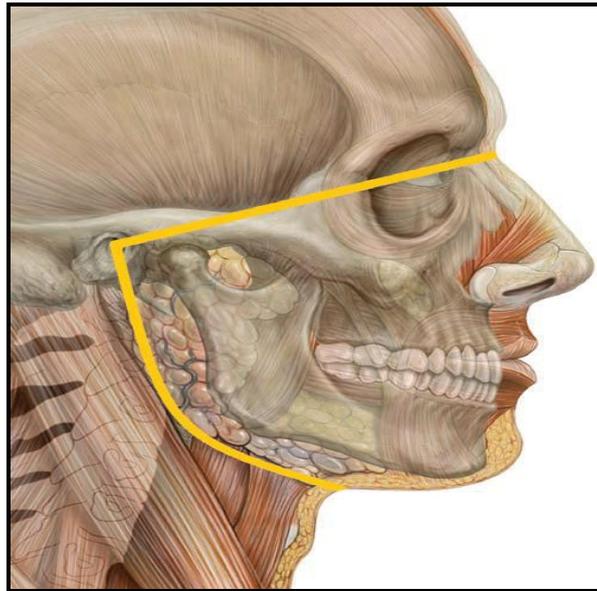
### 1.1 Definition

- Pain is defined as an “unpleasant emotional experience usually initiated by a noxious stimulus and transmitted over a specialized neural network to the central nervous system where it is interpreted as such”.<sup>1</sup>
- International association for the study of pain (IASP) has defined pain as an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage.<sup>2</sup>

Orofacial pain refers to pain associated with the soft and hard tissues of the head, face, and neck. The potential origin of orofacial pain includes pulpal and periodontal, vascular, gland, muscle, bones, sinuses, and joint structures. These numerous structures in the head and neck along with their complex innervation account for the wide range of diagnostic possibilities in patients with the complaint of orofacial pain.<sup>3</sup>

Orofacial pain occurs in the area above the neck, in front of the ears, and below the orbitomeatal line, as well as in the oral cavity (Figure 1). This type of pain also includes dental pain and temporomandibular joint (TMJ) disorders, making it widely prevalent with significant effect on daily life, including eating, drinking, and speaking.<sup>4</sup>

Orofacial pain is a common experience in the population that has profound sociologic effects and impact on quality of life. It is estimated that one-third of the population of industrialized nations suffers some chronic pain and the oral health care provider will undoubtedly treat patients with or facial pain. New scientific evidence is constantly providing insight into the cause and path physiology of or facial pain.<sup>3</sup>



**Fig 1. Area Affected by Orofacial Pain<sup>4</sup>**

Risk factors for chronic orofacial pain include chronic widespread pain with increasing age, psychologic factors, and female sex. Many orofacial conditions have overlapping presentations, leading to diagnostic uncertainty, significant morbidity, and high healthcare costs.<sup>4</sup>

Evaluation and management of orofacial pain requires collaboration among all fields of medicine because pain has the potential to arise from multiple trigeminal receptive fields. The quest to better manage pain problems involving the trigeminal system such as TMDs and headaches has led to the establishment of orofacial pain as a discipline in the field of dentistry.<sup>5</sup>

Recognition and understanding of orofacial pain using an evidence-based approach is important for proper evaluation and management, often beginning with a dentist or primary care provider, with referral to specialists as needed.<sup>4</sup>

# Chapter 2

## **Anatomical Considerations of Orofacial Pain**

---

Orofacial pain may be defined as pain and dysfunction affecting motor and sensory transmission in the trigeminal nerve system. From a sensory perspective, the trigeminal system oversees the efficacy and tissue integrity of the highly integrative orofacial behaviours that are controlled by cranial nerves and modulated by the autonomic nervous system (ANS) and the greater limbic system.<sup>5</sup>

Orofacial nerves transmit information about pressure (touch), position, temperature, and potential pain to the trigeminal nuclei, which have extensive bidirectional connections throughout the brain. These trigeminal connections affect the sensory, motor, and autonomic-endocrine changes that occur during orofacial behaviours, and orofacial pain may result when these behaviours are impaired.<sup>5</sup>

### **2.1 Neuroanatomy of the Orofacial Structures**

Cranial nerves are extensions of the brain that directly or indirectly innervate tissues involved with the trigeminal system. The specialized neurons of the olfactory, optic, and vestibulocochlear nerves that send smell, sight, sound, and balance information to the CNS do not travel through the trigeminal nuclei. However, nerves associated with the nose, eye, and ear tissues do transmit proprioceptive, pressure, and potential pain impulses into the trigeminal nuclei. A comprehensive orofacial pain evaluation should include a basic assessment of the function of all cranial nerves.<sup>5</sup>

### **2.2 Trigeminal Nerve**

The trigeminal nerve, which provides sensory innervations to most of the head and face, is the primary nerve involved in TMDs, migraine, sinus, pulpal, and periodontal pathology. It is the largest cranial nerve and consists of three peripheral divisions: the ophthalmic, maxillary, and mandibular. These branches receive sensory input that is conveyed on

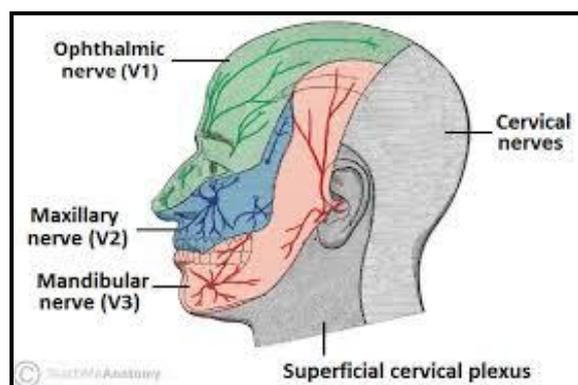
first-order neurons through the trigeminal ganglion, where most neuronal cell bodies are located. Although these neurons enter the ganglion on three branches, they exit in one large sensory root that enters the brainstem at the level of the pons before reaching the trigeminal nuclei.<sup>5</sup>

**Wilcox SL et al (2013)** assessed the volume and microstructure of the trigeminal nerve in 3 different orofacial pain conditions. The trigeminal root entry zone was selected on high-resolution T1-weighted magnetic resonance images and the volume (mm<sup>3</sup>) calculated. Additionally, using diffusion-tensor images (DTIs), the mean diffusivity and fractional anisotropy values of the trigeminal nerve root were calculated. Trigeminal neuralgia patients displayed a significant (47%) decrease in nerve volume. Conversely, trigeminal neuropathy subjects displayed a significant (40%) increase in nerve volume. Both showed no change in DTI values. In contrast, TMD subjects displayed no change in volume or DTI values. The data suggest that the changes occurring within the trigeminal nerve are not uniform in all orofacial pain conditions. These structural and volume changes may have implications in diagnosis and management of different forms of chronic orofacial pain.<sup>6</sup>

**Ophthalmic branch (V1):** This branch of the trigeminal nerve leaves the skull through the superior orbital fissure and transmits sensory information from the scalp and forehead, upper eyelid, conjunctiva and cornea of the eye, nose, nasal mucosa, frontal sinuses and parts of the meninges and deep structures in these regions. It also carries postganglionic parasympathetic motor fibres to the glands and sympathetic fibres to the pupillary dilator muscles.<sup>5</sup>

**Maxillary branch (V2):** This branch exits the skull at the foramen rotundum. Near its origin, it divides to form the middle meningeal nerve. It has a sensory function for the lower eyelid and cheek; the nares and upper lip; the maxillary teeth and gingiva; the nasal mucosa; the palate and roof of the pharynx; the maxillary, ethmoid, and sphenoid sinuses; and parts of the meninges. Near its origin, it divides to form the middle meningeal nerve, which supplies the middle meningeal artery and part of dura mater. The terminal V2 branches—the anterior and greater palatine nerves and the superior, middle, and anterior alveolar nerves - innervate the soft palate, uvula, hard palate, maxillary gingiva and teeth, and mucous membranes of the cheek.<sup>5</sup>

**Mandibular branch (V3):** This branch leaves the skull through the foramen ovale and functions in both sensory and motor transmission. V3 carries sensory information from the lower lip, mandibular teeth and gingiva, floor of the mouth, anterior two-thirds of the tongue, the chin and jaw, parts of the external ear, parts of the meninges, and deep structures. The auriculotemporal nerve is a branch of V3 that innervates most of the TMJ. The motor nuclei use V3 to provide motor fibres to the muscles of mastication.<sup>5</sup>



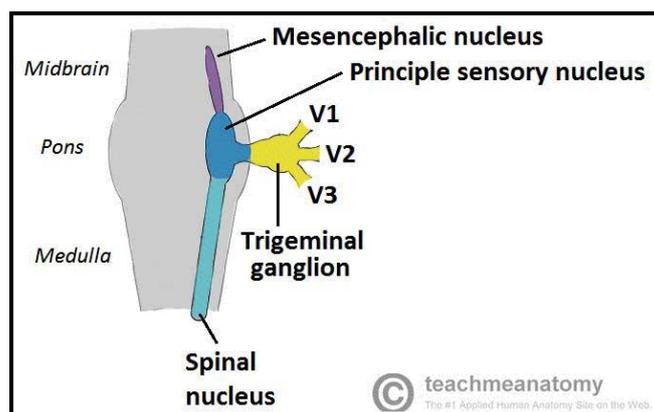
**Fig. 2. Branches and Innervation of the Trigeminal Nerve.**

**Trigeminal sensory nuclei:** The trigeminal sensory nuclei lay in bilateral columns on either side of the brainstem. They originate in the midbrain and terminate in the dorsal horn of the cervical spinal cord. All touch, position, and temperature sensory input from the face is sent to the trigeminal nuclei, as is potential pain input from the face, head, and neck. They are, in a rostro caudal orientation, the mesencephalic nucleus, the main sensory nucleus, and the spinal trigeminal nucleus.<sup>5</sup>

The **mesencephalic nucleus**, houses the cell bodies of the proprioceptive neurons that convey input from the apical periodontal ligament and the muscle fibres that contract during the jaw-closing reflex. The neurons are monosynaptic and pass through the mesencephalic nucleus to synapse in the trigeminal motor nuclei located medially to the much larger main sensory nucleus.<sup>5</sup>

The **main sensory nucleus** receives the facial proprioceptive and pressure input for orofacial behaviours other than the jaw-closing reflex. These neurons have their cell bodies in the trigeminal ganglion and synapse in the main sensory nucleus, where input is conveyed to the motor nuclei by arrays of small interneurons.<sup>5</sup>

The **spinal trigeminal nucleus** consists of three subnuclei: subnucleus oralis, subnucleus interpolaris, and subnucleus caudalis. Subnucleus oralis and subnucleus interpolaris receive some peripheral nociceptive fibers, but they mostly receive temperature information on A $\delta$  fibres and touch impulses on A $\beta$  fibres from the periphery and convey this input via interneurons to the motor nuclei. The subnucleus caudalis is the main terminus for most slow first-order neurons that convey potential pain from trigeminal receptive fields.<sup>5</sup>



**Fig. 3 Trigeminal Sensory Nuclei**

**Wilcox SL et al (2015)** used brain imaging techniques to determine whether anatomical changes were present in the spinal trigeminal nucleus in subjects with chronic orofacial neuropathic pain. Voxel-based morphometry of T1-weighted anatomical images and diffusion tensor images were used to assess regional gray matter volume and microstructural changes within the brainstem. In addition, deterministic tractography was used to assess the integrity of ascending pain pathways. Orofacial neuropathic pain was associated with significant regional gray matter volume decreases, fractional anisotropy increases, and mean diffusivity decreases within the spinal trigeminal nucleus, specifically the subnucleus oralis.<sup>7</sup>

## 2.3 Facial Nerve

The seventh cranial nerve is a mixed nerve that has five branches that course through the parotid gland but do not innervate the gland. Its main function is motor control of most of the muscles of facial expression and the stapedius muscle of the middle ear. The facial nerve supplies parasympathetic fibres to the sublingual, submandibular and lacrimal

gland. In addition, it conveys taste sensations from the anterior two-thirds of the tongue to the solitary tract nucleus and transmits cutaneous sensation from the skin in and around the earlobe.<sup>5</sup>

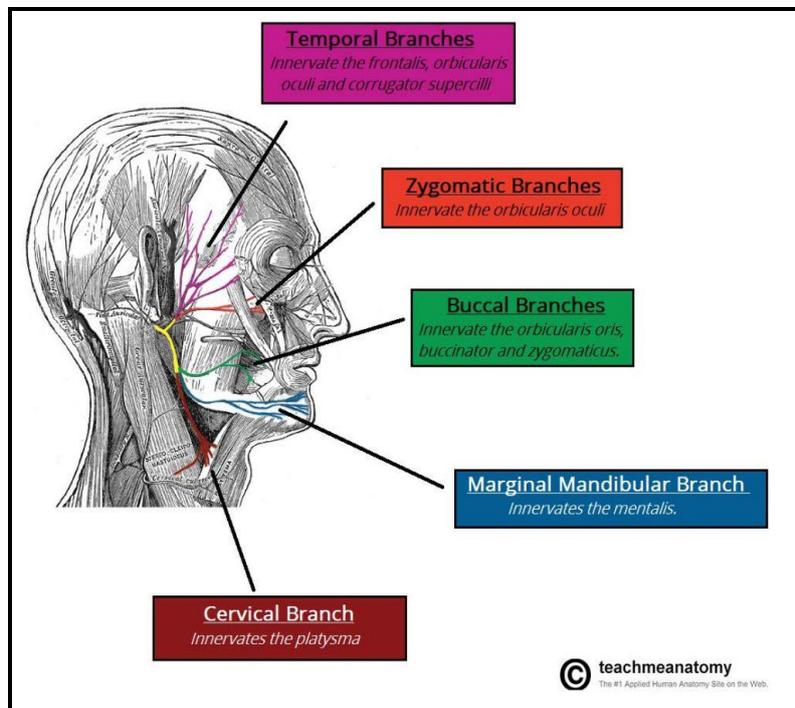


Fig. 4 Branches of Facial Nerve

## 2.4 Glossopharyngeal Nerve

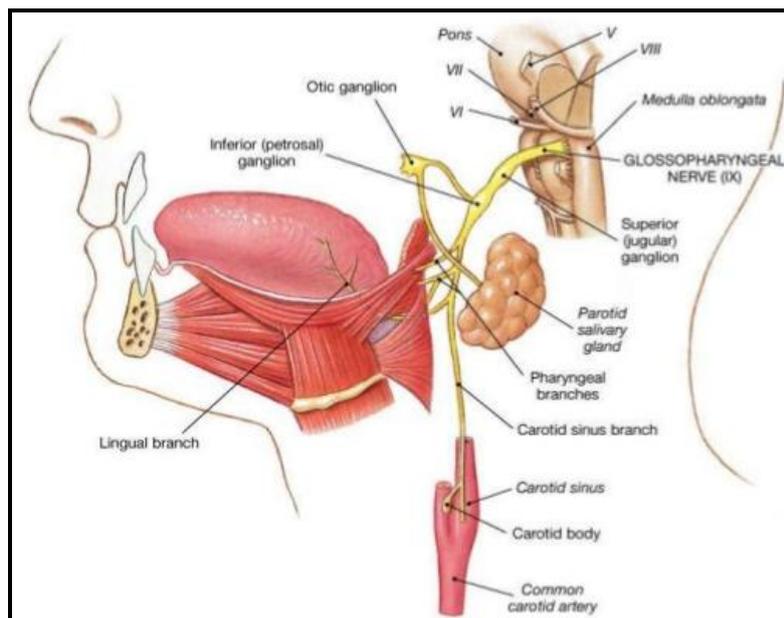
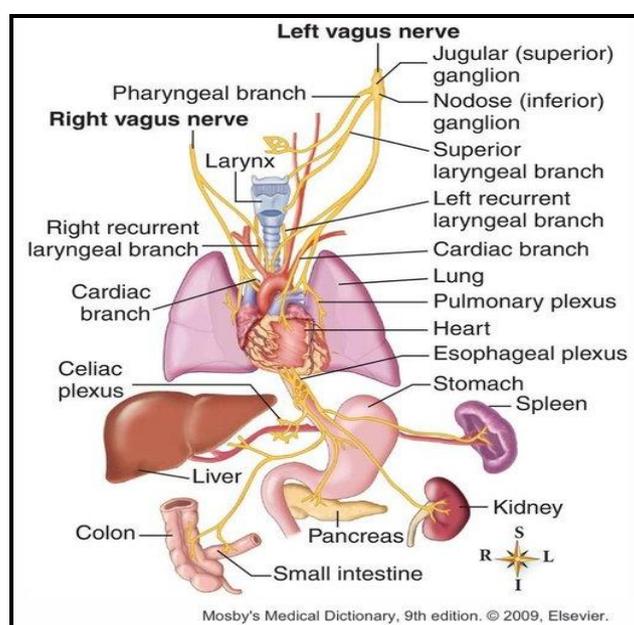


Fig. 5 Branches of Glossopharyngeal Nerve

The ninth cranial nerve is a mixed nerve comprising somatic, visceral, and motor fibres. It conveys sensory information from the posterior third of the tongue, tonsils, pharynx, middle ear, and carotid body. From the inferior salivatory nucleus, the glossopharyngeal nerve delivers parasympathetic control to the parotid and mucous glands throughout the oral cavity, while motor fibres from the nucleus ambiguus project to the stylopharyngeus muscle and upper pharyngeal muscles.<sup>5</sup>

## 2.5 Vagus Nerve

The tenth cranial nerve originates in the brainstem and extends to the abdomen. It supplies visceral afferent fibres to the mucous membranes of the pharynx, larynx, bronchi, lungs, heart, oesophagus, stomach, intestines, and kidneys, and it distributes efferent or parasympathetic fibres to the heart, oesophagus, stomach, trachea, bronchi, biliary tract, and most of the intestine. The vagus nerve also affects motor control of the voluntary muscles of the larynx, pharynx, and palate. Through these connections, the vagus affects activities as varied as respiration, cardiac function, sweating, digestion, peristalsis, hearing, and speech.<sup>5</sup>



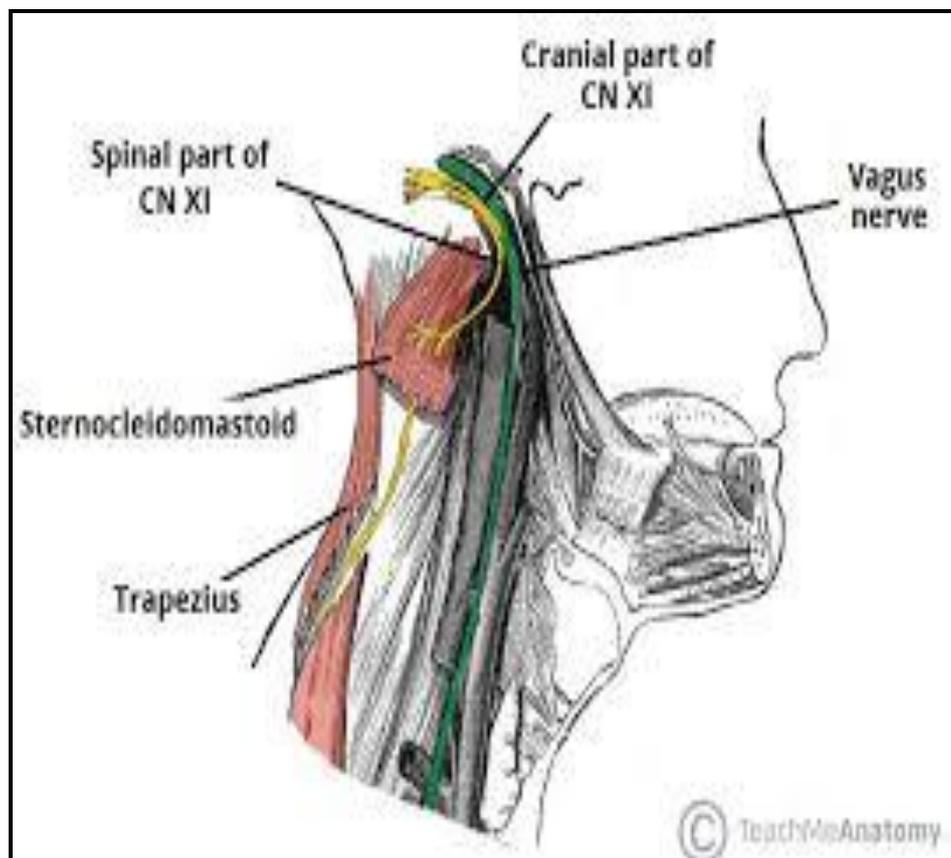
**Fig. 6 Branches of Vagus Nerve**

**Guclu B et al (2011)** evaluated the anatomy (length and volume) of the central myelin portion and the central myelin-peripheral myelin transitional zone of the trigeminal, facial, glossopharyngeal and vagus

nerves from fresh cadavers and the incidences of the corresponding cranial dysfunctional syndromes. Study concluded that primary trigeminal neuralgia, hemifacial spasm and vagoglossopharyngeal neuralgia have as one of the main causes a vascular compression. The strong correlations were found between the lengths and volumes of the central myelin portions of the nerves and the incidences of the corresponding diseases is a plea for the role played by this anatomical region in the mechanism of these diseases.<sup>8</sup>

## 2.6 Spinal Accessory Nerve

The eleventh cranial nerve innervates the cervical muscles, the sternocleidomastoid and trapezius, which are coactivated during masticatory behaviours. Like the trigeminal motor nucleus, the accessory motor nuclei are rich in norepinephrine receptors, which can facilitate vigilant behaviours. Nociceptive afferents from the cervical muscles converge onto the spinal trigeminal nucleus. It is notable that cervical myofascial pain seems to be prominent in patients with orofacial pain.<sup>5</sup>



**Fig. 7 Branches of Spinal Accessory Nerve**

## **2.7 Upper Cervical Nerves**

Spinal nerves C1 to C4 and possibly C5 are important considerations in orofacial pain because their sensory fibres converge onto the trigeminal subnucleus caudalis. As C1 to C4 leave the spine, they combine to form the cervical plexus, which yields cutaneous, muscular, and mixed branches. These nerves innervate the back of the head and neck, the auricle and external acoustic meatus, the anterior neck and angle of the mandible and the shoulders, and the upper thoracic region. The muscular branch—the ansa cervicalis—innervates the sternohyoid, the sternothyroid, and the omohyoid muscles. The mixed branch is the phrenic nerve, which innervates the diaphragm.<sup>5</sup>

## **2.8 Autonomic Nervous System**

The ANS, which is commonly viewed as a largely involuntary motor system, is composed of three peripheral divisions—the sympathetic, parasympathetic, and enteric—that function to maintain homeostasis. The peripheral ANS is controlled by the central ANS, which comprises cortical, limbic, and reticular formation structures and nuclei. Stimuli that activate the central ANS induce increased sympathetic activity initially in the brainstem and then in the periphery. The sympathetic and parasympathetic systems have preganglionic neurons that originate in different parts of the CNS and postganglionic neurons that deliver impulses to target tissues.<sup>5</sup>

The enteric system provides local sensory and motor fibres to the gastrointestinal tract, the pancreas, and the gallbladder. It plays a vital role in homeostasis. Persistent sympathetic arousal that impairs parasympathetic function and leads to disturbances of the enteric system may be related to orofacial pain because functional disorders of visceral organs controlled by the ANS seem to be common comorbid conditions.<sup>5</sup>

**Sympathetic input to the orofacial region:** Sympathetic preganglionic neurons originates in the spinal cord and exit via the ventral horn at the segmental level. Their cell bodies are found in the intermediolateral gray matter at the level of the T12 and L1 to L3 vertebrae. The superior portion of the sympathetic chain contains four cervical ganglia: superior cervical, middle cervical, intermediate cervical, and stellate ganglia. Postganglionic fibres leaving these sympathetic ganglia transmit motor input to the blood vessels in the head and neck, various glands, and the eyes.<sup>5</sup>

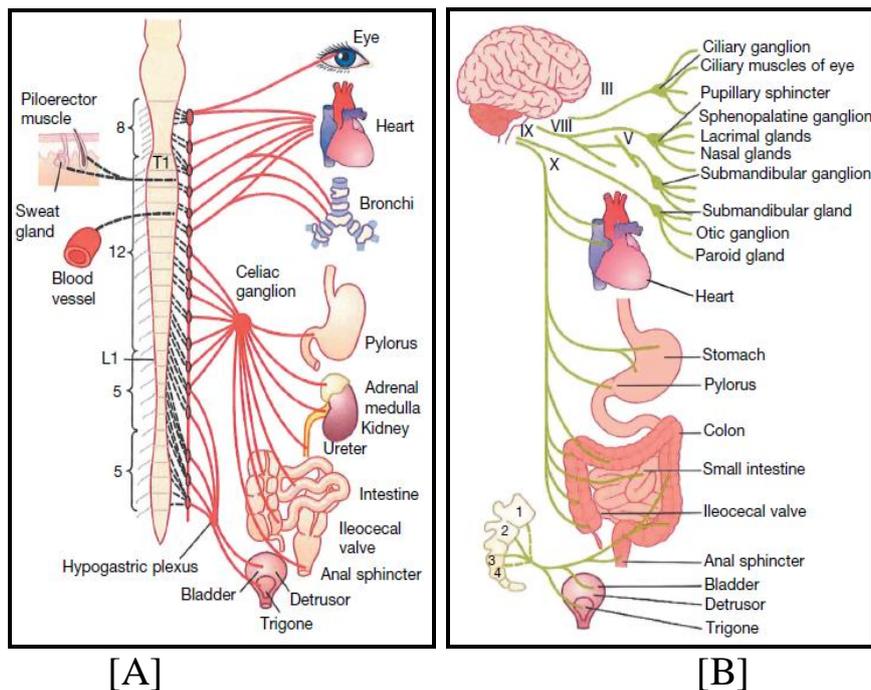


Fig. 8 [A] sympathetic [B] parasympathetic nervous system.<sup>9</sup>

**Parasympathetic input to the orofacial region:** Parasympathetic preganglionic neurons originate in the brainstem nuclei, where their cell bodies are located, or in the lateral gray columns of the sacral spinal cord (S2 to S4). Cranial nerves III, VII, IX, X, and the splanchnic nerve in the pelvic region carry parasympathetic preganglionic neurons, which are considerably longer than the postganglionic fibres because ganglia are generally located close to or embedded in the target organ.<sup>5</sup>

# Chapter: 3

## Pathophysiology of Orofacial Pain

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The Subjective experience of pain arises by 4 distinct process:

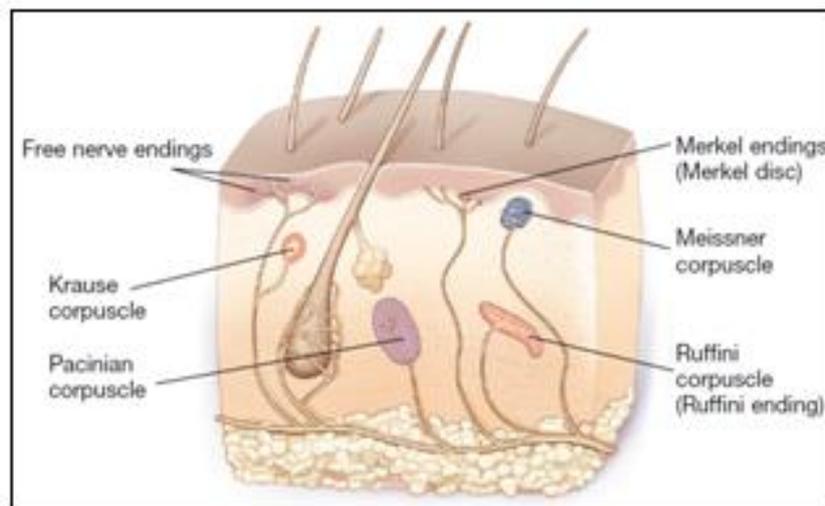
### 3.1 Transduction

Process by which noxious stimuli lead to electrical activity in sensory nerve endings.<sup>10</sup>

#### Sensory receptors

At the distal terminals of afferent (sensory) nerves are specialized sensory receptors that respond to physical or chemical stimuli. Once these receptors have been adequately stimulated, an impulse is generated in the primary afferent neuron and carried centrally into the CNS. Sensory receptors are specific for certain types of stimuli. They can be classified into three main groups, namely, exteroceptors, proprioceptors, and interoceptors.<sup>9</sup>

- **Exteroceptors:** They are stimulated by the immediate external environment. These receptors provide information from the skin and mucosa. Most impulses arising from these receptors are sensed at conscious levels.<sup>9</sup>



**Fig. 9 Several Types of Sensory Exteroceptors.**

- **Proprioceptors:** They provide information from the musculoskeletal structures concerning the presence, position, and movement of the body. For the most part, sensations conducted from proprioceptors are below conscious levels, even though many such sensations can be brought into consciousness voluntarily.<sup>9</sup>
- **Interoceptors:** They are located in and transmit impulses from the viscera (supply system) of the body. Sensation from these receptors for the most part is involved in the involuntary functioning of the body and as such occurs below conscious levels.<sup>9</sup>

### 3.2 Transmission

Neural events that carry the nociceptive input into the CNS. There are three types of neurons as follows:<sup>10</sup>

- **First Order Neuron:** (Primary afferent neuron) Peripheral sensory nerve carries nociceptive input from the sensory organ (receptors) into the spinal cord.
- **Second Order Neuron:** Carries input to the higher centres through spinal cord.
- **Third Order Neuron:** Interaction of neurons between the thalamus cortex and the limbic system as the nociceptive input reaches these higher centres.

### 3.3 Modulation

Ability of the CNS to control the pain transmitting neurons. It can either enhance or reduce the stimulus.<sup>10</sup>

### 3.4 Perception

On reaching the cortex a complex interaction of neurons takes place which helps to perceive pain. It is at this level suffering & pain behaviour begins.<sup>10</sup>

**After Receiving A Nociceptive Stimulus, 2 Types of Nerve Fibres Are Stimulated<sup>11</sup>:**

'A-δ' fibres	'C' fibres
Thick & finely myelinated.	The thin & non myelinated.
Fast rate of conduction (15-20m/s).	Slower rate of conduction (0.5-2m/s).

Fast and momentary (sharp, pricking, unpleasant, but bearable)	Throbbing, aching, lingering and unbearable
Stimulation threshold is relatively low.	Stimulation threshold is high.

### 3.5 Electrophysiology of Nerve Conduction

The function of nerve is to carry messages from one part of the body to another in the form of electrical action potential called IMPULSES initiated by chemical, mechanical, thermal or electrical stimuli.<sup>11</sup>

**Action Potential:** Transient depolarization of membrane that result from a brief increase in permeability of the membrane to sodium, and usually also from a delayed increase in permeability of potassium.<sup>11</sup>

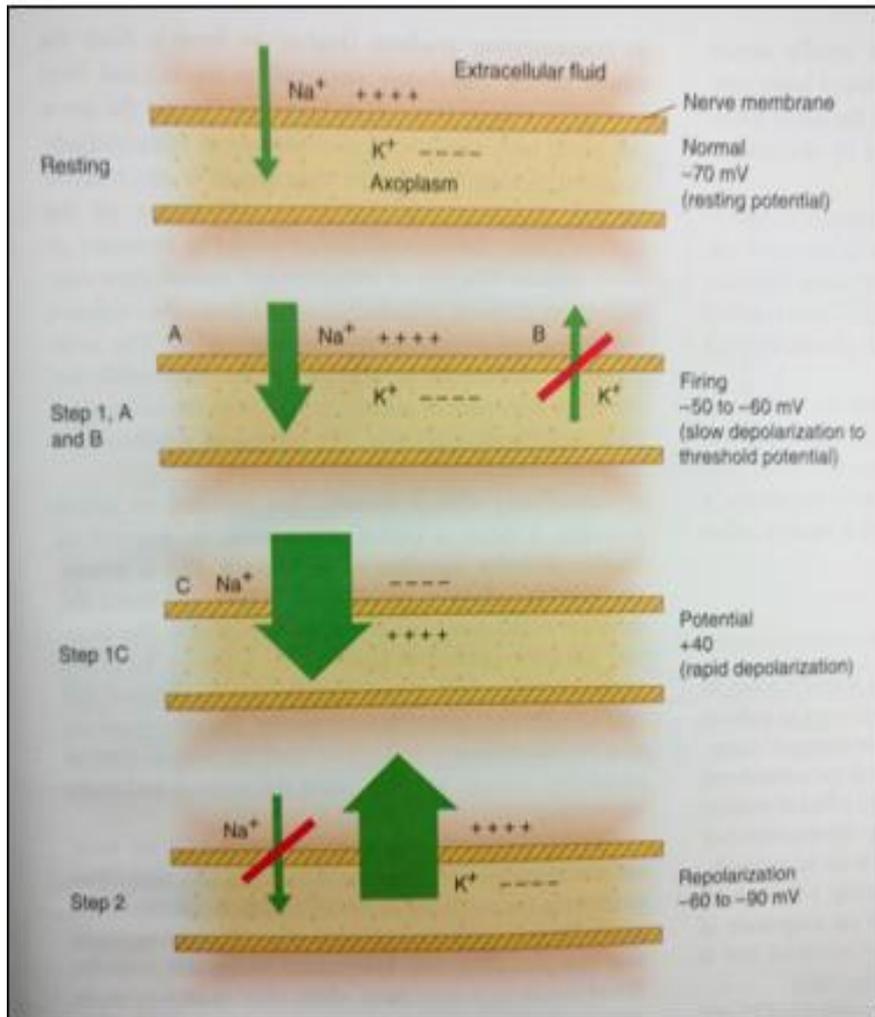
**Resting Potential:** Internal to the nerve membrane is negative in respect to the outer part. Nerve possesses a resting potential (step 1) which is negative electrical potential of  $-70\text{mV}$  because of differing in concentration of ions on either side of membrane.<sup>11</sup>

**STEP 1:** Stimulation excites the nerve cells.

- a. Initial phase of slow depolarization, the electrical potential in the nerve becomes slightly less negative.
- b. When the falling electrical potential reaches a critical level, extremely rapid phase of depolarisation results. This term threshold potential or firing threshold.
- c. This phase of rapid depolarization result in a reversal of the electrical potential across the nerve membrane. Internal to the membrane becomes positive in respect to the outside ( $+40\text{mV}$ ).

**STEP 2:** This is a phase of Repolarisation.

Electrical potential gradually becomes more negative in respect to the outside until  $-70\text{mv}$  is achieved.



**Fig.10 Top, Resting Potential. Step 1, A And B, Slow Depolarization to Threshold. Step 1, C, Rapid Depolarization. Step 2, Repolarization.<sup>12</sup>**

### 3.6 Neurotransmitters

The neurochemicals that are released by the presynaptic neuron into the synaptic cleft and activate ion channels are called neurotransmitters.<sup>9</sup>

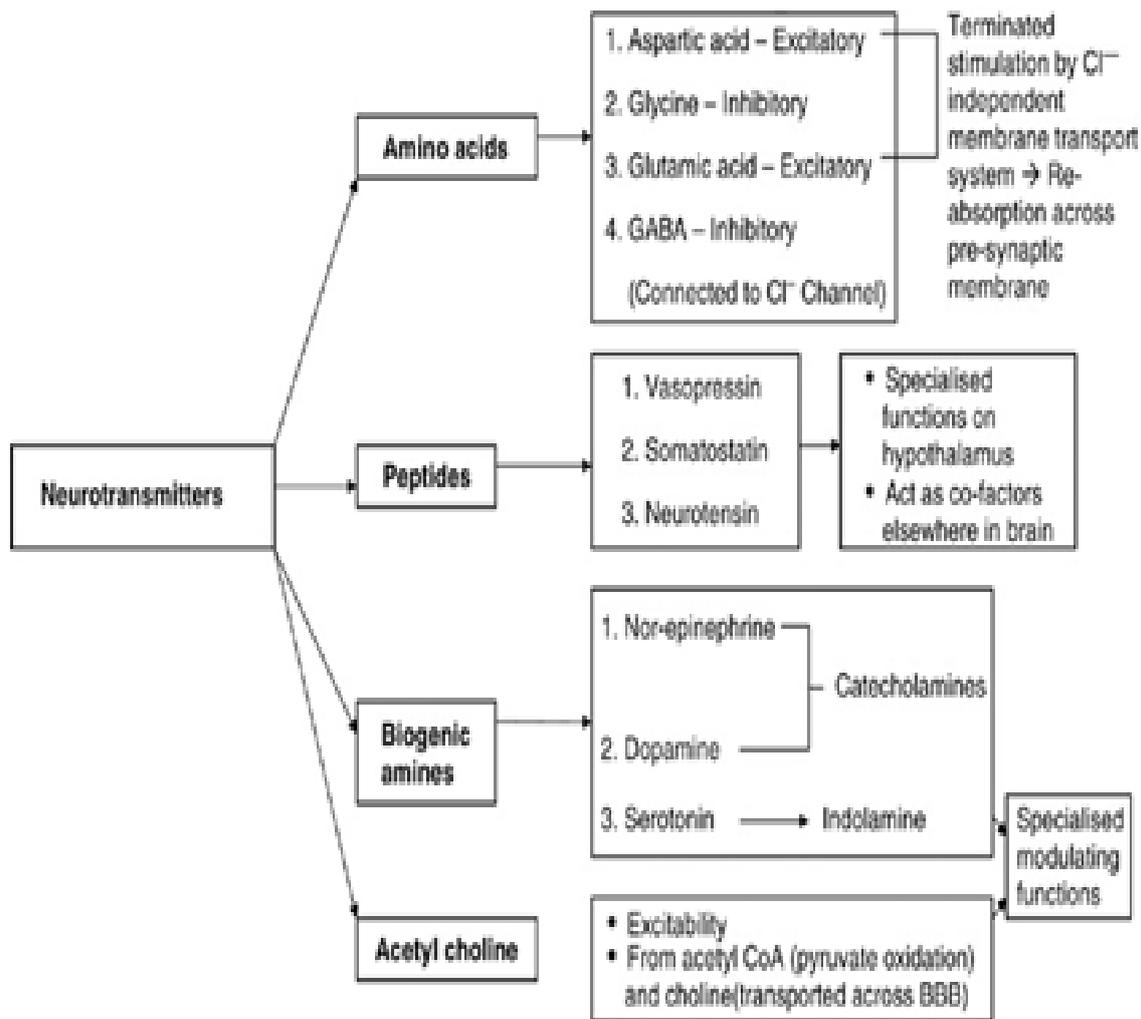


Fig. 11 Classification of Neurotransmitters<sup>13</sup>

**Small, Rapid-Acting Transmitters:** Cause acute responses of the nervous system, such as transmission of sensory signals to and inside the brain and motor signals back to the muscles.<sup>9</sup>

**Larger, Slower-Acting Transmitters:** The larger molecules are the neuropeptides and represent a different group of chemicals. These are much slower acting than the smaller molecules but, when released, have a much longer effect on the postsynaptic neuron.<sup>9</sup>

### 3.7 Pathways of Pain Sensation

The fifth cranial nerve i. e. trigeminal nerve is the principal sensory nerve of the head region. Any stimulus in the area of the trigeminal nerve is first received by both myelinated and non-myelinated fibres of the

ophthalmic, maxillary and mandibular branches into the semilunar or gasserian ganglion.<sup>1</sup>

From the ganglion, the impulse is mediated by the sensory root of the nerve into the pons. Here the sensory root either ends directly in the main sensory nucleus or bifurcates into ascending and descending fibres. The ascending fibres convey general tactile sensibility, whereas the descending fibres convey pain and temperature.<sup>1</sup>

Thus, the pain impulse descends from the pons by the spinal tract fibres of the trigeminal nerve, through the medulla, down to about the level of second cervical segment, where the tract terminates. The mandibular, maxillary and ophthalmic branches terminate in the nucleus in that order.<sup>1</sup>

Axons of the secondary neurons emerge from the spinal nucleus, cross the midline and ascend to join with fibres of the mesencephalic nucleus to form the trigeminal lemniscus or spinothalamic tracts of the fifth nerve. These tracts continue upwards and terminate in the posteroventral nucleus of the thalamus. Some fibres of the lateral spinothalamic tract cause a general stimulation of the reticular formation that increases the patient's awareness of and reaction to pain.<sup>1</sup>

The pain impulse, on reaching the posteroventral nucleus of the thalamus, is mediated by secondary connecting neurons that project from the posteroventral thalamus to the posteroventral convolutions of the cerebral cortex.<sup>1</sup>

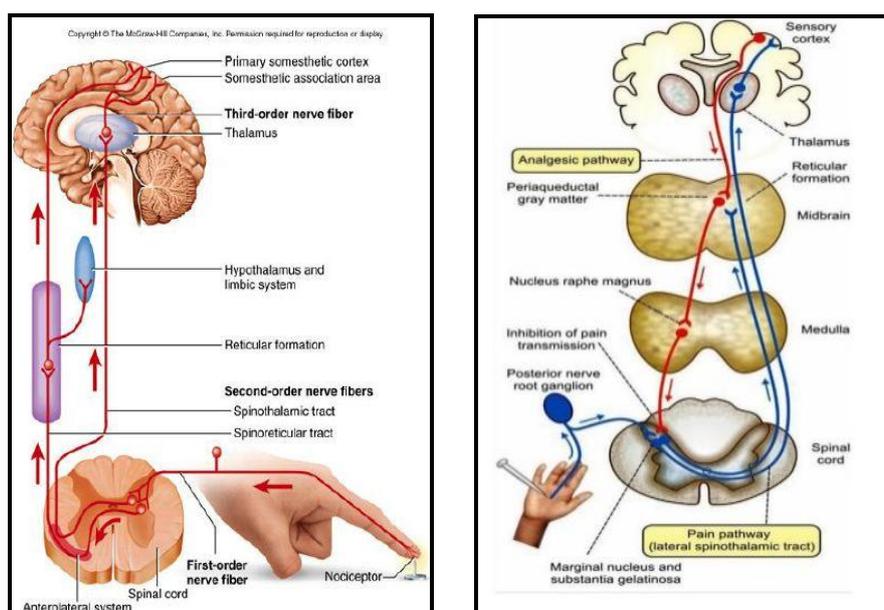


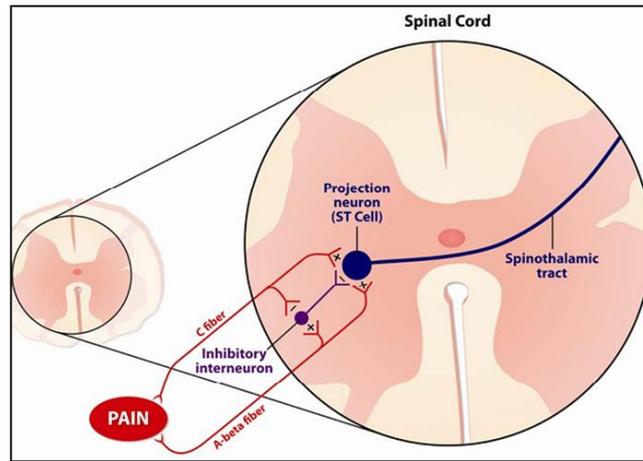
Fig. 12 Pathways of Pain Sensation

### 3.8 Theories of Pain

In past few decades many theories have been put forward to understand the pain mechanism. Three widely popular theories are as follows:

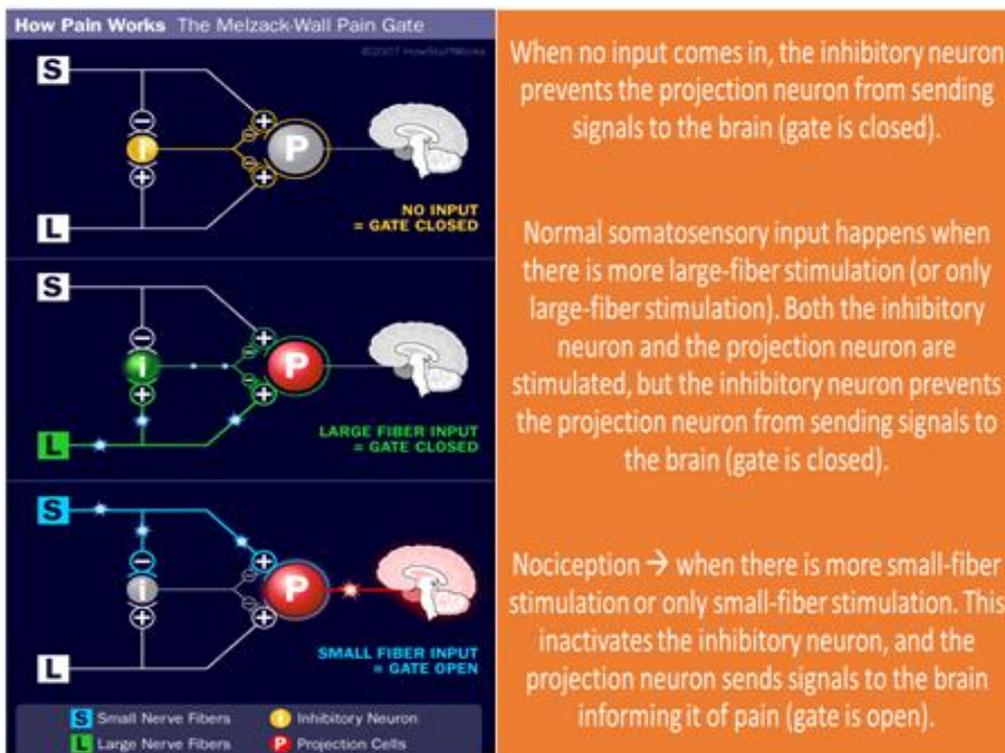
- **Specific Theory (Descartes, 1644):** Pain occurs due to stimulation of specific pain receptors (nociceptors) with transmission by nerves directly to the brain. Pain is purely an afferent sensory experience. The specificity theory was responsible for the development of several surgical approaches to the management of chronic pain by cutting straight through tracts.<sup>1</sup>
- **Pattern Theory (Goldscheider, 1894):** There is no separate system for perceiving pain, and the receptors for pain are shared with other senses, such as of touch, pressure. Particular patterns of nerve impulses that evoke pain are produced by summation of sensory input within the dorsal horn of spinal cord. Pain results when total output of the cells exceeds a critical level.<sup>1</sup>
- **Gate Control Theory (Melzack And Wall, 1965):** information about the presence of injury is transmitted to central nervous system by small peripheral nerves. Cells in the spinal cord or nucleus of fifth cranial nerve, which are excited by these injury signals, are also facilitated or inhibited by other large peripheral nerves that also carry information about innocuous events (for eg. Temperature or pressure). Descending control systems originating in the brain modulate the excitability of cells that transmit information about injury.<sup>1</sup>

Therefore, the brain receives messages about injury by the way of the gate control system, which is influenced by (1) injury signals, (2) other types of afferent impulses, and (3) descending control.<sup>1</sup>



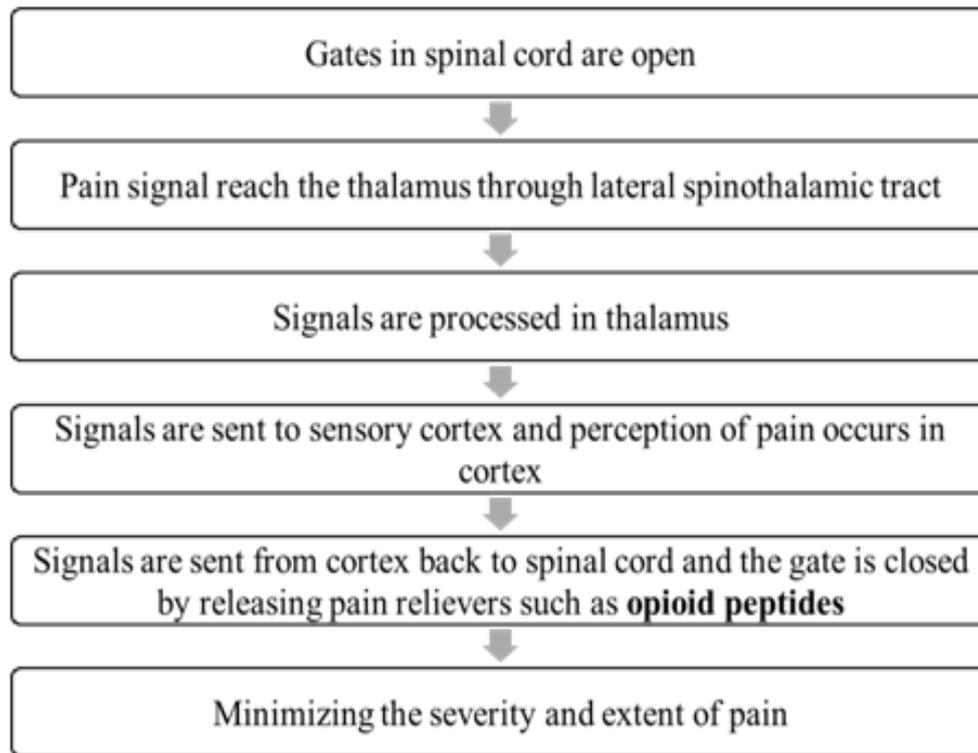
**Fig. 13 Gate Control Theory**

A gating mechanism exists within the dorsal horn of the spinal cord. Small nerve fibres (pain receptors) and large nerve fibres ("normal" receptors) synapse on projection cells (P), which go up the spinothalamic tract to the brain, and inhibitory interneurons (I) within the dorsal horn. The interplay among these connections determines when painful stimuli reaches brain.<sup>1</sup>



**Fig. 14 Mechanism of Gate Control Theory**

### Role of Brain in Gate Control Mechanism:

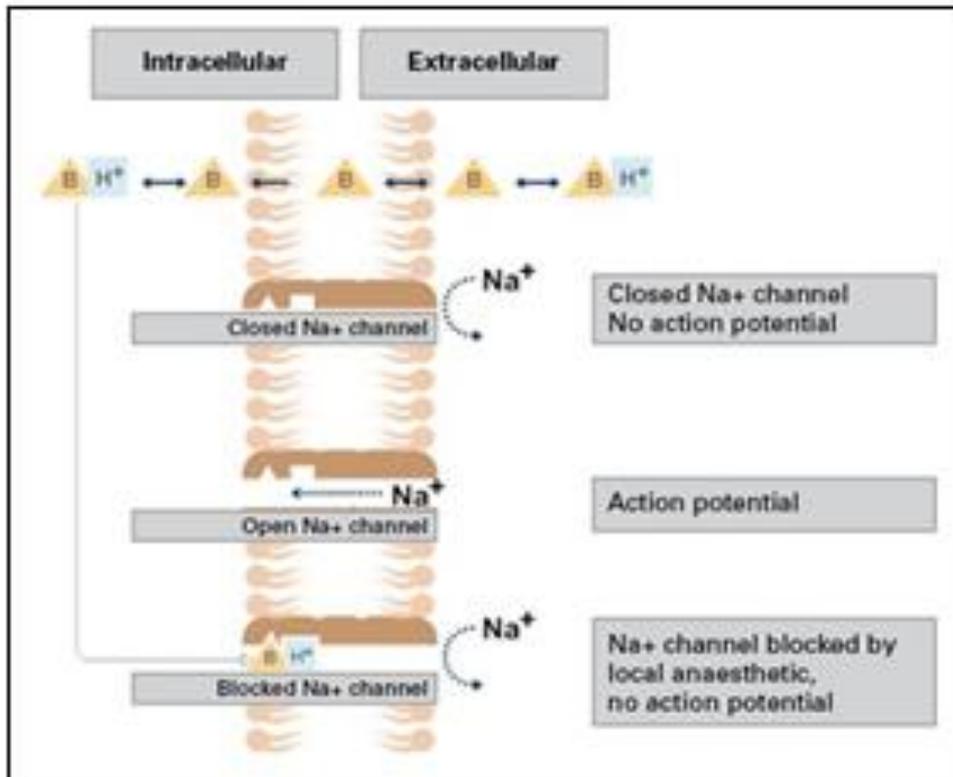


### 3.9 The Dual Nature of Pain

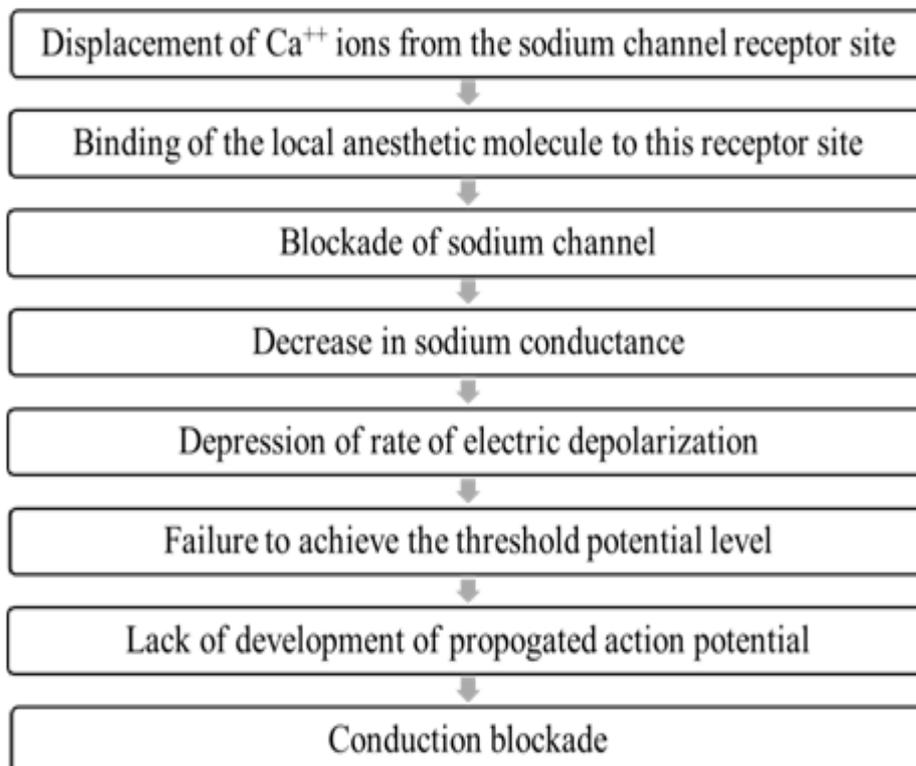
The first aspect, pain perception, is the physio anatomical process whereby an Impulse is generated, following application of an adequate stimulus, and is transmitted to the central nervous system. Stimulus intensity as well as the duration for which it must be applied are relatively uniform, as is the rate of impulse conduction for particular nerve types. Impulse that involve nociception travel over a specialized neural network that has chemical neurotransmitter peculiar to it.<sup>1</sup>

The second aspect of pain, pain reaction, is a psychophysiological process that represents the individual's overt manifestation of the unpleasant perceptual process that just occurred. This aspect of pain embraces extremely complex neuroanatomical and psychological factors involving the cortex, limbic system, hypothalamus, and thalamus. These complex factors determine how the individual will react to the unpleasant experience and are analogous to the events triggered and occurring within the action described in gate control theory.<sup>1</sup>

### 3.10 Mechanism of Action of Local Anaesthetics<sup>11</sup>



**Fig. 15 Mechanism of Action of Local Anaesthetics**



# Chapter 4

## Classification of Orofacial Pain

International Headache Society has published the “Classification and diagnostic criteria for headache disorders, cranial neuralgias and facial pain” in 1988 and revised in 2004.<sup>14</sup>

### Box 1. Hierarchical International Headache Classification (ICHD) II.

#### Hierarchical ICHD-II

- Part I: the primary headaches
  1. Migraine
  2. Tension-type headache
  3. Cluster headache and other trigeminal autonomic cephalalgias
  4. Other primary headaches
- Part II: the secondary headaches
  5. Headache attributed to head and/or neck trauma
  6. Headache attributed to cranial or cervical vascular disorder
  7. Headache attributed to nonvascular intracranial disorder
  8. Headache attributed to a substance or its withdrawal
  9. Headache attributed to infection
  10. Headache attributed to disorder of homeostasis
  11. Headache or facial pain attributed to disorder of cranium, neck, eyes, ears, nose, sinuses, teeth, mouth or other facial or cranial structures
  12. Headache attributed to psychiatric disorder
- Part III: Cranial neuralgias central and primary facial pain and other headaches
  13. Cranial neuralgias and central causes of facial pain
  14. Other headache, cranial neuralgia, central or primary facial pain

### Chapter 13. ICHD of cranial neuralgias and central causes of facial pain (ICD-10 G44.847, G.44.848 or G44.8)

- 13.1. Trigeminal neuralgia
- 13.2. Glossopharyngeal neuralgia
- 13.3. Nervus intermedius neuralgia [G51.80]
- 13.4. Superior laryngeal neuralgia [G52.20]
- 13.5. Nasociliary neuralgia [G52.80]
- 13.6. Supraorbital neuralgia [G52.80]
- 13.7. Other terminal branch neuralgias [G52.80]
- 13.8. Occipital neuralgia [G52.80]
- 13.9. Neck–tongue syndrome
- 13.10. External compression headache
- 13.11. Cold-stimulus headache
- 13.12. Constant pain caused by compression, irritation or distortion of cranial nerves or upper cervical roots by structural lesions [G53.8] + [code to specify etiology]
- 13.13. Optic neuritis [H46]
- 13.14. Ocular diabetic neuropathy [E10-E14]
- 13.15. Head or facial pain attributed to herpes zoster
- 13.16. Tolosa–Hunt syndrome
- 13.17. Ophthalmoplegic ‘migraine’
- 13.18. Central causes of facial pain

### Chapter 14. Other headache, cranial neuralgia, central or primary facial pain (ICD-10 R51)

- 14.1. Headache not elsewhere classified
- 14.2. Headache unspecified

## 4.1 New Additions to Classification Criteria<sup>15</sup>

### *a) Primary Headaches:*

- Typical aura without headache [1.2.3]
- Cyclical vomiting [1.3.1]
- Abdominal migraine [1.3.2]
- Chronic migraine [1.5.1]
- Persistent aura without infarction [1.5.3]
- Migraine-triggered seizure [1.5.5]
- Probable chronic migraine [1.6.5]
- Episodic paroxysmal hemicrania [3.2.1]
- SUNCT[3.3]
- Hypnic headache [4.5]
- Primary thunderclap headache [4.6]
- Hemicrania continua [4.7]
- New daily persistent headache [4.8]

### *b) Secondary Headaches:*

- Acute and chronic headache attributed to whiplash injury [5.3, 5.4]
- Postcraniotomy headache [5.7]
- Headaches attributable to dural AV fistula [6.3.3], cavernous angioma [6.3.4] or Sturge-Weber syndrome [6.3.5]
- Headaches attributable to carotid angioplasty [6.5.3], endovascular procedure [6.5.4] or angiography [6.5.5]
- Headaches attributable to other intracranial vascular disorders – CADASIL[6.7.1], MELAS [6.7.2], benign angiopathy of the CNS [6.7.3], pituitary apoplexy [6.7.4]
- Headaches attributable to spontaneous low CSF pressure [7.2.3]
- Headaches attributable to epileptic seizure [7.6]
- Headaches attributable to Chiari Malformation type 1 [7.7]
- HaNDL(Syndrome of transient Headache and Neurological Deficits with cerebrospinal fluid Lymphocytosis) [7.8]
- Headaches attributable to phosphodiesterase inhibitors [8.1.2], cocaine [8.1.6], cannabis [8.1.7], histamine [8.1.8], CGRP[8.1.9]
- Headaches as an acute adverse event attributed to medications used for other indications [8.1.10]
- Headaches induced by acute substance use or exposure [8.1.11]
- Headaches as an adverse event attributed to chronic medication [8.3]
- Exogenous hormone-induced headache [8.3.1]
- Headaches attributable to HIV/AIDS [9.3]
- Chronic postinfection headache [9.4]
- Diving headache [10.1.2]
- Headaches attributable to hypothyroidism [10.4]
- Headaches attributable to fasting [10.5]
- Cardiac cephalgias [10.6]
- Headaches attributable to other disorders of homeostasis [10.7]
- Headaches attributable to craniocervical dystonia [11.2.3]
- Headaches attributable to ocular inflammatory disorders [11.3.4]
- Headaches attributable to somatisation disorder [12.1]
- Headaches attributable to psychotic disorder [12.2]
- Nasociliary neuralgia [13.5]
- Supraorbital neuralgia [13.6]
- Trigeminal branch neuralgias [13.7]
- Facial pain due to multiple sclerosis [13.18.3]
- Persistent idiopathic facial pain [13.18.4]
- Burning mouth syndrome [13.18.5]
- Headache unspecified [14.2]

A complete pain classification must assess the pain condition on two levels or axes. One axis represents the physical factors that are responsible for the nociceptive input; the other axis represents the psychologic factors that influence the pain experience.<sup>16</sup>

<p><b>Box 2. Orofacial pain classification</b></p> <p><i>Axis I: Physical conditions</i></p> <p>Somatic pain</p> <p>Superficial somatic pain</p> <p>Cutaneous pain</p> <p>Mucogingival pain</p> <p>Deep somatic pain</p> <p>Musculoskeletal pain</p> <p>a. Muscle pain (<i>see the article by Clark in this issue</i>)</p> <p>i. Protective co-contraction</p> <p>ii. Local muscle soreness</p> <p>iii. Myofascial pain</p> <p>iv. Myospasm</p> <p>v. Myositis</p> <p>vi. Centrally mediated myalgia</p> <p>vii. Central mediated movement disorders (<i>see the article by Balasubramaniam and Ram in this issue</i>)</p> <p>b. Temporomandibular joint pain (<i>see the article by de Leeuw in this issue</i>)</p> <p>i. Ligamentous pain</p> <p>ii. Retrodiscal pain</p> <p>iii. Capsular pain</p> <p>iv. Arthritic pain (<i>see the article by Mercuri in this issue</i>)</p> <p>c. Osseous and periosteal pain</p> <p>d. Soft connective tissue pain</p> <p>e. Periodontal dental pain</p> <p>Visceral pain</p> <p>a. Pulpal dental pain</p> <p>b. Vascular pain</p> <p>i. Arteritis</p> <p>ii. Carotidynia</p> <p>c. Neurovascular pain (<i>see the article by Nixdorf, Velly, and Alonso in this issue</i>)</p> <p>i. Migraine</p> <p>ii. Tension-type headache</p> <p>iii. Cluster headache and other trigeminal autonomic cephalalgias</p> <p>iv. Other primary headaches</p> <p>v. Neurovascular variants</p> <p>d. Visceral mucosal pain</p> <p>e. Glandular, ocular, and auricular pain</p> <p>Neuropathic pain</p> <p>Episodic neuropathic pains (<i>see the article by Benoliel and Eliav in this issue</i>)</p> <p>Paroxysmal neuralgia pain</p> <p>a. Trigeminal neuralgia</p> <p>b. Glossopharyngeal neuralgia</p> <p>c. Geniculate neuralgia</p>	<p>d. Superior laryngeal neuralgia</p> <p>e. Nervous intermedius</p> <p>f. Occipital neuralgia</p> <p>Neurovascular pain (already listed under visceral pain)</p> <p>Continuous neuropathic pains</p> <p>Peripheral mediated pain</p> <p>a. Entrapment neuropathy</p> <p>b. Deafferentation pain</p> <p>c. Neuritic pain</p> <p>Central mediated pain</p> <p>a. Burning mouth syndrome (<i>see the article by Klasser, Fischer, and Epstein in this issue</i>)</p> <p>b. Atypical odontalgia (phantom pain)</p> <p>c. Postherpetic neuralgia</p> <p>d. Chronic regional pain syndromes</p> <p>e. Sympathetically maintained pain</p> <p>Metabolic polyneuropathies</p> <p>a. Diabetic neuropathy</p> <p>b. Hypothyroid neuropathy</p> <p>c. Alcoholic neuropathy</p> <p>d. Nutritional neuropathies</p> <p><i>Axis II: Psychologic conditions (see the article by Carlson in this issue)</i></p> <p>Mood disorders</p> <p>Depressive disorders</p> <p>Bipolar disorders</p> <p>Mood disorders because of a medical condition</p> <p>Anxiety disorders</p> <p>Generalized anxiety disorders</p> <p>Posttraumatic stress disorders</p> <p>Anxiety disorders because of a medical condition</p> <p>Somatoform disorders</p> <p>Undifferentiated somatoform disorders</p> <p>Conversion disorders</p> <p>Pain disorders</p> <p>Hypochondriasis</p> <p>Other conditions</p> <p>Malingering</p> <p>Psychological factors affecting a medical condition</p> <p>Personality traits or coping style</p> <p>Maladaptive health behavior</p> <p>Stress-related physiologic response</p> <p>Any other mental disorders not mentioned in this classification</p> <p><small>Data from Olesen J. The International Classification for Headache Disorders. Cephalalgia 2004;24(Suppl 1):1-160.</small></p>
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#### 4.2 American Academy of Orofacial Pain Classification<sup>14</sup>:

- Vascular and Nonvascular Intracranial Disorders
- Primary Headache Disorders
- Episodic and continuous neuropathic pain

- Intraoral Pain Disorders
- Temporomandibular Disorders
- Cervicogenic Mechanisms of Orofacial Pain and Headaches
- Extracranial and Systemic Causes of Head and Facial Pain
- Axis II: bio-behavioural considerations

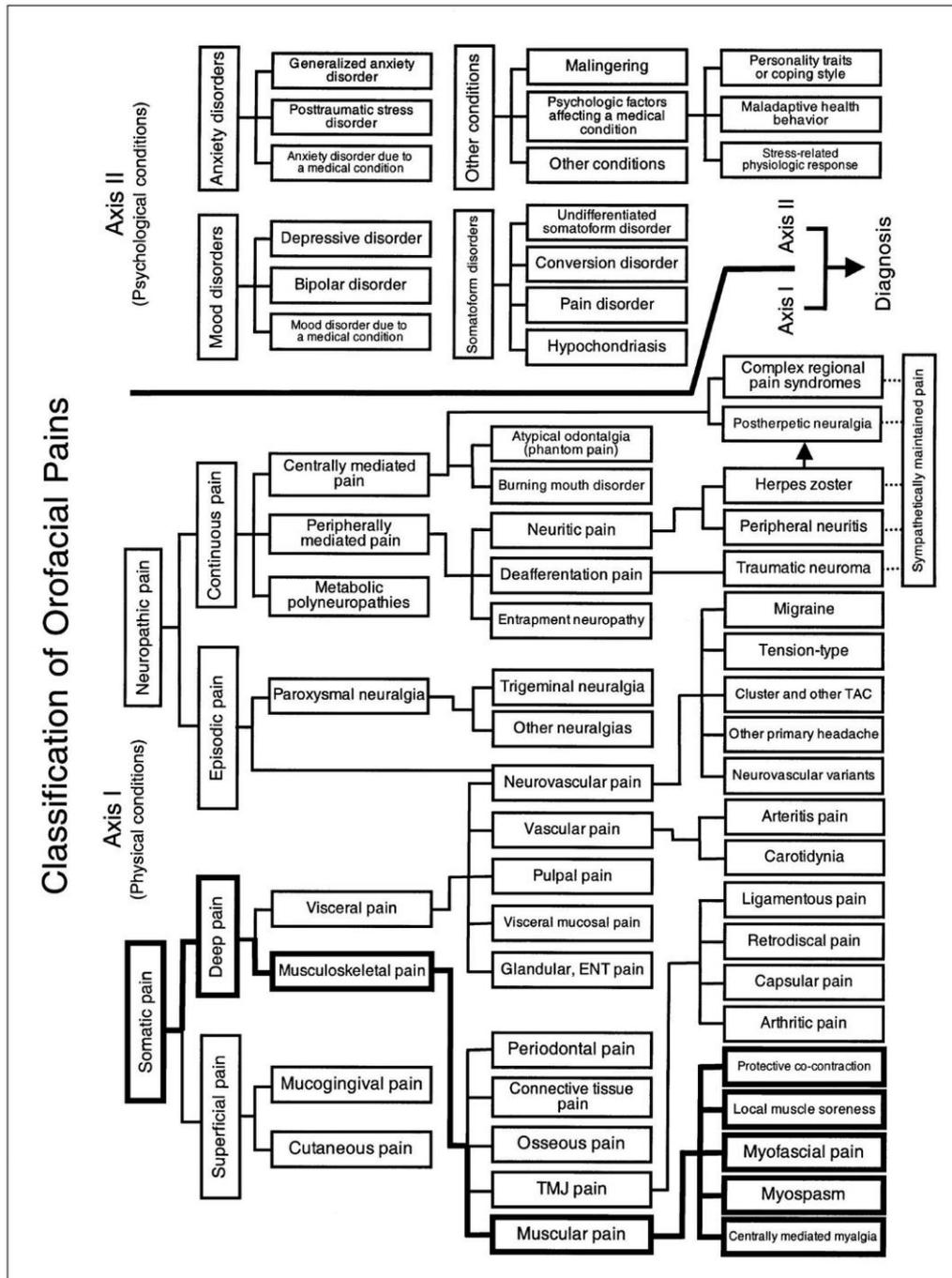


Fig. 16 Facial Pain Classification Chart, which can be Used as a Diagnostic Road Map.<sup>9</sup>

# Chapter 5

## Clinical Assessment of Orofacial Pain

Accurate diagnosis of chronic pain disorders of the mouth, jaws, and face is frequently complex because there are multiple structures localized in one small anatomic region that can be a source of painful sensations. It is common for patients with chronic orofacial pain to consult multiple clinicians and receive an incorrect diagnosis and receive ineffective treatment before a correct diagnosis is reached.<sup>17</sup>

A clinician treating a patient with chronic orofacial pain can minimize error by starting the diagnostic procedure with the well-established method of a careful, accurate history and thorough head and neck examination followed by a thoughtfully constructed differential diagnosis.<sup>17</sup>

### 5.1 Comprehensive History<sup>17</sup>

Chief complaint	Described in patients words
History of present illness	Chronology of onset Location of symptoms as pointed by patient Quality of symptoms: aching, dull, pressure pain most often represents musculoskeletal category, whereas throbbing, stabbing, pounding pain is neurovascular and burning, itching, electric shock-like pain describes neuropathic pain (some degree of overlap may occur) Timing, frequency, and duration (constant vs intermittent) Pain intensity can be measured by verbal rating (mild/moderate/sever), numeric rating (0–10), or VAS (10-cm line starting at 0 = no pain and ends at 10 = pain as bad as could be) Modifying factors that aggravate or alleviate pain (eg, chewing, light touch, emotional stress) Associated symptoms (eg, tearing; nasal congestion; nausea; vomiting; sensitivity to light, sounds, or motions; paresthesia; otalgia; headache)
Medical and dental history	Comorbid systemic disorders (eg, musculoskeletal, rheumatologic, and arthritic conditions) History of trauma to head and neck Parafunctional history: clenching, grinding History of previous treatments, and outcomes. Obtain information about medication dosage and length of treatment to avoid retreatment and determine whether previous treatment given was for the appropriate time and dose
Psychological and social history	Stressors and response to stress (social and occupational) Depression and anxiety are often comorbid factors Litigation, disability, and second gain Activity level and expectations

## 5.2 Physical Examination <sup>17</sup>

System	Physical Examination	Examples of Related Disease
General appraisal	Asymmetry, swelling, tremors, posture Palpation of extraoral soft tissues such as lymph nodes and salivary glands	Neoplastic disease Dyskinesia Cervical spine disorders Multiple sclerosis
Musculoskeletal evaluation	Palpation of cervical and muscles of mastication. Palpation (and auscultation) of the TMJs for joint noises and their time of occurrence, tenderness, and swelling Measuring mandibular range of vertical and lateral movements. Inspect for corrected and uncorrected deviations, maximum opening with comfort, with pain, and passive range of motion (assisted opening) and signs of parafunction	Primary or secondary myalgia Myofascial pain Chronic widespread pain Localized arthritis Rheumatoid osteoarthritis Polyjoint osteoarthritis Disc displacement with or without reduction
Neurologic evaluation	Cranial nerve screening	CNS neoplasia Multiple sclerosis Secondary trigeminal neuralgia Chronic daily headaches Acute trigeminal neuritis
Vascular evaluation	Compression of temporal and carotid arteries	Temporal arteritis Trigeminal neuralgia caused by vascular compression
Ear, nose, and throat	Ear discharge, external lesions, swelling of parotid, external auditory canal examination by trained clinician, palpation of the maxillary and frontal sinuses, and visualization of oropharynx	Sinusitis Acute otitis media Neoplastic disease Parotid disease
Intraoral evaluation	Dental and periodontal examination Soft tissue condition (ulceration, mass, and infection) Stability of maxillomandibular relationship, and signs of parafunction	Vesiculobullous and ulcerative disease Dental disorders Periodontal disease

## 5.3 Pain-Quality Descriptors and Secondary Symptoms <sup>5</sup>

Pain category	Quality	Secondary symptoms
Musculoskeletal	<ul style="list-style-type: none"> <li>• Dull</li> <li>• Aching</li> <li>• Pressure</li> <li>• Depressing</li> <li>• Tight</li> <li>• Stiff</li> <li>• Occasionally sharp</li> </ul>	<ul style="list-style-type: none"> <li>• Flushing</li> <li>• Hyperalgesia</li> <li>• Allodynia</li> <li>• Can refer to or be referred from distant sites</li> <li>• Worse with function</li> </ul>
Neurovascular	<ul style="list-style-type: none"> <li>• Throbbing</li> <li>• Stabbing</li> <li>• Pounding</li> <li>• Rhythmic</li> </ul>	<ul style="list-style-type: none"> <li>• Worsened by increasing intracranial pressure (eg, Valsalva, bending over, physical activity)</li> <li>• Sensitivity to light and/or sound</li> <li>• Nausea, vomiting</li> </ul>
Neuropathic	<ul style="list-style-type: none"> <li>• Shooting</li> <li>• Bright</li> <li>• Stimulating</li> <li>• Burning</li> <li>• Itchy</li> <li>• Electric shock-like</li> <li>• Cutting</li> </ul>	<ul style="list-style-type: none"> <li>• Numbness</li> <li>• Hyperalgesia</li> <li>• Paresthesia</li> <li>• Allodynia</li> <li>• Dysesthesia</li> </ul>
Psychogenic	<ul style="list-style-type: none"> <li>• Descriptive</li> </ul>	<ul style="list-style-type: none"> <li>• Complaint patterns often do not match anatomical sensory supply</li> </ul>

## 5.4 Cranial Nerve Evaluation<sup>17</sup>

Cranial Nerve	Function
I. Olfactory	Sense of smell
II. Optic	Visual acuity, visual fields
III. Oculomotor	Movement of eyeball, pupil, and upper eyelid
IV. Trochlear	Eye movement
V. Trigeminal	Tactile facial sensation, motor innervation of muscle of mastication, corneal reflex
VI. Abducens	Lateral movements of the eyes
VII. Facial	Movement of facial muscles Extrinsic and intrinsic ear muscles, taste (anterior two-thirds of tongue)
VIII. Acoustic vestibular	Hearing, equilibrium and orientation of head in space
IX. Glossopharyngeal	Elevation of palate, movement of pharynx and larynx. General sensation from palate, posterior one-third of tongue, and oropharynx. Taste from posterior one-third of tongue and oropharynx
X. Vagus	Muscles of soft palate, base of tongue, pharynx, larynx. Parasympathetic fibers to thoracic and abdominal viscera
XI. Accessory	Movement of sternocleidomastoid and trapezius muscles
XII. Hypoglossal	Movement of the tongue

- **Olfactory Nerve:** It is tested by asking the patient to detect differences between the odours for example peppermint, vanilla, and chocolate. It must also be determined whether or not the patient's nose is obstructed. This can be done by asking the patient to exhale nasally onto a mirror. Fogging of the mirror from both nostrils denotes adequate air flow.<sup>9</sup>
- **Optic Nerve:** It is tested by having the patient cover one eye and read a few sentences. The other eye is checked in the same manner. The visual field is assessed by standing behind the patient and slowly bringing your fingers from behind around into view. The patient should report when the fingers first appear. There normally will be no variation between when they are seen on the right and on the left.<sup>9</sup>



**Fig. 17 Checking the Patient's Visual Field. with the Patient Looking Forward, the Examiner's Fingers are Brought to the Front From Behind. The Initial Position at which the Fingers are Seen Marks the Extent of the Visual Field.<sup>9</sup>**

- **Oculomotor, Trochlear, And Abducent Nerves:** they are tested by having the patient follow the examiner's finger as it makes an X. Both eyes should move smoothly and similarly as they follow the finger. The pupils should be of equal size and rounded and should react to light by constricting. The accommodation reflex is tested by having the patient change focus from a distant to a near object. The pupils should constrict as the object (eg, a finger) approaches the patient's face. Not only should they both constrict to direct light, but each should also constrict to light directed in the other eye (consensual light reflex).<sup>9</sup>



[A]

[B]

**Fig. 18 [A] Checking the Patient's Extraocular Muscles. Without Moving the Head, the Patient Uses Only the Eyes to Follow one of the examiner's fingers as it makes an X. Any Variation in Right or Left Eye Movement is Noted. [B] Constriction of the Pupil can be Seen When Light is Directed Toward the Eye. The Opposite Pupil Should Also Constrict, Demonstrating the Consensual Light Reflex.<sup>9</sup>**

- **Trigeminal Nerve:** Sensory input is tested by lightly stroking the face with a cotton tip bilaterally in three regions: forehead, cheek, and mandible. This will give a rough idea of the function of the ophthalmic, maxillary, and mandibular branches of the trigeminal nerve. The patient should describe similar sensations on each side. The corneal reflexes can be tested by observing the patient's blink in response to light touch on the cornea with a sterile cotton pledget or tissue. Gross motor input is tested by having the patient clench while the examiner feels both masseter and temporal muscles. The muscles should contract equally bilaterally.<sup>9</sup>



**Fig.19 [A] Cotton Tip Applicators Used to Compare Light Touch Discrimination Between the Right and Left Branches of the Trigeminal Nerve. [B] ask the Patient to Clench the Teeth Together While the Examiner Feels for Bilateral Contraction.<sup>9</sup>**

- **Facial Nerve:** Sensory component is tested by asking the patient to distinguish between sugar and salt using just the tip of the tongue. The motor component is tested by asking the patient to raise both eyebrows, smile, and show the mandibular teeth. During these movements, any bilateral differences are recorded.<sup>9</sup>
- **Acoustic Nerve:** The patient should be questioned regarding any recent changes in upright posture or in hearing. Gross hearing can be evaluated by rubbing strands of hair near the patient's ear and noting any difference between right and left sensitivities.<sup>9</sup>



**Fig. 20 Gross Hearing can be Evaluated By Rubbing Strands of Hair Between the Finger and Thumb and Noting any Difference in Hearing Between the Right and Left Ears.<sup>9</sup>**

- **Gloss Pharyngeal and Vagus Nerves:** The ninth and tenth cranial nerves are tested together because they both supply fibres to the back of the throat. The patient is asked to say “ah,” and the soft palate is observed for symmetric elevations. The gag reflex is tested by touching each side of the pharynx.<sup>9</sup>
- **Accessory Nerve:** The trapezius is tested by asking the patient to shrug the shoulders against resistance. The patient is then asked to tilt the head to one side while the clinician resists the movement. The sternocleidomastoid is tested by having the patient look first to the right and then to the left against resistance. Any differences in muscle strength between each side should be noted.<sup>9</sup>



**Fig. 21 The Spinal Accessory Nerve is Tested by Asking the Patient to Move the Head Laterally to One Side Against Resistance. The Examiner Assesses for Equal Muscle Strength Between the Right and Left Sides.<sup>9</sup>**

- **Hypoglossal Nerve:** To test it, the examiner asks the patient to protrude the tongue and notes any uncontrolled or consistent lateral

deviation. The strength of the tongue can also be evaluated by having the patient push laterally against a tongue blade.<sup>9</sup>

### 5.5 Considerations when Screening for Behavioural and Psychological Factors During Pain Assessment<sup>17</sup>

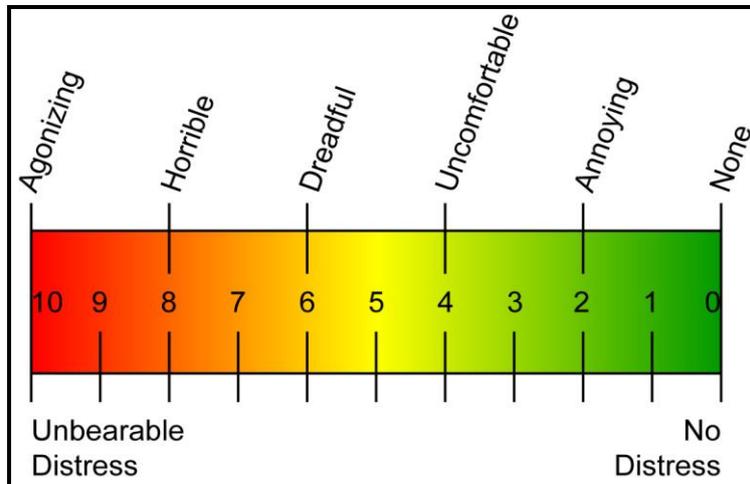
- Disability in daily work, household maintenance, and recreational and social activities that is out of proportion to objective findings
- Symptoms of psychological disorders: depression, anxiety, somatization
- Prolonged / excessive use of opiates, benzodiazepines, alcohol, or other drugs
- Evidence of secondary gain
- Major life events and variation of pain depending on those events
- Repeated failure to conventional therapy
- Symptoms incompatible with innervation pathway
- Other chronic pain elsewhere in the body

### 5.6 Red Flags: Symptoms that May Indicate Serious Disease<sup>4</sup>

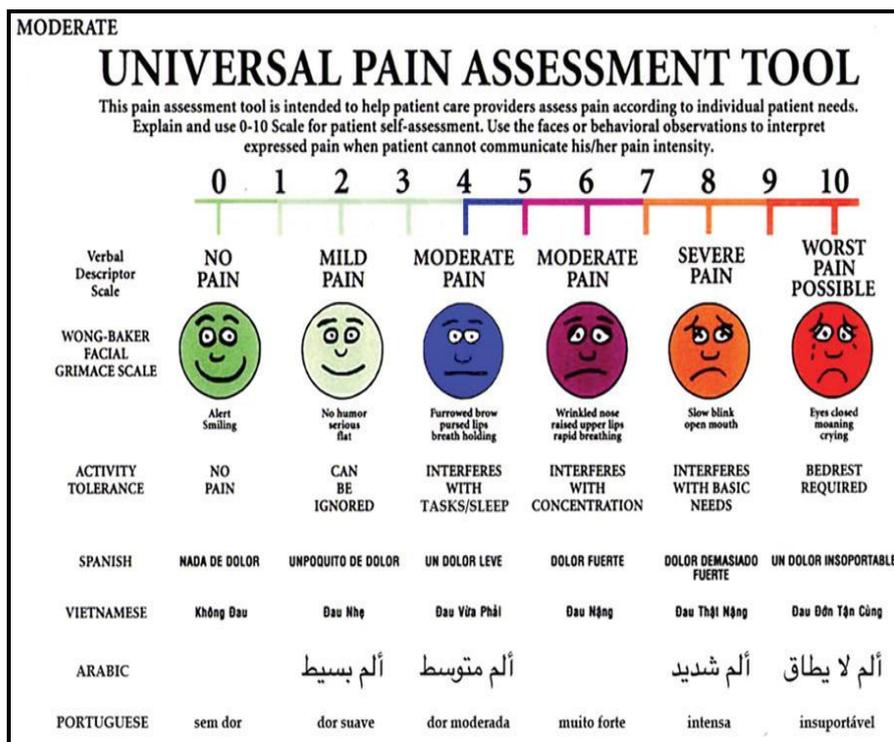
Patient age	Signs and symptoms	Condition to consider
Over 50 years	Temporal area pain mimicking TMJ disorder, swollen tender artery, jaw claudication	Giant cell arteritis
	Progressive neuropathic pain	Primary or metastatic carcinoma
	New-onset head pain with increasing severity of nausea, vomiting, early morning occurrence with or without focal neurologic signs	Mass effect or increased intracranial pressure
Under 50 years	Trigeminal neuralgia	Multiple sclerosis
	Intermittent bilateral pain at the angle of the jaw	Cardiac ischemia
	Orofacial pain, facial paralysis, trigeminal neuralgia, tinnitus, hearing loss, or imbalance	Acoustic neuroma
	Focal neuropathy with pain or altered sensation	Tumor invasion of nerve
	Earache, trismus, altered sensation in mandibular branch distribution of cranial nerve V	Infratemporal fossa or acoustic nerve impingement

## 5.7 Pain Assessment Tools

- **Visual Analog Pain Scale** <sup>18</sup>



- **Universal Pain Assessment Tool** <sup>19</sup>



- **Mcgiill Pain Questionnaire** <sup>20</sup>:

Gagliese L et al (2005) compared the feasibility and validity of the Numeric Rating Scale (NRS), Verbal Descriptor Scale (VDS), and Visual Analog Scale (horizontal (VAS-H) and vertical (VAS-V) line orientation) for the assessment of pain intensity in younger and

## Chapter 5: Clinical Assessment of Orofacial Pain

older surgical patients. 504 patients, who were receiving IV morphine via patient-controlled analgesia, completed the pain intensity measures and the McGill Pain Questionnaire (MPQ) in a randomized order. The NRS was the preferred pain intensity scale. It had low error rates, and higher face, convergent, divergent and criterion validity than the other scales. Most importantly, its properties were not age-related. This was followed by VDS scale and VAS scale. MPQ was least preferred.<sup>21</sup>

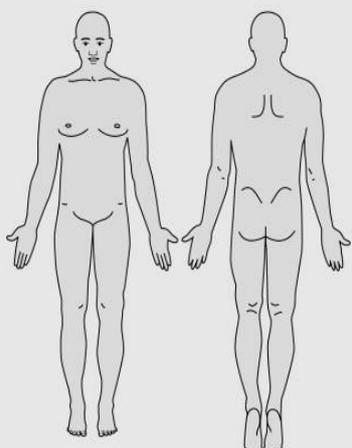
**McGill Pain Questionnaire**

Patient's Name \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_ am/pm

PRI: S \_\_\_\_\_ A \_\_\_\_\_ E \_\_\_\_\_ M \_\_\_\_\_ PRI(T) \_\_\_\_\_ PPI \_\_\_\_\_  
(1-10) (11-15) (16) (17-20) (1-20)

1 FLICKERING	11 TIRING	BRIEF	RHYTHMIC	CONTINUOUS
QUIVERING	EXHAUSTING	MOMENTARY	PERIODIC	STEADY
PULSING		TRANSIENT	INTERMITTENT	CONSTANT

2 JUMPING FLASHING SHOOTING  3 PRICKING BORING DRILLING STABBING LANCINATING  4 SHARP CUTTING LACERATING  5 PINCHING PRESSING GNAWING CRAMPING CRUSHING  6 TUGGING PULLING WRENCHING  7 HOT BURNING SCALDING SEARING  8 TINGLING ITCHY SMARTING STINGING  9 DULL SORE HURTING ACHING HEAVY  10 TENDER TAUT RASPING SPLITTING	12 SICKENING SUFFOCATING  13 FEARFUL FRIGHTFUL TERRIFYING  14 PUNISHING GRUELING CRUEL VICIOUS KILLING  15 WRETCHED BLINDING  16 ANNOYING TROUBLESOME MISERABLE INTENSE UNBEARABLE  17 SPREADING RADIATING PENETRATING PIERCING  18 TIGHT NUMB DRAWING SQUEEZING TEARING  19 COOL COLD FREEZING  20 NAGGING NAUSEATING AGONIZING DREADFUL TORTURING  PPI 0 NO PAIN 1 MILD 2 DISCOMFORTING 3 DISTRESSING 4 HORRIBLE 5 EXCRUCIATING	 <div style="border: 1px solid black; padding: 2px; display: inline-block;">                     E = EXTERNAL I = INTERNAL                 </div> <div style="border: 1px solid black; padding: 5px; min-height: 100px;">                     COMMENTS:                 </div>
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## 5.8 Diagnostic Anaesthesia <sup>5</sup>

Type of anaesthetic block	Type of pain
Dental block	Odontogenic pain or neuropathic pain
Trigger point injections	Myofascial pain and headache
Trigger zone infiltration	Trigeminal neuralgia
Auriculotemporal nerve block	Intracapsular TMJ pain
Intracapsular block	Intracapsular TMJ pain
Greater and lesser occipital block	Cervicogenic pain and headache
Sphenopalatine block	Neuropathic facial pain, Neurovascular pain, sympathetically maintained pain
Stellate ganglion block	Sympathetically maintained pain

A comprehensive assessment may include selective serologic testing. The clinician should know the appropriate serologic studies and be able to collect and interpret the data to establish a differential diagnosis. If it is established that complaints of orofacial pain are related to a systemic disease, referral to a physician is indicated.<sup>14</sup>

## 5.9 Hematology Investigations<sup>14</sup>

The most frequently employed haematological investigations for orofacial pain include:

- Full blood count – predominately looking for anaemias
- Haematinics: ferritin, B12, folate – looking for deficiency states
- causing secondary burning mouth syndrome
- Zinc levels – necessary for Fe absorption
- Hypothyroidism – causing headache
- HBA1c – examining likelihood of diabetes related neuropathy
- Antibody screen to exclude connective tissue disorders
- Extractable nuclear antigens
- Antinuclear antibody test
- Erythrocyte sedimentation rate or C-reactive protein if inflammatory condition suspected

Diagnostic imaging, when indicated, is an important part of the examination process for TMD and orofacial pain patients. Imaging may be used to confirm suspected disease, rule-out disease, and gather additional information when the clinical diagnosis is equivocal or unclear. Certain historical and clinical presentations increase the likelihood of positive findings on imaging examinations.<sup>22</sup>

## Imaging Modalities<sup>22</sup>

### 1. Two-Dimensional

- Periapical radiography
- Panoramic radiography
- Conventional tomography
- Transcranial, transmaxillary, transpharyngeal projections
- Submentovertex projection
- Posteroanterior and lateral cephalometric projections
- Open and closed views

### 1. Three-Dimensional

- Multislice computed tomography (MSCT)
- Cone beam computed tomography (CBCT)
- Magnetic resonance imaging (MRI)

## 5.10 Advantages and Disadvantages of Different Imaging Modalities<sup>22</sup>

Imaging Modality	Advantages	Disadvantages
Conventional tomography	Optional technique on panoramic units, accessibility	Does not depict subtle osseous changes or soft tissues, technique sensitive
Transcranial, transmaxillary, transpharyngeal projections	These techniques were used in the past to evaluate gross osseous changes	Do not depict subtle osseous changes or soft tissues, technique sensitive, limited trained personnel
Submentovertex projection	Optional technique on panoramic units	Provides limited diagnostic information
Posteroanterior and lateral cephalometric projections	Low radiation dose	Provides limited diagnostic information for TMJ
Panoramic radiography including open and closed views of the TMJ	Availability, expense, low radiation dose	Does not depict subtle osseous changes or soft tissues
Multislice computed tomography (MSCT)	Availability, 3-dimensional technique	High radiation dose
Cone beam computed tomography (CBCT)	Typically low radiation dose relative to MSCT, 3-dimensional technique	Availability, variable radiation dose based on imaging parameters, advanced training for interpretation
Magnetic resonance imaging (MRI)	Depicts soft tissue and osseous changes, uses nonionizing radiation, 3-dimensional technique	Time, expense, certain metallic implants preclude use, pacemakers preclude use

# Chapter 6

## Various Presentations of Pain

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The clinician who attempts to understand and manage pain needs to have a thorough appreciation for different types of pain that can be encountered.

### **Pain can be presented as:**

1. Acute and chronic pain
2. Primary and secondary pain
3. Somatic and neuropathic pain
4. Superficial and deep somatic pain
5. Inflammatory pain
6. Pain of dental origin
7. Referred pain
8. Non-odontogenic pain
9. Temporomandibular joint pain
10. Musculoskeletal pain

### **6.1 Acute Pain**

Acute pain is defined as ‘pain of recent onset and probable limited duration. It usually has an identifiable temporal and causal relationship to injury or disease’.<sup>18</sup>

### **6.2 Chronic Pain**

Chronic pain was originally defined as pain that has lasted 6 months or longer. More recently it has been defined as pain that persists longer than the temporal course of natural healing, associated with a particular type of injury or disease process. Chronic pain ‘commonly persists beyond the time of healing of an injury and frequently there may not be any clearly identifiable cause’.<sup>18</sup>



**Fig. 22 Acute Versus Chronic Pain.**

### **6.3 Primary Versus Secondary Pain**

The site where pain occur may or may not identify the location of the source of pain. If pain does in fact emanate from the structures that hurt, it constitutes a primary nociceptive input. If, however the true source of pain is located elsewhere, the area of discomfort represents secondary pain. Secondary pain is also called as heterotopic pain.<sup>18</sup>

### **6.4 Somatic Versus Neuropathic Pain**

Pain emanating from a particular area may result from noxious stimulation of the somatic structures. When this occurs, the nociceptive impulses are being received and transmitted by normal components of the sensory nervous system. Such pain is referred to as somatic pain. Quite a different type of pain, however, may emanate not from abnormality in the somatic structures but from abnormality in the neural components that innervate the area. Such pain is termed neuropathic.<sup>18</sup>

### **6.5 Superficial Versus Deep Somatic Pain**

Pain emanating from the cutaneous and mucogingival tissues present clinical characteristics that are similar to other exteroceptive sensations. They are precisely localized by the patient and relate faithfully to the provocation in timing, location and intensity. In contrast pains resulting from stimulation of deeper musculoskeletal and visceral structures resemble other proprioceptive and interoceptive sensations. As such they are more diffusely felt respond less faithfully to provocation and frequently initiate secondary effects such as referred pain.<sup>18</sup>



**Fig. 23 An Example of Superficial Somatic Pain. Note the Cluster of Minor Aphthous Ulcers Located on the Free Mucosa of the Floor of the Mouth.<sup>9</sup>**

## 6.6 Inflammatory Pain

Tissue injury initiates an inflammatory reaction that characteristically induces pain. Inflammatory pain is due to the action of prostaglandins and bradykinin substances released by inflammatory process. Prostaglandins are important mediators of inflammation, fever and pain. Although in some situation's prostaglandins contribute to pain by directly activating nociceptors, they are generally considered to be sensitizing agents.<sup>18</sup>



**Fig. 24 Note the Tissue Inflammation Around this Erupting Third Molar. This Pericoronitis Is an Example of Deep Pain Input that Can Influence the Musculoskeletal Structures.<sup>9</sup>**

## 6.7 Pain of Dental Origin

Dental pains may have their origin in the dental pulps or in the periodontal structures.

- **Dental Pain of Pulpal Origin:** The pain is of threshold type so no response occurs until the threshold level is reached. Pulpal pain

responds to noxious stimulation, it responds to impact shock, thermal and chemical irritants, the pain is often very difficult for patient to localize.

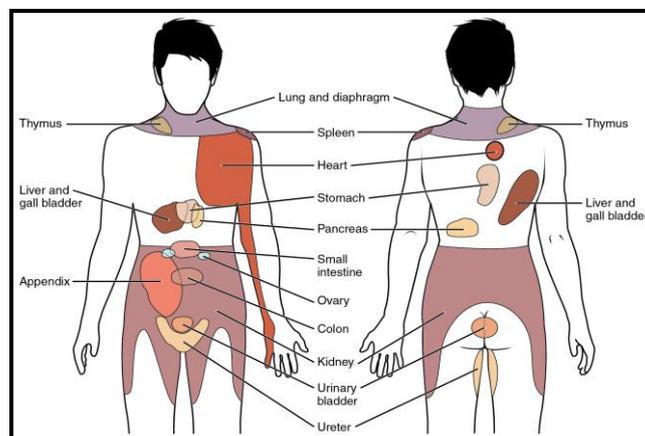
Pulpal pains may be classified as acute, chronic, recurrent or mixed with periodontal elements. A basic clinical feature of pulpal pain is that it does not remain the same indefinitely. Generally, it resolves become chronic or proceeds to involve the periodontal structures.<sup>18</sup>

- **Pain of Periodontal Origin:** Periodontal pain is deep somatic pain of the musculoskeletal type. As such, it is more localized than is pulpal pain. It responds to provocation proportionately and in graduated increments, rather than as a threshold response like pulpal pain. In the PDL are proprioceptors which allow a precise localization of the pressure stimuli, so a periapical pain is easily diagnosed.

It may occur as a primary periodontal inflammatory condition arising from a local cause such as trauma, occlusal forces. Pain may occur as a result of dental prophylaxis, endodontic treatment, orthodontic treatment, inadequate opposing occlusal contact, overcontoured or undercontoured proximal contact points.<sup>18</sup>

## 6.8 Referred Pain

The term referred or reflected pain, denotes the pain felt in the body part which is remote from the place of stimulation or tissue damage. A reflected pain originates in one place (eg. The lower first molar), and is felt in the other (eg. ear). Contrary to that, odontalgia is the pain caused by pathological changes in other places and reflected on the teeth.



**Fig. 25 Referred Pain.**

Referred pain is felt in an area innervated by a different nerve from the one that mediates the primary pain. Both teeth and non-odontogenic sources (such as muscles, sinuses, pathology, and so forth) can refer pain to other teeth or to other anatomic regions of the head and neck.<sup>18</sup>

- **Dermatomal Rule:** When pain is referred, it is usually to a structure that developed from the same embryonic segment or dermatome as the structure in which the pain originates.<sup>11</sup>
- **Convergence-projection theory:** It may be due to convergence of somatic and visceral pain fibres on the same second order neurons in the dorsal horn that projects to the thalamus and then to somatosensory cortex.<sup>11</sup>

## 6.9 Non-Odontogenic Pain

- **Muscular Toothache:** Muscle or myofascial pain is a condition characterized by dull, aching muscles with localized tender areas. These tender areas can refer pain to other structures in consistent patterns. Jaw muscles can refer pain to the teeth, and this can be perceived as dental or intraoral pain.<sup>18</sup>
- **Cardiac Toothache:** The clinical description of ischemic heart disease is characterized by substernal pain, which spreads to the shoulders, arms and neck. In some cases, the pain may spread to the jaws and teeth. The cause of cardiac pain referred to the orofacial region can be explained by convergent mechanisms in the trigeminal complex.<sup>18</sup>
- **Sinus or Nasal Mucosal Toothache:** Problems in the maxillary sinuses and/or paranasal mucosa can refer pain to the upper teeth. The pain is usually felt in several teeth as dull, aching or throbbing.<sup>18</sup>
- **Neurovascular Toothache:** Neurovascular pains or headache is a common complaint. Typically, headache is pain localized to the cranium. However, it may also present as a variant involving the orofacial region hence mimicking toothache.<sup>1</sup>

## 6.10 Temporomandibular Joint Pain

Signs and symptoms of temporomandibular disorders (TMDs) may include pain, impaired jaw function, malocclusion, deviation or deflection, limited range of motion, joint noise, and locking. Because of many etiologic factors, the diagnosis and treatment of patients with temporomandibular joint disorders is complex. Temporomandibular joint disorders can be subdivided into muscular and articular categories.<sup>18</sup>



**Fig. 26 Temporomandibular Joint Pain.**

## 6.11 Musculoskeletal Pain

- **Myofascial Pain Dysfunction Syndrome (MpdS):** Myofascial pain is a common form of pain arising from hyperirritable foci in muscle, usually referred to as myofascial trigger points.<sup>18</sup>
  - **Active Trigger Point:** An active trigger point causes spontaneous pain at rest, with an increase in pain on contraction or stretching of the muscle involved.
  - **Latent Trigger Point:** A latent trigger point is a focal area of tenderness and tightness in a muscle that does not result in spontaneous pain.

# Chapter 7

## Neurovascular Pain

Primary headache disorders also known as neurovascular pain include migraine, tension-type headaches, and the trigeminal autonomic cephalgias (TACs). “Primary” refers to a lack of clear underlying causative pathology, trauma, or systemic disease. The TACs include cluster headache (CH), paroxysmal hemicrania (PH), and short-lasting neuralgiform headache attacks with conjunctival injection and tearing (SUNCT); hemicrania continua (HC), although classified separately by the International Headache Society (IHS), shares many features of both migraine and the TACs.<sup>42</sup>

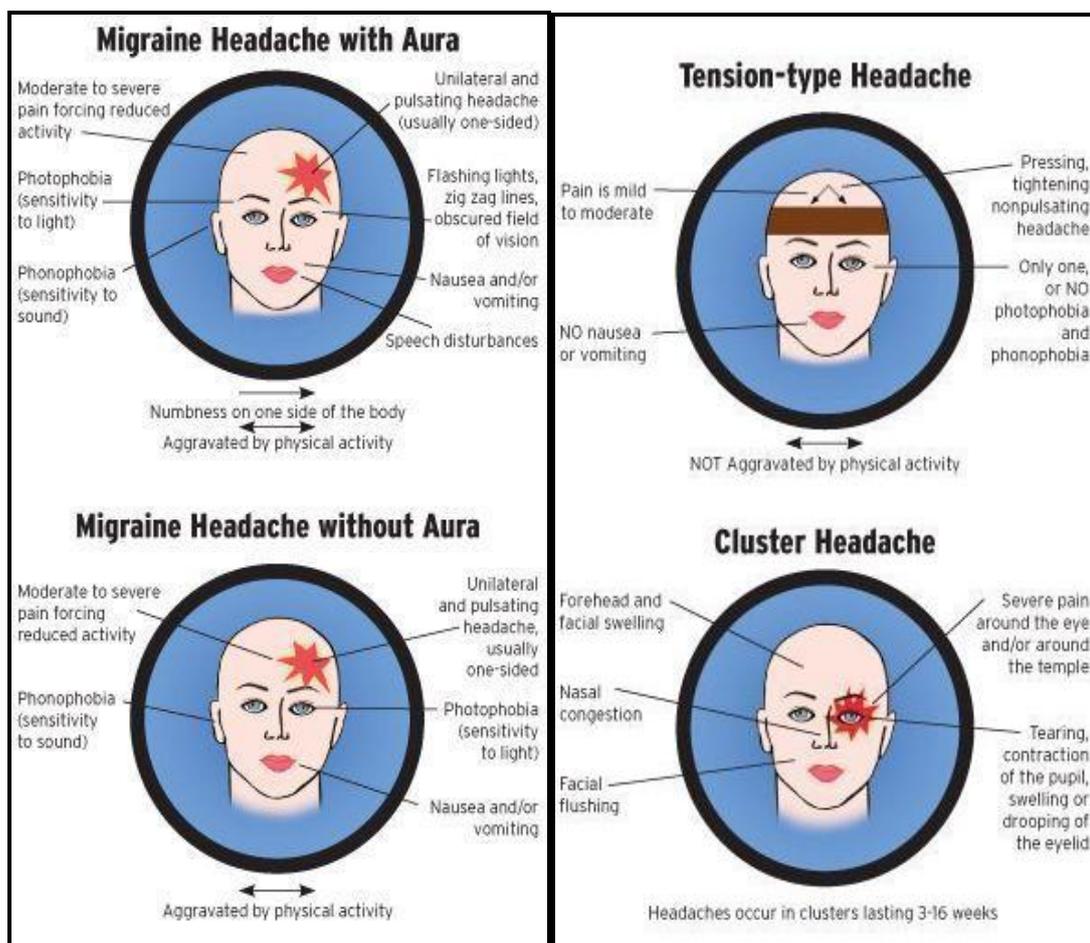


Fig. 41 Different Types of Primary Headache

## 7.1 Migraine

Migraine is a common primary headache that affects approximately 10% to 12% of the adult population. The 2 most common types of migraine headaches are migraine without aura (MWA) and migraine with aura (MA). The combination of a high prevalence, severe pain, and debilitating neurologic symptoms results in a substantial social impact with decreased quality of life.<sup>42</sup>

MWA is an inherited disorder affecting the young, with an onset before the age of 20 years in about half of the cases. There is up to a twofold increase of MWA among first-degree relatives of patients with MWA and a fourfold increase in MA. Studies suggest that multiple receptor polymorphisms and multigene inheritance are involved. Migraine presentation may be divided into phases and each may occur alone or in combination with each other. The headache phase is identical in MA and MWA.<sup>42</sup>

- **Prodrome**<sup>42</sup>
  - Premonitory signs and symptoms occurring days or hours before some or all headaches.
  - Nonspecific neurologic/autonomic signs and constitutional symptoms. Tiredness, difficulty in concentration, and stiff neck.
  
- **Aura (in MA)**<sup>42</sup>
  - Focal neurologic signs or symptoms: Visual (flashing lights), sensory (pins and needles), and motor (speech) symptoms.
  - Develop over 5 to 20 minutes and last for less than 60 minutes.
  - Followed in about 10 minutes by a typical headache.<sup>16</sup>
  
- **Headache Phase (in MWA)**<sup>42</sup>
  - Typically, unilateral; no side preference.
    - ✓ Side-locked migraine in up to half of migraineurs.
    - ✓ Bilateral in some patients.
  - Usually ocular, temporal, and frontal regions.
    - ✓ Also, occipital and neck regions.
  - Throbbing or pulsating; occasionally pressing.
  - Moderate to severe intensity.
  - Not uniform.
  - Sharp periorbital “ice-pick” pains interictally.

- Routine physical activity aggravates pain.
    - ✓ Moving the head or coughing will accentuate headaches.
  - Headache is insidious, may take 0.5 to 2.0 hours.
  - Periodic, typically lasting 4 to 72 hours.
  - Frequency is, in most cases, less than 1 per month<sup>9,24,25</sup> but may vary from up to 2 to 12 headaches per month.
  - Vast majority report nausea and photophobia or phonophobia.
    - ✓ 50% vomit during an attack.
  - Autonomic signs (AS)
    - ✓ Usually lacrimation (z50%), linked to severity.
- **Postdrome**<sup>42</sup>
    - Depressed, irritable, and tired.

### Common Migraine Triggers <sup>42</sup>:

<b>Diet</b> Hunger Alcohol Additives (eg, nitrites, monosodium glutamate) Certain foods (eg, red wine, aged cheese)
<b>Chronobiologic</b> Sleep (too much or too little) Change in schedule
<b>Hormonal changes (eg, menstruation)</b>
<b>Environmental factors</b> Light (eg, bright, flashing, glaring) Odors (eg, perfume, cigarette smoke) Altitude (eg, airplane travel) Weather changes
<b>Head and neck pain</b> Temporomandibular disorders or joint pain Cervical myofascial pain Toothache
<b>Physical exertion</b> Exercise Sexual activity
<b>Stress and anxiety</b> Increased exposure to emotional stress Letdown after a stressful period
<b>Head trauma</b>

- Anxiety and stress.
- Fatigue, sleeping difficulties.
  - Occasionally woken from sleep by a migraine, early morning.
  - Interestingly, sleeping may abolish headache.
- Foods and drinks.
- Menstruation.
  - Hormone variations associated with migraine onset and patterns.

- A quarter of women report menstrual related migraine, more so in clinic-based populations.
- Improvement or resolution of migraine headaches during late pregnancy.
- Weather changes.
- Smells, smoke, and light.

### Differential Diagnosis of Headaches<sup>23</sup>

Condition	Signs and Symptoms
Migraine <sup>2,3</sup>	<ul style="list-style-type: none"> <li>• Prodromal symptoms—euphoria, depression, irritability, food cravings, constipation, neck stiffness, increased yawning</li> <li>• Aura—visual, sensory, verbal, and/or motor disturbances</li> <li>• Throbbing and pulsatile</li> <li>• Photophobia and phonophobia</li> <li>• Long duration</li> </ul>
Cluster Headache (Subclassification of TAC) <sup>4-6</sup>	<ul style="list-style-type: none"> <li>• Orbital and temporal regions</li> <li>• Short-lived</li> <li>• Unilateral</li> <li>• Autonomic symptoms—ptosis, miosis, lacrimation, rhinorrhea, nasal congestion</li> </ul>
Tension-type <sup>7</sup>	<ul style="list-style-type: none"> <li>• Diffuse, dull, aching pain</li> <li>• Bilateral</li> <li>• Precipitated by stress and mental tension</li> </ul>
Paroxysmal Hemicrania (subclassification of TAC) <sup>8</sup>	<ul style="list-style-type: none"> <li>• Unilateral</li> <li>• Shorter-lived than cluster headaches (lasts 2–30 minutes)</li> <li>• Most often in V1 distribution</li> <li>• Orbital, temporal, and frontal regions</li> <li>• Abrupt onset and cessation</li> <li>• Similar autonomic symptoms as cluster headaches</li> </ul>
Temporal arteritis <sup>9</sup>	<ul style="list-style-type: none"> <li>• Age &gt;50 y</li> <li>• Localized headache of new onset</li> <li>• Tenderness or decreased pulse of the temporal artery</li> <li>• Erythrocyte sedimentation rate &gt;50</li> </ul>
Other TACs	<ul style="list-style-type: none"> <li>• SUNCT (short-lasting unilateral neuralgiform headache attacks with conjunctival injection and tearing)</li> <li>• SUNA (short-lasting unilateral neuralgiform headache attacks with cranial autonomic symptoms)</li> </ul>

### Chronic Migraine

Some migraine sufferers may have a clinically progressive disease in which migraine episodes increase in frequency over time. A proportion of migraineurs (15.6%) describe daily or near-daily headaches and approximately 2.5% of the general population has chronic migraine (CM). MWA is most prone to accelerate with frequent use of symptomatic medication, resulting in medication-overuse headache. The risk increases

significantly in whites, with obesity and a high baseline headache frequency.<sup>42</sup>

### **Effectiveness of Medications for Migraine Prevention<sup>9</sup>:**

- **Level A: Effective and Should be Offered**
  - Antiepileptic drugs: divalproex sodium, sodium valproate, topiramate
  - Beta blockers: metoprolol, propranolol, timolol
  - Triptans: frovatriptan (for short-term prevention)
  
- **Level B: Probably Effective and Should be Considered**
  - Antidepressants: amitriptyline, venlafaxine
  - Beta blockers: atenolol, nadolol
  - Triptans: naratriptan, zolmitriptan (for short-term prevention)
  
- **Level C: Possibly Effective and May be Considered**
  - Angiotensin-converting enzyme (ACE) inhibitors: lisinopril
  - Angiotensin receptor blockers: candesartan
  - Beta agonists: clonidine, guanfacine
  - Antiepileptic: carbamazepine
  - Beta blockers: nebivolol, pindolol
  
- **Level U: Conflicting or Inadequate Evidence to Support or Refute Use**
  - Antiepileptic drugs: gabapentin
  - Antidepressants: selective serotonin reuptake inhibitor, selective serotonin norepinephrine reuptake inhibitors (fluoxetine, fluvoxamine)
  - Tricyclics: protriptyline, bisoprolol
  - Antithrombotics: acenocoumarol, coumadin, picotamide
  - Calcium-channel blockers: nifedipine, nimodipine, verapamil, acetazolamide

**Choice of Migraine Preventive Treatment <sup>42</sup>:**

Drug	Dose, mg	Adverse Events	Contraindications	Relative Indications
Propranolol (SR)	80-240	Bradycardia Hypotension Fatigue Sleep disturbances Dyspepsia Depression	Asthma Depression Cardiac failure Raynaud disease Diabetes	Hypertension Angina
Amitriptyline	10-50	Sedation Weight gain Dry mouth Blurred vision Constipation Urinary retention Postural hypotension	Mania Urinary retention Heart block	Insomnia Anxiety Depression TTH Other chronic pains
Sodium valproate	500-1000	Nausea, vomiting Alopecia Tremor Weight gain/loss	Liver disease Bleeding disorder	Mania Epilepsy Anxiety
Topiramate	25-200	Dizziness, confusion, language problems, paresthesias, nausea, anorexia, diplopia	Renal disease, Respiratory disorders Glaucoma	Overweight

**Hepp Z et al (2016)** evaluated headache-related health care utilization among adults with chronic migraine (CM) treated with onabotulinumtoxin A or oral migraine prophylactic medications (OMPMs). Assessment was done at six, nine, and 12 months pre- and post-treatment. Regression analyses showed that the odds of having a headache-related emergency department (ED) visit were 21%, 20%, and 19% lower and hospitalization were 47%, 48%, and 56% lower for the onabotulinumtoxin A group compared to the OMPM group for the six-month, nine-month, and 12-month post-index periods, respectively. Study implies that onabotulinumtoxinA is associated with reduced health care resource utilization.<sup>43</sup>

**Some of the Common Abortive Treatments for Migraine <sup>42</sup>:**

Class	Drugs	Initial Oral Dose, mg
Analgesics	Aspirin	500-1000
Combinations	Aspirin and Paracetamol and Caffeine	500-600
	Paracetamol and Caffeine	200-400
	Paracetamol and Codeine	50-200
	Paracetamol and Codeine	400
	Codeine	25
Ergot alkaloids	Dihydroergotamine NS	2
NSAIDs:		
Nonspecific	Naproxen sodium	550-825
	Ibuprofen	400-800
	Diclofenac	50-100
Selective COX 2 inhibitors	Rofecoxib	25-50
Triptans (5HT agonist)	Sumatriptan	50-100
	Sumatriptan NS	20 (1 NS metered dose)
	Sumatriptan SC	6
	Naratriptan	2.5
	Eletriptan	40
	Rizatriptan	10
	Zolmitriptan	2.5
	Zolmitriptan NS	2.5 (1 NS metered dose)
	Frovatriptan <sup>a</sup>	2.5
	Opioids	Butorphanol NS

**Thorlund K et al (2014)** aimed to determine the relative efficacy of all available triptans to abort migraine headache among patients with previous adequate response to migraine treatments. Double-blinded randomized clinical trials comparing triptans to either placebo or another triptan were included in the study. Primary and secondary outcomes were pain-free response and headache response at two hours and 24-hour sustained response respectively. Results showed that eletriptan is the most likely of all triptans to produce a favorable outcome was 68% for pain-free response at two hours, and 54% for 24-hour sustained pain-free response.<sup>44</sup>

## 7.2 Tension-Type Headache (Tth)

Episodic tension-type headache (ETTH) is a common primary headache affecting the occipital, parietal, temporal, or frontal areas. Infrequent ETTH refers to < 12 headache days per year, while frequent ETTH to  $\geq 1$  but < 15 headache days per month. The pain is typically bilateral, has a tightening or pressing quality, mild to moderate intensity, and may last from a few hours to 7 days. Anorexia, photophobia or phonophobia may occur. The pain may be precipitated by stress and is usually associated with fatigue and poor sleep. Treatment consists of stress management, relaxation training, and pharmacotherapy. Simple analgesics and NSAIDs are typically effective in aborting the pain.<sup>33</sup>

Chronic tension-type headache (CTTH) is characterized by presence of headache on  $\geq 15$  days per month for at least 3 months. CTTH usually evolves from ETTH and may be associated with no more than one of the following: photophobia, phonophobia, or mild nausea. Even though CTTH is often refractory to treatment, stress management, physical therapy, and prophylactic pharmacotherapy with tricyclic antidepressants may be beneficial.<sup>33</sup>

Tension-type headache comes in the group of musculoskeletal disorders; however, it has been hypothesized that there is a continuum between tension-type headache and migraine. Sensitization of the nociceptive central nervous system pathways secondary to nitric oxide production, has also been implicated; inhibition of nitric oxide was found effective in CTTH, providing hope for more specific and successful treatment in the future.<sup>33</sup>

Chronic tension-type headache needs to be differentiated from medication overuse headache, which is the result of frequent use of anti-headache drugs (analgesics, ergot alkaloids, serotonin agonists, combined preparations with caffeine or codeine). Withdrawal therapy, often under in-patient conditions, is essential for the effective management of medication overuse headache.<sup>33</sup>

### **Treatment of TTH**<sup>42</sup>

- Pharmacologic
  - Abortive therapy
    - ✓ 800 mg ibuprofen or 825 mg naproxen.
    - ✓ 1 g of paracetamol.
    - ✓ Triptans for CTTH, or mixed migraine and ETTH.
  - Prophylactic
    - ✓ Tricyclic antidepressants are effective in CTTH but not in ETTH.
    - ✓ 10 mg daily taken just before bedtime and then titrated. CTTH may need up to 75 mg.
  - Muscle relaxants and botulinum toxin, mixed results.
- Nonpharmacological interventions
  - Relaxation and electromyographic biofeedback therapies
  - Cognitive-behavioural (stress-management) therapy
    - ✓ In patients with CTTH, the combination of stress management with a tricyclic antidepressant induced significant reductions in headache index scores than each therapy alone or placebo.
  - Temporomandibular disorder therapies.
    - ✓ Occlusal splints or physiotherapy: Reduction in severity and frequency of headaches.

### **7.3 Trigeminal Autonomic Cephalalgias (Tacs)**

TACs are primary headaches with a common clinical phenotype consisting of trigeminal pain and autonomic signs (AS). The current pathophysiologic model attempts to explain the 3 major features of the TACs: trigeminal pain, rhythmicity and autonomic signs. Current data suggest that cluster headache and other TACs are conditions whose pathophysiological basis is in the central nervous system, including the hypothalamus, which drives the initiation of the clinical phenotype.<sup>42</sup>

## 7.4 Cluster Headache (CH)

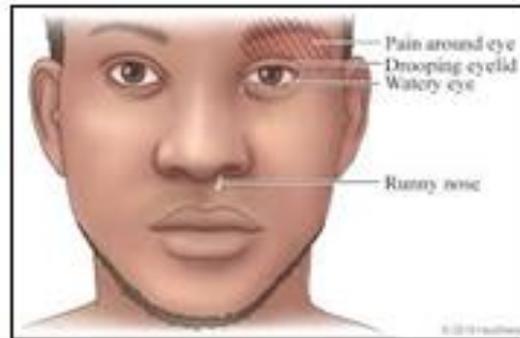
CH is the archetypal TAC, with severe pain and major autonomic activation. CH is likely to have an autosomal dominant gene with low penetrance. CH typically appears between the ages of 20 and 29 years and seems to affect men more than women. A unique feature of episodic CH is the distinctive circadian and circannual periodicity.<sup>42</sup>

Episodic CH commonly occurs at least once daily for a period of weeks, at the same time of day or night. Active periods (6–12 weeks) are followed by a temporary remission that may last from weeks to years (average 12 months). Attacks tend to be shorter and less severe at the beginning and toward the end of each cluster period.<sup>42</sup>

There are 2 distinct temporal presentations of CH; most (80%–85%) suffer from the episodic type, characterized by at least 2 cluster periods separated by pain-free periods of 1 month or more over 7 to 365 days. In chronic CH, repeated attacks recur over more than a year without remission or with remission periods lasting less than 1 month. Interictal pain may also be present between attacks or between clusters.<sup>42</sup>

**CH Features:** The IHS requires at least 5 attacks that meet the criteria outlined.<sup>42</sup>

- Periorbital or ocular<sup>86</sup> pain.
  - “Lower” and “upper” subtypes of CH:
    - Upper CH: forehead, temporal, and parietal regions.<sup>93</sup>
    - Lower CH: temporal, and suboccipital with radiation to the teeth, jaws, neck,<sup>93</sup> teeth, and cheeks.<sup>87,94</sup>
- Unilateral.
  - 20% of cases may change sides.<sup>86</sup>
  - Attacks alternate sides; more common between clusters than between attacks in the same cluster.<sup>86</sup>
- Excruciating severity.
  - Rated as 8 to 10 on a 10-point visual analog scale (VAS) by more than 85% of patients and some report considering suicide.<sup>86</sup>
- Pain is nonspecific: throbbing or boring, burning, stabbing.<sup>95</sup>
  - “Hot poker” or a “stabbing” feeling in the eye.<sup>94</sup>
  - Sudden jabs of intense pain often felt.
- Accompanied by at least 1 of the following ipsilateral autonomic signs:
  - Conjunctival injection/lacrimation
  - Nasal congestion/rhinorrhea
  - Eyelid edema
  - Forehead/facial sweating
  - Miosis and ptosis
  - Restlessness (not a local autonomic sign but frequent [ $>80\%$ ]).
    - Patients appear agitated, continually move around, particularly during severe attacks<sup>96</sup>; in sharp contrast to the quiet-seeking behavior observed in migraine.
- Lasts 15 to 180 minutes
  - Peak intensity is usually rapid: within 3 minutes but may take 9 to 10 minutes.<sup>95</sup>
  - Long-lasting attacks are rare, but may last from 3 to 48 hours.<sup>87</sup>
- Frequency of 1 every other day to 8 per day.



**Fig. 42 Symptoms of Cluster Headache.**

### **Additional Features**<sup>42</sup>

- Nocturnal CH is high particularly prevalent (51%–73%). Pain awakens patients within 90 minutes; the onset of rapid eye movement (REM) sleep. Patients with CH significantly suffer from obstructive sleep apnoea.
- Alcohol may precipitate CH attacks during active cluster periods.
- CH prodromes include AS and mild pain or nonpainful sensations in the area that subsequently becomes painful. Blurred vision, sensitivity to smells, nausea, dyspepsia, hunger, irritability, tiredness, and tenseness.
- Premonitory symptoms may predict CH days before onset similar to those experienced by migraineurs. Auralike symptoms in 14% of cases.

### **Autonomic Signs**<sup>42</sup>

- Ipsilateral lacrimation most frequent AS; in approximately 90% of cases.
  - of AS may be related to pain severity.
  - Common and pronounced in CH, subtler in other TACs.
  - Rarely ptosis and miosis (partial Horner syndrome) may persist.
- Intensity Migrainous features are common in CH.
  - Photophobia, phonophobia, nausea, and vomiting in up to half of cases.
  - Phonophobia and photophobia are unilateral: in migraine bilateral.
- CH associated with transient hemiparesis, visual symptoms, photophobia, phonophobia, and nausea, strikingly similar to side-locked migraine.

## Nonpharmacologic Treatment <sup>42</sup>

- Based on attack patterns, patients avoid daytime naps.
- Avoid alcoholic beverages and other triggers.
- Altitude hypoxemia may trigger an attack during active periods, but may be pharmacologically prevented.
- Abortive (first line)
  - Rapid symptomatic relief with oxygen inhalation - Useful diagnostic test. In resistant cases try higher flow rates (15 L/min).
  - Subcutaneous sumatriptan if medically fit.
- Transitional and prophylactic
  - Rapid transitional prophylaxis may be attained with corticosteroids
  - Long-term prophylaxis with verapamil in both episodic and chronic CH.
    - ✓ Topiramate or lithium carbonate as second-line therapy.
- Surgical, for carefully selected recalcitrant cases.

## Prophylactic Treatment of Episodic Cluster Headache <sup>42</sup>

Agent	Target Dose	Comments	Side Effects
Verapamil	160-480 mg/d (PO)	First-line treatment. Perform baseline and 6 monthly ECGs.	Hypotension, bradycardia, heart block, dizziness, and fatigue
Prednisone	80 mg (PO) Typical schedule: 80 mg first 2 d. Reduce by 20 mg every 2 d. Reduce to 10 mg/d for last 2 d	Good for initial and transitional therapy until, eg, verapamil takes effect. Prolonged use not recommended because of side effects. Taper over 10-21 d.	Increased appetite, nervousness, hyperglycemia, insomnia, headaches
Topiramate	25-200 mg/d (PO)	Increase by 25 mg/d every 5 d.	Cognitive effects, paresthesias, dizziness
Valproic acid	600-2000 mg/d (PO)	Efficacious in patients with pronounced migrainous features. Monitor liver function.	Nausea, dizziness, dyspepsia, thrombocytopenia
Gabapentin	900 mg/d (PO)	Few studies but promising results.	Drowsiness
Melatonin	9-10 mg/d nocte (PO)	Few studies.	None

## Abortive Pharmacologic Treatment Options for Episodic Cluster Headache <sup>42</sup>

Agent	Dose	Comments	Side Effects
Oxygen (inhaled via face mask)	5–10 L/min 15 min 15 L/min may be tried	First line but cumbersome. Hyperbaric oxygen also efficacious but impractical.	None
Sumatriptan	6–12 mg SC  20 mg IN	First line, fast, and efficacious; 12 mg as effective as 6 mg but with more side effects. Marginally less effective in chronic CH. Less effective but easier to use.	Contraindicated in CV disease. Fatigue Nausea/vomiting Chest symptoms Skin reactions over puncture wound. Contraindicated in CV disease. IN<SC
Zolmitriptan	5–10 mg IN	Limited efficacy, alternative to IN sumatriptan.	Contraindicated in CV disease. Better in episodic CH.
Dihydroergotamine	0.5–1.0 mg IN (bilateral)	Reduces severity but not frequency. Risk of rebound.	Contraindicated in CV disease. Do not use with a triptan.
Lignocaine	1 mL of 4%–10% solution applied IN on cotton pledget bilaterally	Pain is decreased but not enough studies. Needs to be inserted deep near pterygopalatine foramen.	Bitter taste

## Treatment of Chronic Cluster Headache <sup>42</sup>

Agent	Target Dose	Comments	Side Effects
Verapamil	360–480 mg/d (PO)	First-line treatment. Perform baseline ECG.	Hypotension, bradycardia, heart block, dizziness, and fatigue
Lithium carbonate	300–900 mg (PO)	Requires monitoring of renal and thyroid function, and of serum concentrations (best at 0.4–0.8 mEq/L).	Weakness, nausea, tremor, slurred speech, blurred vision <i>Side effects &gt; verapamil.</i>

## Paroxysmal Hemicrania (PH)

PH is rare, with an estimated prevalence of 2 to 20 per 100,000. Mean age of onset is usually 34 to 41 years. The episodic form is considered to have an earlier mean age of onset (27 years) than the chronic form (37 years). Only 20% of PHs behave episodically, and many of these eventually develop into a chronic form. The IHS requires at least 20 attacks that meet the criteria outlined below <sup>42</sup>:

- Unilateral, severe orbital, or periorbital pain.
  - Rarely may become bilateral.<sup>127</sup>
  - Also temporal, periauricular, maxillary, and, rarely, occipital areas.<sup>125,128</sup>
  - Referral to the shoulder, neck, and arm is quite common.<sup>128</sup>
  - Strong pain may cross the midline.
  - The vast majority of attacks do not change sides.<sup>125</sup>
- Last 2 to 30 minutes.
  - More usually 13 to 29 minutes, but may last nearly an hour.
  - Pain onset is rapid and mostly peaks in less than 5 minutes.<sup>125</sup>
- Sharp and excruciating.<sup>125</sup>
  - Also throbbing, stabbing, sharp, or boring.<sup>125,129</sup>
- Accompanied by at least 1 of the following ipsilateral autonomic signs:
  - Conjunctival injection/lacrimation
  - Nasal congestion/rhinorrhea
  - Eyelid edema
  - Forehead/facial sweating
  - Miosis and ptosis
- More than 5 attacks daily.
  - Usually 8 to 30 attacks per 24 hours.<sup>124</sup>
  - Seasonal pattern of attacks in PH patients has been described.<sup>130</sup>
  - The temporal similarity to CH behavior has led to the term “modified cluster pattern.”<sup>128</sup>
  - 30% report REM-related<sup>131</sup> nocturnal attacks that wake.<sup>124</sup>
- Absolute response to indomethacin.

## Additional Features 42

AS may occur bilaterally but are more pronounced on the symptomatic side. The most commonly seen are ipsilateral lacrimation, nasal congestion, conjunctival injection, and rhinorrhoea.

Secondary paroxysmal hemicrania 42:

- Malignancy, central nervous system disease, and benign tumours.
- Parotid gland epidermoid carcinoma with cerebral metastasis.
- Systemic diseases.
- All PH cases require imaging

## 7.5 Short-Lasting Unilateral Neuralgiform Headache Attacks With Conjunctival Injection And Tearing (SUNCT) / Short-Lasting Unilateral Neuralgiform Headache Attacks With Cranial Autonomic Symptoms (SUNA)

SUNCT syndrome is a unilateral headache/facial pain characterized by brief paroxysmal attacks accompanied by ipsilateral local AS, usually conjunctival injection and lacrimation. The similarities of this syndrome to trigeminal neuralgia (TN) are marked, particularly the triggering mechanism and many believe SUNCT to be a TN variant.<sup>42</sup>

Estimates suggest SUNCT/ SUNA to be as common as PH. SUNCT is presently considered only slightly more common in men, with a mean

onset at approximately 50 years. SUNCT occurring in siblings has recently been presented as “familial SUNCT.” The IHS requires at least 20 attacks that meet the criteria outlined below <sup>42</sup>:

- Unilateral, ocular/periocular pain, but may involve most head areas.
- Pain spreading across the midline or changing sides is rare.
- Moderate to severe pain; less severe than TN.
- Pain accompanied by ipsilateral conjunctival injection and lacrimation.
  
- Usually stabbing or pulsating. Sometimes electric or burning.
- Lasts from 5 to 240 seconds (mean 1 minute).
  - Longer attacks of up to 10 minutes and even 2 to 3 hours reported.
  - “SUNCT status”; (rare) pain most of the day for 1 to 3 days.
  - Low-grade background pain/discomfort occurs.
- Three patterns of attacks described.
  - Classical single attacks.
  - Groups of a number of stabs/attacks.
  - “Saw-tooth” pattern with numerous stabs/attacks lasting minutes.
- Frequency is from 3 to 200 daily.
  - Inconsistent and irregular; average of 28 per day.
  - A bimodal distribution of attacks occurring in the morning and late afternoon
  - Fewer than 2% of attacks occur at night.
  - A “clusterlike” pattern reported with active and inactive periods.
  - A seasonal pattern has been reported in SUNA.

### **Additional Features**

Pain in SUNCT may be triggered by light mechanical stimuli in the areas innervated by the trigeminal nerve but with a short latency until pain onset. Extratrigeminal triggers, including neck movements, have also been shown to precipitate attacks. By definition, SUNCT is accompanied by marked ipsilateral conjunctival injection and lacrimation that appear rapidly with onset of pain. Nasal stuffiness and rhinorrhoea are common; sweating may accompany attacks but is rare and often subclinical. <sup>42</sup>

## 7.6 Suna

This is a relatively novel diagnostic entity included in the IHS classification's appendix. Essentially 2 criteria differentiate it from SUNCT: SUNA may be accompanied by any autonomic sign (eg, nasal congestion), and attack duration has been extended to up until 10 minutes.<sup>42</sup>

### Secondary SUNCT/SUNA 42

- Brainstem infarction.
- Cerebellopontine region: arteriovenous malformations, astrocytoma, or other tumours/cysts.
- Cavernous haemangioma of the brainstem.
- Cavernous sinus tumour, extraorbital cystic mass, vertebral artery dissection, and neurofibromatosis.
- Posttraumatic.
- All patients with SUNCT should be referred for imaging.

## 7.7 Hemicrania Continua (Hc)

Clinical features of HC<sup>42</sup>:

- Unilateral headache for more than 3 months.
  - Pain in the frontal and temporal regions and periorbitally.
  - Although very rare, pain can also change sides. Few bilateral cases.
- Daily and continuous pain.
- Severity is moderate.
  - Characterized (74%) by fluctuations in pain severity.
  - Exacerbations are totally disabling in about 40% of patients and result in severe pain lasting 30min to 10hrs, even upto 2-5 days.
  - During exacerbation, HC is almost indistinguishable from migraine.
  - Patients may report a sharp pain similar to that of “jabs and jolts.”
  - Some patients (18%) describe a distinct ocular sensation mimicking a foreign body (or sand), that may accompany or precede the headaches.
- Pain is throbbing (one-third of cases); may appear as pain intensity increases.

- Complete response to indomethacin.
- During exacerbations, following ipsilateral autonomic phenomena/signs:
  - Conjunctival injection/lacrimation
  - Nasal congestion/rhinorrhoea
  - Miosis and ptosis

### Additional Features

Two forms of HC have been described: remitting and continuous. The remitting form is characterized by headache that can last for some days followed by a pain-free period lasting from 2 to 15 days. One-third of remitting cases become continuous following a mean duration of 7.8 years. Nocturnal attacks were seen in up to half of patients. The most common signs present are photophobia, nausea, conjunctival injection, phonophobia, and tearing.<sup>42</sup>

### Secondary hemicrania continua<sup>42</sup>:

- Medication abuse.
- Mesenchymal tumour in the sphenoid bone has been reported.
- Head trauma and surgery.

### Treatment Options for the Trigeminal Autonomic Cephalalgias<sup>45</sup>:

Headache Type	Paroxysmal Hemicrania	SUNCT/SUNA	Hemicrania Continua
Nonpharmacologic treatment options	Explanation to patient as with CH	Explanation to patient as with CH  Avoidance of cutaneous triggers if present	Explanation to patient as with cluster headache
First-line treatment	Indomethacin (100%)	None because of short pain duration	Indomethacin (100%)
Abortive (% response)	25 mg/d titrating to 150 mg/d TID	Lamotrigine 25 mg BID to start and titrating in 25-mg increments every 7–14 d	25 mg/d titrating to 150 mg/d TID
Preventive	GON blocks	None	GON blocks
Alternative treatment	Topiramate Melatonin Alternative NSAID	Topiramate Gabapentinoids Zonisamide IV lidocaine Carbamazepine Oxcarbazepine	Topiramate Melatonin Alternative NSAID
Abortive			
Preventive			
Benefit from neuromodulation/type	Yes Hypothalamus GON unilateral SPG	Yes Hypothalamus GON bilateral SPG Vagal Surgical: microvascular decompression of trigeminal nerve root	Yes Hypothalamus GON unilateral SPG

# Chapter 8

## Musculoskeletal Pain

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Pains of muscle origin are the most frequent cause of discomfort in the head and neck area. Musculoskeletal pain emanates from the skeletal muscles, tendons, joint and fascia. Muscle pain is usually felt as a nonpulsatile, variable, dull aching sensation, constant background discomfort which may escalate to or be punctuated by sharper, more severe lancinating pains occurring both spontaneously and in response to stretching, contraction, manipulation, or manual palpation.<sup>9</sup>

### 8.1 Classification of Musculoskeletal Pain <sup>33</sup>

Temporomandibular disorders

- a. Masticatory muscle disorders
  - Myofascial pain
  - Myositis
  - Myospasm
  - Local myalgia
- b. Articular disc derangements
  - Disc displacement with reduction
  - Disc displacement without reduction
- c. Temporomandibular joint disorders
  - Synovitis/capsulitis
  - Osteoarthritis

### 8.2 Temporomandibular Disorders (Tmd)

TMD is a collective term that includes a number of clinical complaints involving the muscles of mastication, the temporomandibular joint (TMJ), or associated orofacial structures. TMD are a major cause of nondental pain in the orofacial region and are considered a subclassification of musculoskeletal disorders. In many TMD patients the most common complaint originates from the muscles of mastication rather

than from the TMJ. Therefore, the terms TMJ dysfunction or TMJ disorder are inappropriate for many complaints arising from the masticatory structures.<sup>24</sup>

Signs and symptoms associated with TMD are a common source of chronic pain complaints in the head and orofacial structures. The primary signs and symptoms associated with TMD originate from the masticatory structures and, therefore, are associated with jaw function. Patients often report pain in the preauricular areas, face, or temples. Reports of pain during mouth opening or chewing are common. TMJ sounds are also frequent complaints and maybe described as clicking, popping, grating, or crepitus. However, on occasion, joint sounds may be associated with locking of the jaw during opening or closing, or with pain.<sup>24</sup>

It is important to appreciate that pain associated with most TMD is increased with jaw function. Because this is a condition of the musculoskeletal structures, function of these structures generally increases the pain. When a patient's pain complaint is not influenced by jaw function, other sources of (orofacial) pain should be suspected.<sup>24</sup>

TMD can be subdivided into two broad categories related to their primary source of pain and dysfunction: masticatory muscle disorders and intracapsular (TMJ) disorders.<sup>24</sup>

### **8.3 Disorders of Masticatory Muscles**

Muscle disorders involving the masticatory muscles have been considered analogous to skeletal muscle disorders throughout the body. Mechanisms behind masticatory muscle pain include overuse of a normally perfused muscle or ischemia of a normally working muscle, sympathetic reflexes that produce changes in vascular supply and muscle tone, and changes in psychological and emotional states.<sup>34</sup>

Neurons mediating pain from skeletal muscle are subject to strong modulatory influences. Bradykinin, serotonin, substance P, prostaglandins, and neuropeptides sensitize nociceptors and can easily sensitize nociceptive endings. Painful conditions of muscle often result in increased sensitivity of peripheral nociceptors and hyperexcitability in the central nervous system with hyperalgesia.<sup>34</sup>

Muscle disorders can be divided into regional disorders, such as myalgia associated with temporomandibular joint (TMJ) disorder, and

systemic disorders, such as pain associated with fibromyalgia. The paucity of data on the etiology and pathophysiology of muscle pain limits the ability to clearly delineate all groups of muscle disorders. Frequently the clinician must rely on clinical judgment to establish a diagnosis.<sup>34</sup>

According to the American Academy of Orofacial Pain, masticatory muscle disorders can be divided into 4 subtypes: (1) myofascial pain (2) local myalgia (3) myositis (4) myospasm.<sup>33</sup>

### **Features of Myofascial Pain<sup>34</sup>**

- Regional dull, aching muscle pain
- Trigger points present and pain referral on palpation with/without autonomic symptoms
- Referred pain often felt as headache
- Trigger points can be inactivated with local anaesthetic injection
- Sensation of muscle stiffness and/or malocclusion not verified clinically
- Otologic symptoms including tinnitus, vertigo, and pain
- Headache or toothache
- Decreased range of motion
- Hyperalgesia in region of referred pain
- Differential diagnosis: arthralgia, myositis, local myalgia, neoplasia, fibromyalgia

### **Trigger Points**

Myofascial pain syndrome associated to trigger points (TrPs), is a noninflammatory disorder of musculoskeletal origin, associated with local pain and muscle stiffness, characterized by the presence of hyperirritable palpable nodules in the skeletal muscle fibres, which are termed TrPs (trigger points).<sup>35</sup>

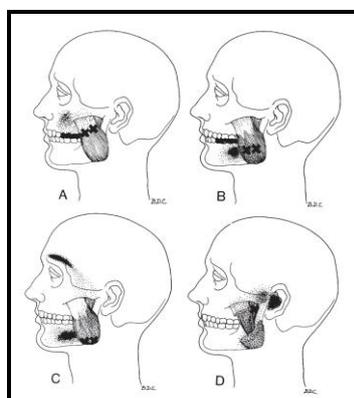
TrPs produce pain to any activating stimulus (direct or indirect trauma) and can provoke referred pain, referred tenderness, motor dysfunction, autonomic phenomena and hyperexcitability of the central nervous system.<sup>35</sup>

### Factors which Increase or Decrease Painful Symptoms of Trigger Points<sup>35</sup>

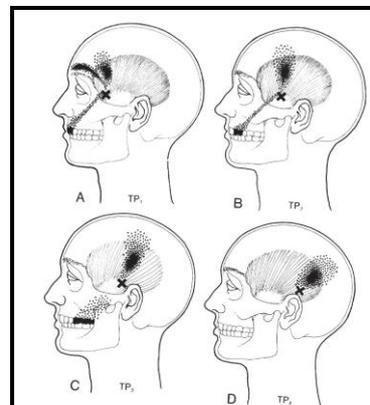
Aggravating Factors	Moderating Factors
Overuse of musculature	Rest
Active stretching	Passive stretching
Pressure on trigger point	Specific myofascial therapy
Prolonged muscle contraction	Non- isometric contraction activity
Cold, damp, viral infection, tension	Local warming of trigger

### Differences and Similarities Between Trigger and Tender Points<sup>36</sup>

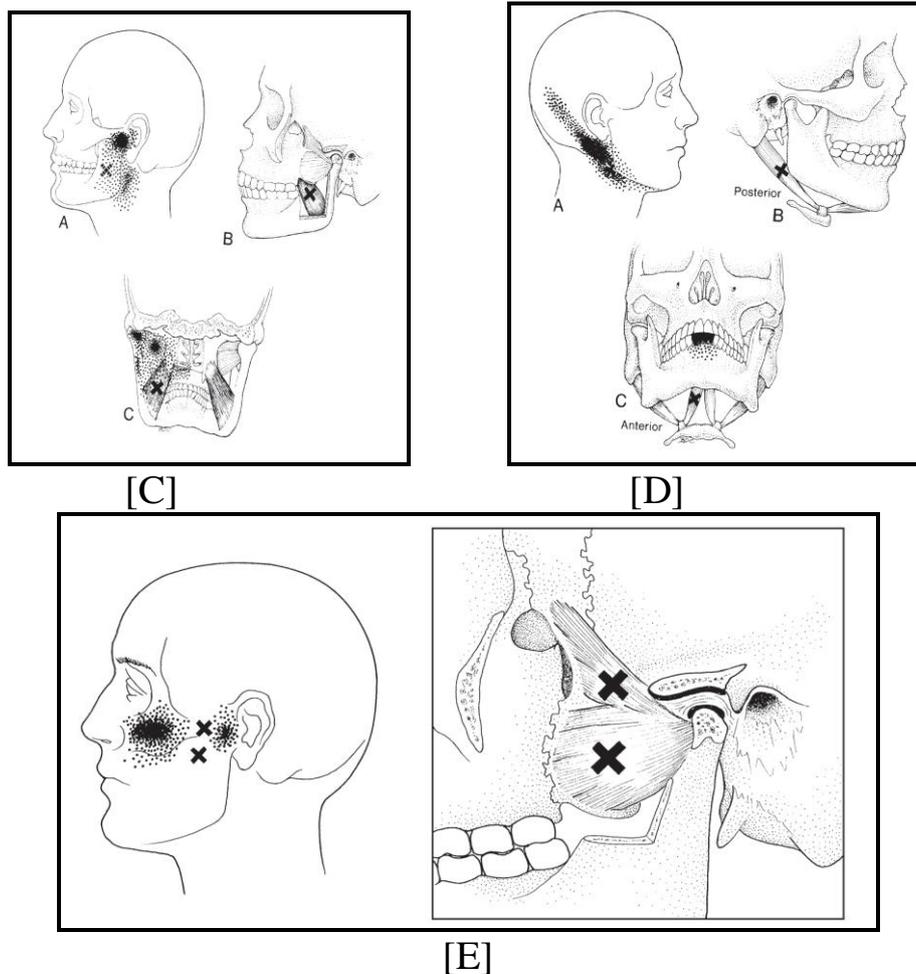
	TRIGGER POINTS	TENDER POINTS
Gender distribution	1:1	4-9 females:1 male
Physical characteristics	Muscular, tense bands, referred pain, reproducible pain, irritability	Tender areas in muscles, tendons, ligaments, joint capsules
Distribution	Focal-asymmetrical. Located in any muscle	Generalized-symmetrical. Concrete locations
Pain pattern	Regional pain Focal tenderness	Generalized pain Generalized tenderness
Skin fold sensitivity	Not known	Often present
Mobility	Restricted movement range	Hypermobility
Histology	No specific changes in biopsy	No specific changes in biopsy
Palpation	Rigid muscle palpation (palpable nodules)	Soft and flaccid muscle palpation
Algometry	Threshold 2 kg/cm <sup>2</sup> over adjacent normal zones	4 kg pressure
Reliability index	Good in pain in response to palpation and with algometry; poor in rest	Good in relation to pain or algometry
MRI findings	No data	No morphological changes
Electromyography	Spontaneous activity at trigger points 1 or 2 mm	No denervation No muscle spasm
Allodynia / hyperalgesia	Only present at trigger points	At tender points and other control sites
Treatment with local injection	Immediate response to injections	Poor response to injections
Comorbidity	20% have fibromyalgia	72% have active trigger points



[A]



[B]



**Fig. 31 Trigger Points (×) Located in Various Parts of the Muscles [A] Masseter [B] Temporalis [C] Medial Pterygoid [D] Digastric [E] Lateral Pterygoid. Solid Black: Reference Pain Zones; Stippled Areas: Spill Over Pain Zones.<sup>9</sup>**

### Features of Local Myalgia<sup>34</sup>

- Sore muscles of mastication with pain in cheeks and temples on chewing, wide opening, and often on waking (eg, nocturnal bruxism)
- Bilateral in nature
- Described as stiff, sore, aching, spasm, tightness, or cramping
- Sensation of muscle stiffness, weakness, fatigue
- Possible reduced mandibular range of motion
- Differential diagnosis: myositis, myofascial pain, neoplasm, fibromyalgia

### **Features of Centrally Mediated Myalgia<sup>34</sup>**

- Trigger points and pain referral on palpation
- Sensation of muscle stiffness, weakness, and/or fatigue
- Sensation of malocclusion not verified clinically
- Otologic symptoms including tinnitus, vertigo, and pain
- Decreased range of motion
- Hyperalgesia
- No response to treatment directed at painful muscle tissue
- Differential diagnosis: arthralgia, myositis, myofascial pain, local myalgia, neoplasm, fibromyalgia

### **Features of Myospasm<sup>34</sup>**

- Sudden and involuntary muscle contraction
- Acute malocclusion (dependent on muscles involved)
- Decreased range of motion and pain on function and at rest
- Relatively rare disorder in orofacial pain population
- Differential diagnosis: myositis, local myalgia, neoplasm

### **Features of Myositis<sup>34</sup>**

- History of trauma to muscle or source of infection
- Often continuous pain affecting entire affected muscle
- Pain aggravated by function
- Severe limited range of motion

### **Features of Myofibrotic Contracture<sup>34</sup>**

- Not usually painful
- Often follows long period of limited range of motion or disuse (eg, intermaxillary fixation)
- History of infection or trauma is common
- Differential diagnosis: TMJ ankylosis, coronoid hypertrophy

### **Features of Masticatory Muscle Neoplasia<sup>34</sup>**

- Pain may or may not be present
- Anatomic and structural changes: tumours may be in muscles or spaces
- Swelling, trismus, paraesthesia, and pain referred to teeth
- Positive findings on imaging or biopsy

## Diagnostic Criteria for Masticatory Muscle Disorders<sup>34</sup>

Disorder	Etiology	Diagnostic Criteria
Centrally mediated chronic muscle pain	Chronic generalized muscle pain associated with a comorbid disease	History of prolonged and continuous muscle pain Regional dull, aching pain at rest Pain aggravated by function of affected muscles Pain aggravated by palpation
Myalgia (local)	Acute muscle pain Protective muscle splinting Postexercise soreness Muscle fatigue Pain from ischemia	Regional dull, aching pain during function No or minimal pain at rest Local muscle tenderness on palpation Absence of trigger points and pain referral
Myofascial pain	Chronic regional muscle pain	Regional dull, aching pain at rest Pain aggravated by function of affected muscles Provocation of trigger points alters pain complaint and reveals referral pattern >50% reduction of pain with vapocoolant spray or local anesthetic injection to trigger point followed by stretch
Myofibrotic contracture	Painless shortening of muscles	Limited range of motion Firmness on passive stretch (hard stop) Little or no pain unless involved muscle is forced to lengthen
Myositis	Inflammation secondary to direct trauma or infection	Continuous pain localized in muscle area following injury or infection Diffuse tenderness over entire muscle Pain aggravated by function of affected muscles Moderate to severe decreased range of motion due to pain and swelling
Neoplasia	Benign or malignant	May or may not be painful Anatomic and structural changes Imaging and biopsy needed
Myospasm	Acute involuntary and continuous muscle contraction	Acute onset of pain at rest and during function Markedly decreased range of motion due to continuous involuntary muscle contraction Pain aggravated by function of affected muscles Increased electromyographic activity higher than at rest Sensation of muscle tightness, cramping, or stiffness

## Etiology of Myogenous Pain<sup>34</sup>

Etiology	Criteria
Focal myalgia from direct trauma	History of trauma preceding pain onset Subjective pain in muscles with function Pain reproduced on palpation
Primary myalgia due to parafunction	No history of trauma Subjective pain in muscle with function Pain reproduced on palpation No trigger points
Secondary myalgia due to active local pathology or recent medications	History of recent joint, oral soft tissue, or pulpal disease or medication (eg, serotonin-selective reuptake inhibitors) that coincides with muscle pain Subjective pain in muscle with function Pain reproduced on palpation
Myofascial pain	No history of recent trauma Subjective pain in muscles with function Pain reproduced on palpation Trigger points and pain referral
Diffuse chronic muscle pain and fibromyalgia	Subjective pain in multiple sites aggravated by function Widespread pain involving more than 3 body quadrants >3 mo duration Strong pain on palpation in 11 of 18 body sites

### History of the Present Illness: Pain Characteristics<sup>34</sup>

Quality	Common patient descriptors: dull, sharp, tight, aching, tired, etc
Location	Unilateral vs bilateral Pain confined to a single muscle or referred to a distant area
Intensity	On a scale of 1–10 Mild, moderate, or severe
Onset, duration, pattern	How long has the pain been present? What if anything caused the pain? (eg, trauma) What has been the course of pain since its onset? (eg, episodic, constant, fluctuating)
Modifiers	What exacerbates or diminishes the pain? Does anything you do or use help or worsen pain?
Chronicity	How long has the pain been present?
Comorbid symptoms and signs	Are there any other conditions or symptoms associated with pain? (eg, depression, acute anxiety, nausea/vomiting, tearing, visual changes, dizziness, numbness/tingling, weakness, generalized pain)

### Differential Diagnosis of Temporomandibular Disorder<sup>23</sup>

Condition	Signs and Symptoms
Myofascial pain and local myalgia	<ul style="list-style-type: none"> <li>• Regional pain of masticatory muscles or muscles of the head and neck on palpation</li> <li>• Fatigue or tightness present</li> <li>• Pain is usually dull, throbbing, and/or aching</li> <li>• Aggravated by function and/or overuse</li> <li>• Possible presence of trigger points or tight bands of muscle</li> <li>• Myospasm of muscles of mastication can cause decreased opening</li> <li>• If chronic, can be more diffuse and centrally mediated</li> </ul>
Disc displacement with reduction	<ul style="list-style-type: none"> <li>• Clicking or popping of the affected side</li> <li>• Not necessarily painful</li> <li>• If unilateral, deviation to the affected side on opening</li> <li>• Usually no limitation of maximal opening</li> </ul>
Disc displacement without reduction	<ul style="list-style-type: none"> <li>• Functional impairment caused by limited opening/locking</li> <li>• If unilateral, deflection to affected side on opening</li> <li>• Clear displacement of the disc on imaging studies</li> <li>• Limitation of maximal opening</li> </ul>
Temporomandibular joint dislocation	<ul style="list-style-type: none"> <li>• Open lock</li> <li>• Condyle positioned anterior to the articular eminence</li> <li>• May require clinician manipulation for reduction</li> </ul>
Osteoarthritis/degenerative joint disease	<ul style="list-style-type: none"> <li>• Pain on palpation of the joint and during function</li> <li>• Adaptive changes (eg, condylar flattening, osteophytic changes) seen on imaging studies</li> <li>• If unilateral, deviation to affected side on opening</li> <li>• Possible limitation in opening</li> <li>• Crepitus present</li> <li>• Can be secondary to another disease or trauma</li> </ul>
Capsulitis/synovitis/retrodiscitis	<ul style="list-style-type: none"> <li>• Localized pain of the affected joint that is exacerbated by function</li> <li>• Can cause difficulty occluding on the posterior teeth of the affected side</li> <li>• Limited (if any) osteoarthritic changes noted on imaging studies</li> </ul>

## Initial Treatment of Masticatory Muscle Disorders<sup>34</sup>

Treatment Component	Description
Education	Explanation of the diagnosis and treatment Reassurance about the generally good prognosis for recovery and natural course Explanation of patient's and doctor's roles in therapy Information to enable patient to perform self-care
Self-care	Eliminate oral habits (eg, tooth clenching, chewing gum) Provide information on jaw care associated with daily activities
Physical therapy	Education regarding biomechanics of jaw, neck, and head posture Passive modalities (heat and cold therapy, ultrasound, laser, TENS) Range of motion exercises (active and passive) Posture therapy Passive stretching, general exercise and conditioning program
Intraoral appliance therapy	Cover all the teeth on the arch the appliance is seated on Adjust to achieve simultaneous contact against opposing teeth Adjust to a stable comfortable mandibular posture Avoid changing mandibular position Avoid long-term continuous use
Pharmacotherapy	NSAIDs, acetaminophen, muscle relaxants, antianxiety agents, tricyclic antidepressants
Behavioral/relaxation techniques	Relaxation therapy Hypnosis Biofeedback Cognitive-behavioral therapy

**Aggarwal VR et al (2011)** reviewed psychosocial interventions for the management of chronic orofacial pain. Studies indicated that psychological factors are associated with chronic pain in the face, mouth or jaws. However, current management, particularly in dentistry, does not target these factors. This review therefore explored whether behavioural interventions like cognitive behavioural therapy (CBT), biofeedback and posture regulation compared with usual care could improve outcomes for patients with chronic orofacial pain. they found that such interventions improved long-term pain intensity, pain interference with daily life activities and depression. However, they recommend that further high-quality trials are needed to support the use of such interventions for chronic orofacial pain.<sup>37</sup>

## Patient's instructions for self-care<sup>34</sup>

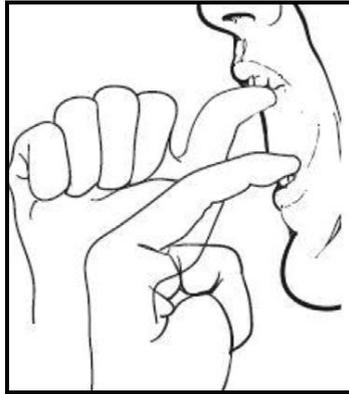
- Be aware of habits or patterns of jaw use.
  - Avoid tooth contact except during chewing and swallowing.
  - Notice any contact the teeth make.
  - Notice any clenching, grinding, gritting, or tapping of teeth, or any tensing or rigid holding of the jaw muscles.
  - Check for tooth clenching while driving, studying, doing computer work, reading, or engaging in athletic activities; when at work or in social situations; and when experiencing overwork, fatigue, or stress.
  - Position the jaw to avoid tooth contacts.
  - Place the tip of the tongue behind the top teeth and keep the teeth slightly apart; maintain this position when the jaw is not being used for functions such as speaking and chewing.
- Modify your diet.
  - Choose softer foods and only those foods that can be chewed without pain.
  - Cut foods into smaller pieces; avoid foods that require wide mouth opening and biting off with the front teeth, or foods that are chewy and sticky and that require excessive mouth movements.
  - Do not chew gum.
- Do not test the jaw.
- Do not open the mouth wide or move the jaw around excessively to assess pain or motion.
- Avoid habitually maneuvering the jaw into positions to assess its comfort or range.
- Avoid habitually clicking the jaw if a click is present.
- Avoid certain postures.
  - Do not lean on or cup the chin when performing desk work or at the dining table.
  - Do not sleep on the stomach or in postures that place stress on the jaw.
- Avoid elective dental treatment while symptoms of pain and limited opening are present.
- During yawning, support the jaw by providing mild pressure underneath the chin with the thumb and index finger or with the back of the hand.
- Apply moist hot compresses to the sides of the face and to the temple areas for 10 to 20 minutes twice daily.

## Patient's Exercise Instructions<sup>34</sup>

Certain exercises can help you relieve the pain that comes from tired, cramped muscles. They can also help if you have difficulty opening your mouth. The exercises described work by helping you relax tense muscles and are referred to as "passive stretching." The more often you do these exercises, the more you'll relax the muscles that are painfully tense.

*Do these exercises 2 times daily:*

1. Ice down both sides of the face for 5 to 10 minutes before beginning (ice cubes in sandwich bags or packs of frozen vegetables work well for this).
2. Place thumb of one hand on the edge of the upper front teeth and the index and middle fingers of the other hand on the edge of the lower front teeth, with the thumb under the chin.
3. The starting position for the stretches is with the thumb of the one hand and index finger of the other hand just touching.
4. Gently pull open the lower jaw, using the hand only, until you feel a passive stretch, not pain, hold for 10 seconds, then allow the lower jaw to close until the thumb and index finger are once again contacting; it is crucial that when doing these exercises not to use the jaw muscles to open and close, but rather manual manipulation only (the fingers do all the work!).
5. Repeat the above stretching action 10 times, performing 2 to 3 sets per day, 1 in the morning and 1 or 2 in the evening.
6. When finished with the exercises, one can place moist heat to both sides of the face for 5 to 10 minutes (heating a wet washcloth in the microwave for about 1 minute works well for this).



**Fig. 32 Demonstration of a Passive Stretch Using the Fingers.**<sup>34</sup>

### **Splint Therapy**<sup>34</sup>

- The appliance most commonly used is described as a stabilization appliance or muscle relaxation splint
- Designed to cover a full arch and adjusted to avoid altering jaw position or placing orthodontic forces on the teeth
  - Should be adjusted to provide bilateral, even contact with the opposing teeth on closure and in a comfortable mandibular posture
  - Should be reexamined periodically and readjusted as necessary to accommodate changes in mandibular posture or muscle function that may affect the opposing tooth contacts on the appliance
- At the beginning of appliance therapy, a combination of appliance use during sleep and for periods during waking hours is appropriate
  - Factors such as tooth clenching when driving or exercising, or pain symptoms that tend to increase as the day progresses, may be better managed by increasing splint use during these times
- To avoid the possibility of occlusal change, no appliance should not be worn continuously (ie, 24 hours per day) over prolonged periods
- Full-coverage appliance therapy during sleep is a common practice to reduce the effects of bruxism and is not usually associated with occlusal change



**Fig. 33 Occlusal Splint Therapy.**<sup>9</sup>

**Öz S et al (2010)** compared the effects of low-level laser with occlusal splints in patients with signs and symptoms of myofascial pain (MP) dysfunction syndrome. Low-level laser was applied to patients in the study

group 2 times per week, for a total of 10 sessions. Patients in the control group were instructed to wear occlusal splints 24 h/d for 3 months. Pressure pain threshold values were obtained with the aid of an algometer in both groups. Patients' self-report of pain was evaluated with visual analogue scale.

Vertical movements showed statistically significant improvements after the treatments in both groups (P < 0.01). In both groups, tenderness to palpation of the muscles decreased significantly. Pressure pain threshold evaluations and visual analogue scale scores revealed similar results, too. This particular type of low-level laser therapy (820 nm, 3 J/cm<sup>2</sup>, 300-mW output power) is as effective as occlusal splint in pain release and mandibular movement improvement in MP.<sup>38</sup>

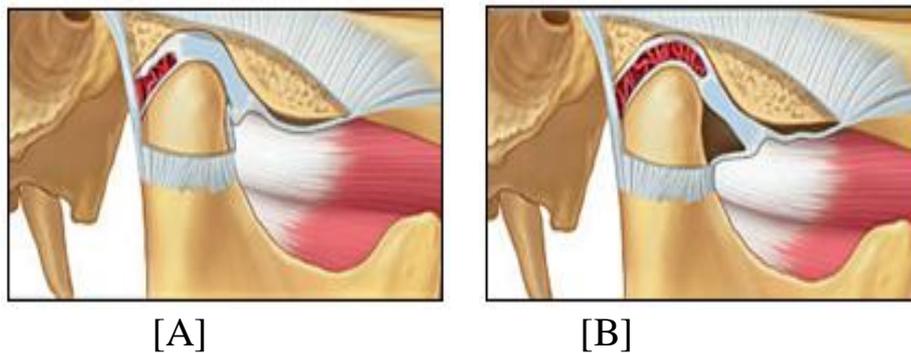
**Goddard G (2005)** studied short term pain reduction with acupuncture treatment for chronic orofacial pain patients. A chart review of 29 patients age 22 to 60, who had acupuncture treatment for chronic orofacial pain was completed. Patients had rated their pain before and after acupuncture treatment on a numerical analogue scale. Results showed that the mean value of pain scores before treatment was 5.28 and after treatment was 2.26. There was a significant difference of pain scores between before treatment and after treatment (Wilcoxon signed rank test, P < 0.0001). Study concluded that acupuncture provided a significant short-term pain reduction in patients with chronic orofacial pain.<sup>39</sup>

### Medications Used for Fibromyalgia Beneficial for Masticatory Muscle Pain<sup>34</sup>

Medication Class	Effect
Tricyclic antidepressants (TCAs)	Moderately helpful for pain More side effects (xerostomia, fatigue)
Serotonin-selective reuptake inhibitors	Fewer side effects than TCAs More effective for anxiety/depression than for pain
Muscle relaxants	Moderately helpful for local muscle pain More side effects (xerostomia, sedation)
Serotonin-norepinephrine reuptake inhibitors	Moderately helpful for fibromyalgia-related pain
Low-potency opioids	Moderately helpful for fibromyalgia-related pain
NSAIDs	Helpful for acute inflammatory pain but not chronic muscle pain or fibromyalgia-related pain

## Articular Disc Derangements

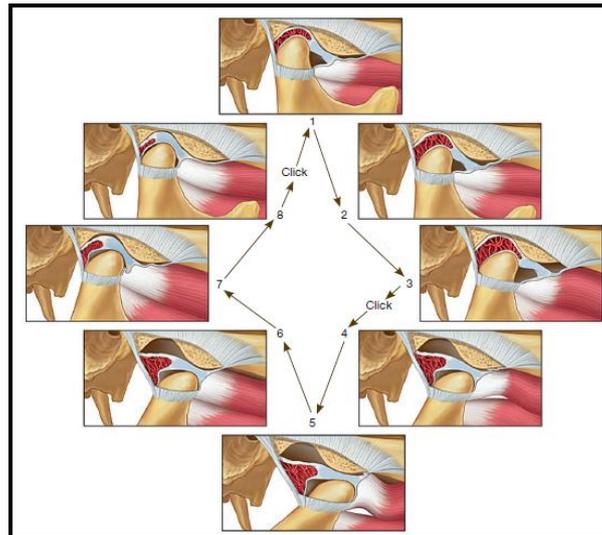
Articular disc derangements are usually characterized by displacement of the articular disc anteriorly and medially. Alterations in the disc-condyle structural relation may result from elongation of the discal ligaments, secondary to trauma. High levels of anxiety and clenching and grinding of the teeth have also been implicated as risk factors.<sup>33</sup>



**Fig. 34 [A] Normal Condyle-Disc Relationship. [B] Disc Displacement.<sup>9</sup>**

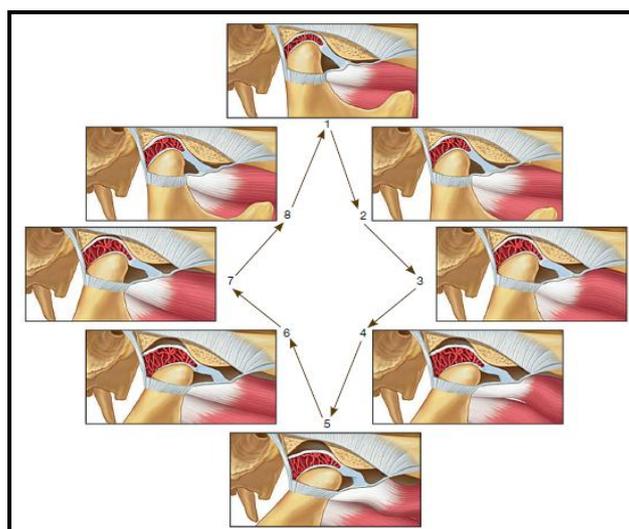
### Disc Displacement With Reduction<sup>33</sup>

- It is characterized by improvement of the position of the displaced disc during opening.
- An opening joint clicking occurs as the condyle positions itself under the posterior band of the disc upon mouth opening, and a closing joint clicking can be heard as the condyle slips off the disc, just before the teeth come together.
- The patient may complain of episodic and momentary catching of the jaw movement during mouth opening. Pain may or may not be present.
- Asymptomatic clicking is a very common sign among the general population and does not require treatment; however, patients should be counselled as to the nature of the clicking.



**Fig. 35 The Movement of the Condyle With a Disc Displacement. Note the Clicking Between 3 and 4, and Again Between 8 And 1.<sup>9</sup>**  
**Disc Displacement Without Reduction<sup>33</sup>:**

- It refers to an altered disc-condyle structural relation that is not improved during mouth opening.
- Frequently, there is a history of clicking and sudden onset of hypomobility. The displaced disc blocks the condylar movement, resulting in limited (25 to 30 mm) mouth opening and restricted lateral excursion to the contralateral side.
- The mandible deflects to the affected side on opening and clicking noises are absent. Pain is typically present in the acute condition, while chronic disc dislocation may be nonpainful.



**Fig. 36 The Movement of the Condyle with a Disc Displacement without Reduction. Note the Disc is Constantly Maintained in the Dislocated Position (A Closed Lock).<sup>9</sup>**

## Wilkes' Staging for Internal Derangement of the TMJ<sup>40</sup>

<p>I. Early stage</p> <ul style="list-style-type: none"><li>A. Clinical presentation: no pain or decreased range of motion, possible clicking</li><li>B. Radiographic presentation: disk anteriorly positioned, normal bony contours</li><li>C. Anatomic correlation: anterior displacement, normal anatomic form of bone, and disk</li></ul> <p>II. Early/intermediate stage</p> <ul style="list-style-type: none"><li>A. Clinical presentation: episodes of pain, opening clicks, intermittent locking</li><li>B. Radiographic presentation: anterior disk displacement, thickened posterior disk, bony contours normal</li><li>C. Anatomic correlation: early disk deformity, anterior displacement, normal bony contours</li></ul> <p>III. Intermediate stage</p> <ul style="list-style-type: none"><li>A. Clinical presentation: many painful episodes, intermittent closed locking, multiple functional symptoms, decreased range of motion</li><li>B. Radiographic presentation: anterior disk displacement with disk deformity</li><li>C. Anatomic correlation: marked disk displacement and deformity, normal bony contours</li></ul> <p>IV. Intermediate/late stage</p> <ul style="list-style-type: none"><li>A. Clinical presentation: increased pain relative to earlier stages</li><li>B. Radiographic presentation: bony changes, such as flattened eminence, condylar deformity, osteosclerotic changes</li><li>C. Anatomic correlation: adhesions of disk, bony changes, evidence of osteoarthritis, osteophytes, no disk perforations</li></ul> <p>V. Late stage</p> <ul style="list-style-type: none"><li>A. Clinical presentation: episodic or continuous pain, crepitus, limited range of motion at all times, constant functional difficulties</li><li>B. Radiographic presentation: disk perforations, gross deformities of bony structures and cartilage, progressive arthritic changes</li><li>C. Anatomic correlation: gross hard and soft tissue changes, perforations, adhesions, subcortical cysts</li></ul>
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Magnetic resonance imaging can be used to substantiate the clinical diagnosis and rule out other pathological conditions of the TMJ that would result in blockage of condylar movement.

In acute disc dislocation, there should be an effort to reduce the disc dislocation by manual manipulation, followed by insertion of an anterior repositioning appliance. Management of chronic disc dislocation may include a stabilization appliance, physical therapy, and NSAIDs if pain is present. Surgical arthrocentesis or arthroscopy may be beneficial for patients who are refractory to conservative treatment.<sup>33</sup>



**Fig. 37 Manual Distraction of the TMJ may be Helpful in Improving Joint Mobility<sup>9</sup>**



**Fig. 38 An Anterior Positioning Appliance. When the Mouth is Closed, the Anterior Teeth Contact on the Guiding Ramp, and the Mandible is Brought Forward (Arrow) to the Therapeutic Position that Keeps the Disc in A More Normal Relationship with the Condyle.<sup>9</sup>**

## **8.4 Temporomandibular Joint Disorders**

### **Synovitis and Capsulitis:**

Synovitis and capsulitis are characterized by inflammation of the synovial lining of the TMJ and the capsular ligament respectively. Synovitis and capsulitis are characterized by constant deep pain in the TMJ, tenderness to TMJ palpation, and restricted mouth opening secondary to pain; acute malocclusion of the posterior teeth on the affected side may also be present.<sup>33</sup>

It can be induced by trauma to the jaw or repetitive chronic microtrauma. In acute trauma, ice should be applied to the affected joint 4 to 6 times daily for the first 24 to 36 hours, followed by moist heat applications for 10 to 15 minutes, 3 to 4 times per day. Restriction of jaw movement to a pain free range of motion and administration of NSAIDs on a regular basis for 10 to 14 days are recommended. A stabilization appliance can be of benefit, especially if parafunctional habits are present.<sup>33</sup>

### **Osteoarthritis**

Osteoarthritis is a noninflammatory arthritic condition characterized by deterioration of the articular surfaces. It presents with pain exacerbated by mandibular movement, tenderness upon joint palpation, crepitus, and limited mandibular motion. The clinical diagnosis is substantiated by

radiographic and MRI evidence of structural bony changes, like surface irregularities, flattening or erosion of the condyle, osteophytes.<sup>33</sup>

Conservative approaches including NSAIDs, moist heat applications, painless use of mandible, jaw exercises and stabilization appliance constitute the mainstay of treatment. For refractory cases, one or two single injections of corticosteroids in the joint, arthrocentesis, or arthroscopic surgery may be recommended.<sup>33</sup>

### Major Types of Occlusal Splints Used in TMD Therapy 40

Splint Type	Design
Stabilization splint	Hard acrylic with full coverage of maxillary and mandibular dentition in centric occlusion
Repositioning splint	Hard acrylic with full coverage of maxillary or mandibular dentition with inclines to guide mandible to a more anterior position
Soft splint	Similar to hard stabilization splints but made from a more inexpensive pliable material

### Types of Medication Used in TMD Treatment<sup>40</sup>

Class	Examples	Function
NSAIDs	Ibuprofen, naproxen, diclofenac, aspirin, etodolac	Reduce inflammation and pain
Opioids	Codeine, oxycodone, morphine, hydromorphone, meperidine	Reduce pain
Corticosteroids	Prednisone, dexamethasone, hydrocortisone	Reduce inflammation and pain
Muscle relaxants	Cyclobenzaprine, carisoprodol, baclofen	Reduce muscle spasm
Antidepressants	Amitriptyline, trazodone, fluoxetine, sertraline	Reduce muscle tension
Anxiolytics	Alprazolam, lorazepam, oxazepam, diazepam, buspirone	Reduce tension and muscle spasm

### Types of Intra-Articular Injections Used in Treatment of TMJ and Articular Disk Disorders<sup>40</sup>

	Hyaluronic Acid	Corticosteroids
Benefits	A natural component of TMJ synovial fluid and lubricates and maintains the normal internal environment of the joints <sup>32</sup>	Reduction of inflammatory factors and reducing the activity of the immune system
Adverse effects	Mild pain and swelling at injection site, mostly transient <sup>33</sup>	Infection and destruction of articular cartilage; avoid long-term repeat injections <sup>34</sup>
Efficacy	Improved long-term clinical signs of TMD and overall improvement of symptoms in comparison with placebo; no difference in radiological progression of disease <sup>32</sup>	Same short-term and long-term improvements in symptoms, clinical signs, and overall condition compared with hyaluronic acid <sup>32</sup>



**Fig. 39 Temporomandibular Joint Injection<sup>41</sup>**

### Treatment Modalities for Articular Disk and TMJ Osteoarthritis<sup>40</sup>

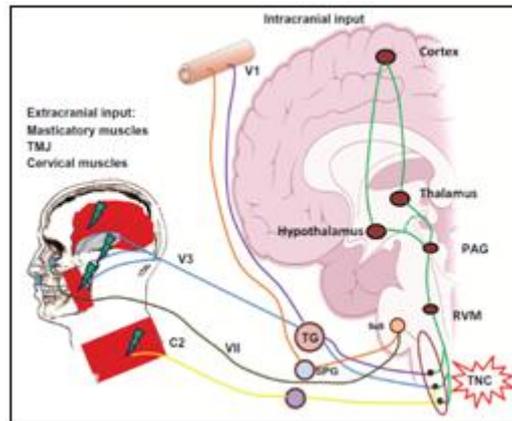
Modality	Description
Exercise therapy	Techniques include manual therapy, postural exercises, muscle stretching, and strengthening exercises. <sup>28</sup> Passive and active stretching of muscles or range-of-motion exercise are performed to increase oral opening and decrease pain. <sup>28</sup>
Thermal therapy	It involves the superficial application of a dry or moist heat/cold pad directly to the affected area typically in 20-min intervals. It is used in conjunction with exercise therapy in the treatment of inflammation and TMJ hypomobility.
Acupuncture	It is thought to stimulate the production of endorphins, serotonin, and acetylcholine within the central nervous system, or it may relieve pain by acting as a noxious stimulus. Treatments involve placement of needles in the face and hands and are typically given weekly for a total of 6 wk. <sup>29</sup>

### Arthrocentesis for TMD Treatment<sup>40</sup>

Description	Saline lavage of the superior joint space, hydraulic pressure and manipulation to release adhesions, and elimination of intra-articular inflammatory mediators (Fig. 3) <sup>36,37</sup> ; less invasive than arthroscopy and can be done in outpatient setting with local anesthesia and intravenous sedation
Indication	<ul style="list-style-type: none"> <li>• Limited opening with anteriorly displaced articular disk without reduction</li> <li>• Chronic pain with good range of movement and displaced articular disk with reduction</li> <li>• Degenerative osteoarthritis</li> </ul>
Contraindications	<ul style="list-style-type: none"> <li>• TMJ with bony or fibrous ankylosis</li> <li>• Extracapsular source of pain</li> <li>• Patients who have not undergone noninvasive treatment modalities</li> </ul>
Efficacy	Recently reported 83.5% treatment success rate in patients with internal derangement and osteoarthritis (as defined as an improvement in maximum jaw opening and a reduction in pain level and mandibular dysfunction) <sup>38</sup>

### Arthroscopy for TMD Treatment<sup>40</sup>

Description	Involves insertion of an arthroscope and inspection of the TMJ under fluid distention under general anesthesia; allows for irrigation of joint space, lysis of these adhesions, and mobilization of the joint under direct visualization <sup>39</sup> (Fig. 4)
Indication	<ul style="list-style-type: none"> <li>• Limited opening and pain secondary to internal derangement</li> <li>• TMJ hypomobility secondary to fibrosis or adhesions</li> <li>• Degenerative osteoarthritis</li> </ul>
Contraindications	<ul style="list-style-type: none"> <li>• TMJ with severe bony or fibrous ankylosis</li> <li>• Extracapsular source of pain</li> <li>• Patients who have not undergone noninvasive treatment modalities</li> <li>• Practitioner with lack of open joint surgery experience</li> </ul>
Efficacy	A large multicenter study reports more than 90% success rate as defined as improved mobility, pain, and function. <sup>40</sup> Arthroscopy led to greater improvement in opening after 12 mo than arthrocentesis; however, there was no difference in pain. <sup>41</sup>



PAG, ventrolateral periaqueductal gray; RVM, rostral ventromedial medulla; SPG, sphenopalatine ganglion; SuS, superior salivatory nucleus; TG, trigeminal ganglion; TNC, trigeminal nucleus caudalis

**Fig. 40 Relationship Between Temporomandibular Disorders and Headache.**<sup>41</sup>

Extracranial nociceptive inputs arising from craniofacial structures due to temporomandibular disorder and cervical input from the cervical muscles, may influence the activation of the trigeminovascular system. These nociceptive inputs converge on the TNC in the same way as do intracranial nociceptive inputs arising from the dural blood vessels and higher centers.<sup>41</sup>

# Chapter 9

## Neuropathic Pain

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Neuropathic pain (NP) is currently defined by the International Association for the Study of Pain (IASP) as “pain caused by a lesion or disease of the somatosensory nervous system.”<sup>2</sup> Neuropathic pain is one of the most challenging and complex pain conditions. It results from an abnormality in one or more components of the nervous system: peripheral, central or autonomic. These pain manifestations are usually maintained by changes in the trigeminal brain stem complex known as central neuroplasticity. When central neuroplasticity is prolonged, the result is a state of chronic or pathophysiologic pain. Because pathophysiologic pain always involves the nervous system, the terms pathophysiologic pain and neuropathic pain are used interchangeably.<sup>23</sup>

### **General characteristics of neuropathic pain include**<sup>23</sup>

1. Pain in the absence of obvious nociception (i.e., detection of noxious stimuli);
2. Pain that can be intense and out of proportion to the degree of stimulation;
3. Pain quality that is bright, stimulating and burning;
4. Pain that is relatively unresponsive to low doses of narcotic analgesics.

Neuropathic pain is divided into episodic neuropathic pain and continuous neuropathic pain.

**Episodic Neuropathic Pains:** They are characterized by periods of very brief, but intense, electrical shock-like pain followed by total remission. Usually, the individual is able to localize the site of pain quite well.<sup>24</sup>

**Continuous Neuropathic Pains:** Continuous neuropathic pains are characterized by a dull, yet burning, pain. The pain is ongoing and unremitting, yet the intensity can show patterns of fluctuation. The pain is often accompanied by other neurologic signs (ie, anaesthesia, paraesthesia,

hypoesthesia, hyperesthesia). Although the pain is present in a particular location, there is no evidence of any tissue changes or disease.<sup>24</sup>

## 9.1 Neuropathic Pain Conditions in the Orofacial Region<sup>25</sup>

CONDITION	QUALITY OF PAIN	TEMPORAL PATTERN	POSSIBLE ETIOLOGY
<b>Trigeminal Neuralgia</b>	Electriclike, sharp, shooting, lancinating	Episodic with periods of remission	Vascular compression in the trigeminal nerve root area
<b>Traumatic Neuropathy</b>	Regional aching sensation with local dysesthesia	Continuous, but may have sharp pain episodes	Neuronal trauma or intense and prolonged inflammation of peripheral nerve
<b>Trigeminal Neuroma</b>	Electriclike and sharp	Triggered by physical contact or movement	Neuroma that develops after transection of the nerve branch
<b>Postherpetic Neuralgia</b>	Burning	Recurrent, persisting pain	Herpes zoster-induced nerve damage
<b>Diabetic Neuropathy</b>	Loss of sensation, burning, tingling	Continuous pain	Metabolic and vascular abnormalities producing neural damage
<b>Cancer-Related Neuropathy</b>	Variable	Variable to continuous	Tumor compression of nerves Tumor infiltration of neural structures Metabolic nerve damage due to chemotherapy or radiation therapy
<b>AIDS*-Induced Neuropathy</b>	Variable	Variable	Human immunodeficiency virus-induced nerve and central nervous system damage Metabolic nerve damage due to chemotherapy

Cranial neuralgia, also known as neuropathic or neurogenic conditions, include structural and/or functional abnormalities in the peripheral or central nervous system (CNS). The nerve abnormality may be caused by infection, trauma, metabolic abnormalities, chemotherapy, surgery, radiation, neurotoxins, compression, inflammation, or tumor infiltration.<sup>26</sup>

### Definitions related to neuralgias

- **Allodynia** is pain resulting from a non-noxious stimulus (ie, a stimulus that normally does not cause pain).<sup>26</sup>
- **Dysesthesia** is an abnormal/unpleasant sensation (burning, stinging, stabbing). **Hyperalgesia** is an exaggerated or increased response to painful stimuli.<sup>26</sup>
- **Hyperpathia** is an exaggerated pain response whereby slightly painful stimulus is perceived as painful.<sup>26</sup>

- **Paraesthesia** is an abnormal but not always unpleasant sensation (eg, heaviness, tingling, or numbness).<sup>26</sup>
- **Refractory period** is when the nerve tissue is unable to propagate an impulse, no sensation is noted, and there are pain-free intervals of varying duration.<sup>26</sup>

IHS classification of cranial neuralgias and central causes of facial pain
13.1 Trigeminal neuralgia
13.1.1 Classic trigeminal neuralgia
13.1.2 Symptomatic trigeminal neuralgia
13.2 Glossopharyngeal neuralgia
13.2.1 Classic glossopharyngeal neuralgia
13.2.2 Symptomatic glossopharyngeal neuralgia
13.3 Nervus intermedius neuralgia
13.4 Superior laryngeal neuralgia
13.5 Nasociliary neuralgia
13.6 Supraorbital neuralgia
13.7 Other terminal branch neuralgias
13.8 Occipital neuralgia

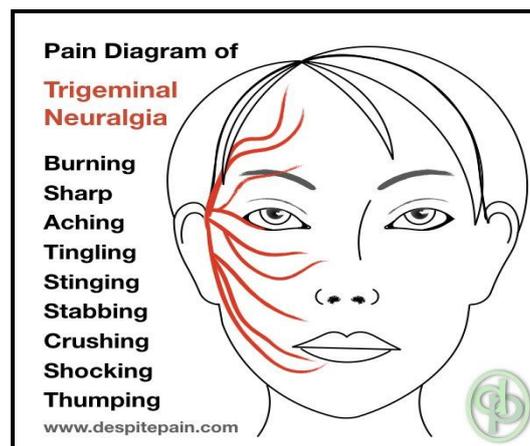
Data from Headache Classifications Subcommittee of the International Headache Society. The international classification of headache disorders, 2nd edition. Cephalalgia 2004;24(Suppl 1): 9-160.

## 9.2 Trigeminal Neuralgia (Tn)

Trigeminal neuralgia (TN) is mainly a unilateral painful (moderate to severe) disorder characterized by brief, electric-shock like pains, which are abrupt in onset and termination, and limited to the distribution of one or more divisions of the trigeminal nerve (usually the maxillary [V2] and mandibular [V3] divisions are affected). Often there are pain-free (refractory) periods between attacks.<sup>27</sup>

The prevalence of TN in the general population is between 0.01% and 0.3%.<sup>6</sup> The gender ratio of women to men is approximately 2:1. Disease onset usually occurs after the age of 40 years with peak age of onset between the ages of 50 and 60 years.<sup>27</sup>

Clinical Presentation	
Classic TN	It is characterized by paroxysmal, severe, intense pain that is almost always (95%–97%) unilateral and with a regional distribution limited to one or more divisions of the trigeminal nerve. It most commonly involves the second (maxillary) and third (mandibular) divisions, with the first (ophthalmic) division involved less than 5% of the time. The pain is frequently described as electric shocklike, lancinating, or shooting, with an abrupt onset and termination. Pain is commonly triggered by minimal stimuli (including washing, shaving, chewing, talking, brushing the teeth, and even cold wind/drafts) within the affected area. The duration of an attack usually ranges from a few seconds to 2 min and may be either isolated or repetitive at short intervals so that the individual attacks blend into one another. Between attacks, patients are usually asymptomatic; however, some patients report a burning or dull sensation, which tends to subside in time. Periods of remission from attacks, ranging from several months to years, occur in about 50% of patients.
Symptomatic TN	It is identical to classic TN except caused by a demonstrable structural lesion other than vascular compression.



**Fig. 27 Trigeminal Neuralgic Pain.**

### Management<sup>27</sup>

- **First-line therapy:** carbamazepine (200–1200 mg/d) or oxcarbazepine (600–1800 mg/d).
- **Second-line therapy:** combination of first-line therapy with lamotrigine (400 mg/d) or a switch to lamotrigine or baclofen (40–80 mg/d).
- **Third-line therapy:** phenytoin, gabapentin, pregabalin, valproate, tizanidine, and tocainide.

- **Peripheral surgical procedures:** cryotherapy, neurectomy or alcohol injection, microvascular decompression (non-destructive surgical technique) of the nerve/ vessel contact or percutaneous ablative techniques (radiofrequency thermocoagulation, balloon compression, and glycerol rhizotomy) of the Gasserian ganglion.
- **Stereotactic radiosurgery:** gamma knife surgery (a focused beam of radiation aimed at the trigeminal root in the posterior fossa).

### 9.3 Glossopharyngeal Neuralgia (GPN)

It is also known as vago-glossopharyngeal neuralgia. It is typically a unilateral painful (mild to moderate) disorder characterized by brief, electric-shock-like pains, is abrupt in onset and termination. GPN incidence in the general population has been reported to be 0.2 per 100,000 persons per year. As observed in TN, a significant association between symptoms of GPN and multiple sclerosis has been reported.<sup>27</sup>

#### Clinical Presentation<sup>26</sup>

Classic GN	It is characterized by paroxysmal, severe, lancinating, or electric shocklike pain that is almost always unilateral and with a regional distribution affecting the tonsillar fossa, posterior oropharynx, posterior region (base) of the tongue, auditory canal, or angle of the mandible. The painful attacks can be triggered by ordinary activity, including swallowing, speaking, laughing, coughing, sneezing, throat clearing, or rotation of the head. Occasionally a trigger zone is identified within the preauricular or postauricular area, the neck, or the external auditory canal. The duration of an attack usually ranges from less than 1 s up to 2 min but can sometimes occur in rapid and continuous succession. Bradycardia and syncope associated with an attack have been reported to occur in about 2% of patients.
Symptomatic GN	It is identical to classic GN except an aching pain may persist between paroxysms, and sensory impairment may be found in the distribution of the glossopharyngeal nerve.

#### Management<sup>27</sup>

- **First-line therapy:** 200–1200 mg/d carbamazepine or 600–1800 mg/d oxcarbazepine.
- **Second-line therapy:** local anaesthetic to the tonsil and pharyngeal wall can prevent attacks for a few hours.
- If medical treatment is unsuccessful, surgical procedures include microvascular decompression, intracranial sectioning of the

glossopharyngeal nerve and the upper rootlets of the vagus nerve, or gamma-knife surgery. The major complications include dysphagia, hoarseness, and facial paresis.

#### 9.4 Herpes Zoster (Hz)/ Postherpetic Neuralgia (Phn)

Acute herpes zoster (HZ) or shingles is a reactivation of latent varicella-zoster virus (VZV) infection that may occur decades after the primary infection. HZ is a disease of the dorsal root and cranial nerve ganglion and therefore induces a dermatomal vesicular eruption. HZ affects trigeminal nerves in approximately 10% to 15% of all cases with isolated involvement of the ophthalmic division in about 80% of those patients. The vesicles and pain are dermatomal and unilateral and will appear intraorally when the maxillary or mandibular branches of the trigeminal nerve are affected. The incidence of HZ is higher among people aged 60 to 70 (6–7 cases per 1000 person-years) and older than 80 years (>10 cases per 1000 person-years). HZ typically begins with prodromal symptoms, such as malaise, headache, photophobia, abnormal skin sensations, and occasionally fever. These symptoms may occur 1 to 5 days before the appearance of the rash.<sup>27</sup>



**Fig. 28 [A] Herpes Zoster Involving the Ophthalmic Division of the Trigeminal Nerve. Note that Cutaneous Herpetic Lesions are Confined to the Peripheral Distribution of the Nerve on the Left Side of the Patient's Face. [B] Permanent Scarring of the Cutaneous tissues Secondary to An acute Herpes Zoster Infection 2 Years Earlier.<sup>9</sup>**

## Management<sup>27</sup>

- **Antivirals** (acyclovir, valacyclovir, famciclovir) initiated less than 72 hours from onset of rash, particularly in patients older than 50 years, decrease rash duration, pain severity, and the incidence of PHN.
- **Nonopioid analgesics:** acetaminophen or nonsteroidal anti-inflammatory drugs used to control fever and mild to moderate pain.
- **Opioids:** used for severe pain.
- **Corticosteroids added to antivirals:** decreases the pain of HZ61
- **Adjunctive therapies:** antidepressants (amitriptyline, desipramine, venlafaxine, bupropion) or gabapentinoids (gabapentin, pregabalin) provide analgesia, shorten illness duration, and reduce the risk of PHN.

PHN, a neuropathic pain syndrome due to replication of the varicella-zoster virus in the basal ganglia causing nerve injury and manifesting as pain in the affected dermatome, is the most common complication of HZ. It occurs in approximately 30% of patients older than 80 years and in approximately 20% of patients 60 to 65 years old; it is rare in patients younger than 50 years. Postherpetic pain may include allodynia, hyperpathia, and dysesthesia. Women are at greater risk of PHN with additional risk factors, including older age, moderate to severe rash, moderate to severe acute pain during the rash, ophthalmic involvement, and history of prodromal pain. PHN may persist from 30 days to more than 6 months after the lesions have healed, and most cases resolve spontaneously.<sup>27</sup>

Management of established PHN should be immediate, as it improves prognosis, with ophthalmic PHN having the worst prognosis. Management options include antidepressants, gabapentinoids, opioids, and topical lidocaine patches. Invasive modalities include epidural and intrathecal steroids and a variety of neurosurgical techniques.<sup>27</sup>

Differential diagnosis of neuropathic pain<sup>28</sup>

Condition	Signs and Symptoms
Trigeminal neuralgia <sup>10,11</sup>	<ul style="list-style-type: none"> <li>• Paroxysmal, intense, sharp, and shooting pain</li> <li>• Short-lived pain (seconds)</li> <li>• Unilateral</li> <li>• V2 and V3 distributions commonly involved</li> <li>• Frequently has triggers such as chewing, talking, brushing teeth, cold air, smiling, or touching of trigger zones</li> </ul>
Glossopharyngeal neuralgia <sup>11</sup>	<ul style="list-style-type: none"> <li>• Paroxysmal, intense, sharp, and shooting pain</li> <li>• Short-lived pain (seconds)</li> <li>• Unilateral</li> <li>• Areas innervated by CN IX and CNX are affected—ear, tonsillar fossa, base of tongue, and the area beneath the angle of the mandible</li> <li>• Less common than trigeminal neuralgia</li> <li>• Pain commonly radiates from the oropharynx toward the ear</li> </ul>
Postherpetic neuralgia <sup>12–14</sup>	<ul style="list-style-type: none"> <li>• Occurs after an acute episode of herpes zoster</li> <li>• Constant or intermittent burning pain</li> <li>• Allodynia</li> <li>• Unilateral</li> <li>• Can occur months to years after resolution of an initial outbreak</li> </ul>
Traumatic neuralgia/neuritis <sup>15</sup>	<ul style="list-style-type: none"> <li>• Clear precipitating traumatic event (eg, extraction, bone graft, tissue graft, root canal, fracture) to a nerve in the affected area</li> </ul>
Burning mouth syndrome <sup>16</sup>	<ul style="list-style-type: none"> <li>• Spontaneous onset</li> <li>• Continuous burning of the tongue, palate, gingiva, lips, and/or pharynx (tongue is the most common location)</li> <li>• More common in women</li> <li>• Bilateral and symmetric</li> <li>• Not associated with systemic or local pathology</li> <li>• Occasional taste changes</li> </ul>
Atypical odontalgia and phantom tooth pain <sup>17,18</sup>	<ul style="list-style-type: none"> <li>• Persistent localized pain in a tooth or area of a missing/extracted tooth</li> <li>• Not associated with a systemic or local pathology</li> <li>• Moderate severity</li> <li>• Onset can coincide with dental treatment</li> <li>• Touching area can trigger more intense pain</li> <li>• Unnecessary dental treatment (eg, endodontic treatment, extractions) often performed without relief of pain</li> </ul>
Atypical facial pain/persistent idiopathic facial pain <sup>19</sup>	<ul style="list-style-type: none"> <li>• Long duration, lasting most of the day (if not continuous)</li> <li>• Unilateral, and is without autonomic signs or symptoms</li> <li>• Often in the nasolabial fold or side of the chin</li> <li>• Psychological symptoms often present</li> <li>• Symptoms do not meet diagnostic criteria of other facial pain syndromes</li> <li>• Treatment is typically less effective than that of other facial pain syndromes, and a multidisciplinary approach is required to address the many facets of this condition</li> </ul>

## Other Neuralgias<sup>26</sup>

	Clinical Presentation	ICHD-II Diagnostic Criteria <sup>a</sup>
NIN (geniculate neuralgia, Hunt neuralgia)	It is typically characterized by brief paroxysms of severe, usually sharp or burning pain that is localized deeply in the auditory canal and radiates to the external auditory meatus. Additional symptoms, such as abnormal tearing and salivation, and taste disturbances (most frequently loss of taste), have sometimes been reported during occurrences. Symptoms are associated with a trigger zone in the posterior wall of the auditory canal.	<p>A. There are pain paroxysms of intermittent occurrence, lasting for seconds or minutes, in the depth of the ear.</p> <p>B. There is presence of a trigger area in the posterior wall of the auditory canal.</p> <p>C. It is not attributed to another disorder.</p>
Supraorbital neuralgia	It is most frequently characterized by episodic, often unilateral, long-lasting attacks of moderate to severe frontal pain in the region of the supraorbital notch and medial aspect of the forehead in the area supplied by the supraorbital nerve.	<p>A. There is paroxysmal or constant pain in the region of the supraorbital notch and medial aspect of the forehead in the area supplied by the supraorbital nerve.</p> <p>B. There is tenderness over the nerve in the supraorbital notch.</p> <p>C. Pain is abolished by local anesthetic blockade or ablation of the supraorbital nerve.</p>
Occipital neuralgia	It is characterized by paroxysmal shooting, stabbing, or jabbing pain at the base of the skull or neck that may radiate over the cranium and that follows the distribution of the greater, lesser, and/or third occipital nerve. Paroxysms can start spontaneously or may be provoked by specific actions, such as brushing the hair or moving the neck and rotation or lateral bending of the cervical spine. It is commonly associated with tenderness over the involved nerve and is sometimes accompanied by diminished sensation or dysesthesia in the affected area.	<p>A. Paroxysmal stabbing pain, with or without persistent aching between paroxysms, in the distributions of the greater, lesser, and/or third occipital nerves.</p> <p>B. There is tenderness over the affected nerve.</p> <p>C. Pain is temporarily eased by local anesthetic block of the nerve.</p>

## 9.5 Peripheral Neuritis

Neuritis is a localized neural pathologic condition resulting from inflammation. It may arise from direct axonal damage due to misdirected dental implant, periapical dental inflammatory lesion near a nerve or as a result of cytokine secretion due to temporomandibular joint pathologic condition, paranasal sinusitis, malignancies. Persistence of the perineural inflammation along a nerve is as a result of macrophage and lymphocyte recruitment. There is an increase in tumour necrosis factor- $\alpha$ , which increases Na<sup>+</sup> conductance in cell membranes, hence resulting in spontaneous nociceptor activity at axons.<sup>29</sup>

### Clinical Presentation

Tactile allodynia may occur a few hours following nerve exposure to the inflammatory process and may last for several days. Hypersensitivity usually peaks at 1 week and may decrease at 1 month. Nevertheless, the neural inflammation plays a role in triggering and maintaining neuropathic pain and hence, in some individuals, symptoms can continue for years.<sup>29</sup>

## **Diagnosis:**

Diagnosis is largely based on clinical history, clinical examination, and investigations, such as radiological imaging and pathologic workup (B12 deficiency, viral infection, autoimmunity) to identify the inflammatory contributor.<sup>29</sup>

## **Management**

Management aims to decrease perineural and neural inflammation. Early administration of corticosteroids or nonsteroidal anti-inflammatory drugs (NSAIDs) may offer benefit.<sup>29</sup>

### **9.6 Persistent Idiopathic Facial Pain (PIFP)**

Persistent idiopathic facial pain (PIFP) refers to persistent extraoral and/or intraoral pain along the territory of the trigeminal nerve that does not fit the classic presentation of other cranial neuralgias or another disorder. PIFP is mainly seen in adult women with a prevalence of 0.03 to 1.0%. The pathophysiology is largely unknown; nevertheless, PIFP appears to be multifactorial with traumatic, psychological, and neurobiological influences.<sup>29</sup>

#### **Clinical presentation<sup>29</sup>**

- Pain is of long duration (if not continuous), unilateral, poorly localized
- Severe ache, crushing, or burning sensation
- No sensory loss
- Headache, backache, irritable bowel, uterine bleeding

## **Diagnosis:**

Other facial pains must be excluded when making a diagnosis. When comparing patients with trigeminal neuropathic pain with PIFP, up to 75% of patients with PIFP demonstrated abnormalities on neurophysiologic testing. Hence, it is important that these patients have some form of psychological testing.<sup>29</sup>

## Management

A multidisciplinary approach is usually undertaken. Some selective serotonin reuptake inhibitors or selective noradrenalin and serotonin inhibitors are used and usually long term. Improved sleep hygiene, which can reduce pain vulnerability, and techniques, such as mindfulness, meditation, and yoga, can be helpful. Hence, techniques such as cognitive behavior therapy are likely to have a positive outcome.<sup>29</sup>

### 9.7 Topical Medication for Neuropathic Pain<sup>25</sup>

MEDICATIONS	EXAMPLES OF TOPICAL PREPARATIONS FOR ORAL AND PERIORAL USE	MECHANISM OF ACTION
<b>Topical Anesthetics</b>	Benzocaine in Orabase (Bristol-Meyers Squibb) cream (20%)* (for intraoral use only)  Lidocaine gel, viscous solution, ointment, spray and adhesive patch <sup>†</sup> (for intraoral use only)  Eutectic mixture of local anesthetic (EMLA cream, AstraZeneca) <sup>†</sup> (lidocaine and prilocaine) (for intraoral and extraoral use)	Sodium channel blockade
<b>Neuropeptides: Capsaicin</b>	Cream in 0.025%* and 0.075%* strengths (for intraoral and extraoral use)	Inhibition of peripheral nociceptor terminal function
<b>Nonsteroidal Anti-inflammatory Drugs</b>	Ketoprofen (10-20%) in a pluronic lecithin organogel, or PLO, base <sup>†</sup> (for extraoral use only)  Diclofenac (10-20%) in PLO base <sup>†</sup> (for extraoral use only)	Blocks prostaglandin production through cyclooxygenase inhibition
<b>Sympathomimetic Agents: Clonidine</b>	Patch <sup>†</sup> (for extraoral use only)  0.01% in PLO base <sup>†</sup> (for intraoral use only)	Influences peripheral alpha adrenergic activity
<b>NMDA-Blocking Agents: Ketamine</b>	0.5% in PLO base or in Orabase <sup>†</sup> (for intraoral use only)	Antagonist to NMDA receptor
<b>Anticonvulsants</b>	Carbamazepine (2%) in a PLO base <sup>†</sup> (for extraoral use only)	Blocks use-dependent sodium channel activity
<b>Tricyclic Medications: Amitriptyline</b>	2% in PLO base <sup>†</sup> (for extraoral use only)	Blocks sodium channels
<b>Antispasmodics: Baclofen</b>	2% in PLO base (for extraoral use only)	Gamma-aminobutyric acid

### 9.8 Local Drug Delivery System<sup>25</sup>

SYSTEM	ADVANTAGES	DISADVANTAGES
<b>Mucoadhesive Creams</b>	Best for intraoral use on specific tissue sites with stent covering site	Can irritate the oral tissues
<b>Transdermal Creams: Pluronic Lecithin Organogel</b>	Best for extraoral use	Does not penetrate to deeper tissues and can cause skin rash or allergic reaction
<b>Toothpaste</b>	Incorporation of the therapeutic agent into the patient's regular daily routine	Not good for regional oral tissue site delivery
<b>Medicated Chewing Gum and Candy Such as Lollipops</b>	Patients keep the gum or candy in the mouth for long periods, which provides increased drug/target area contact	May aggravate temporomandibular joint problem  Does not deliver agent to regional oral tissue sites
<b>Dissolving Tablets or Lozenges</b>	Best when problem is located on tongue (either dorsal or ventral surface), palate or cheek	Medication is swallowed and moves down throat
<b>Adhesive Patches and Powders</b>	Best for intraoral use on specific tissue sites	Patches must be replaced frequently  Less durable than tissue-covering stents when needed for long-term use
<b>Tissue-Covering Stents</b>	Best for labial and palatal mucosal sites  Durability and ease of fabrication	Cannot be used for movable mucosal sites such as cheek, tongue or soft palate
<b>Dissolving Polymeric Devices</b>	Typically fabricated as a retainer; medication is swallowed as the device dissolves	As these are experimental devices, they are not available at this time
<b>Mouthwashes</b>	Possibility of delivery to the oropharyngeal area	Duration of application is usually less than 60 seconds
<b>Medicated Lipstick</b>	Specific therapy for the lips  Convenient application technique	None if used for lip therapy only

**Atul Patel et al (2002)** conducted a retrospective review of their database and identified patients who presented for treatment of presumed GPN. They collected follow-up information regarding symptom relief, complications, functional outcomes, and patient satisfaction. Univariate and multivariate analyses were performed to identify predictors of good outcomes after microvascular decompression. The overall immediate success rate exceeded 90%, and long-term patient outcomes and satisfaction were best for the typical GPN group (with pain restricted to the throat and palate). Complication rates decreased across quartiles for all categories evaluated.<sup>30</sup>

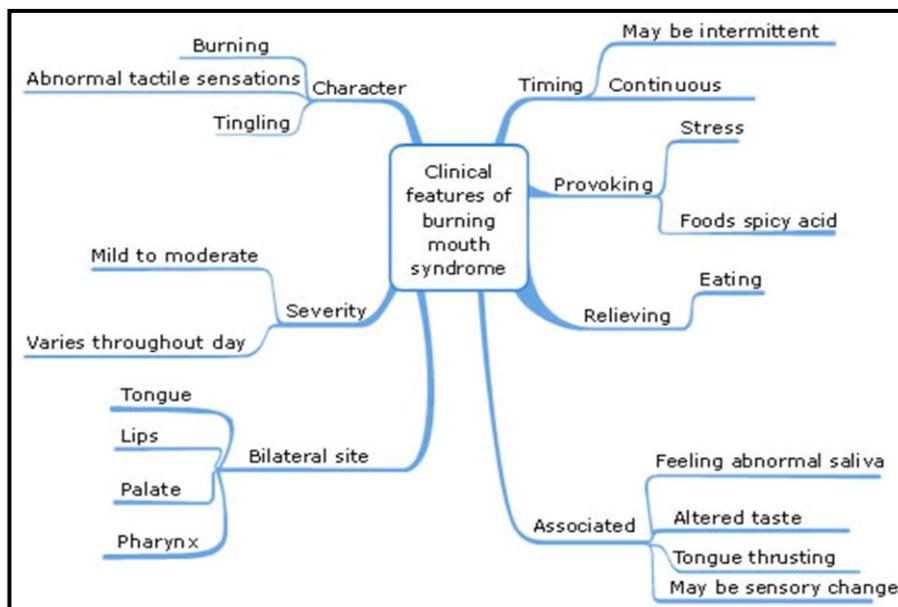
**Rodríguez-Lozano FJ et al (2010)** reviewed neuropathic orofacial pain (NOP) that can begin after deafferentation of trigeminal nerve fibres after root canal treatment, apicoectomy, tooth extraction, or implant placement or idiopathically. A case of NOP occurring after a surgical implant procedure in a 62-year-old woman is presented. Continuous pain started 6 months after the placement of 8 dental implants in the maxilla, at the time of positioning the prosthesis on her implants. After being subjected to a physical examination and relevant complementary radiologic imaging, the patient was diagnosed with a NOP secondary to nerve impingement due to dental implant placement as well as myofascial head and neck pain.<sup>31</sup>

For the myofascial pain, patient received relaxation techniques, physiotherapy, nonsteroidal anti-inflammatory drugs, and, for episodes of intense pain, anaesthetic infiltration of the affected. For the neuropathic pain, she received Lyrica (pregabalin) 125 mg per day. Two months after treatment, the patient reported a notable improvement, with a decrease in her pain score and the number of painful episodes, allowing the patient to lead a normal life.<sup>31</sup>

## **9.9 Burning Mouth Syndrome (Bms)**

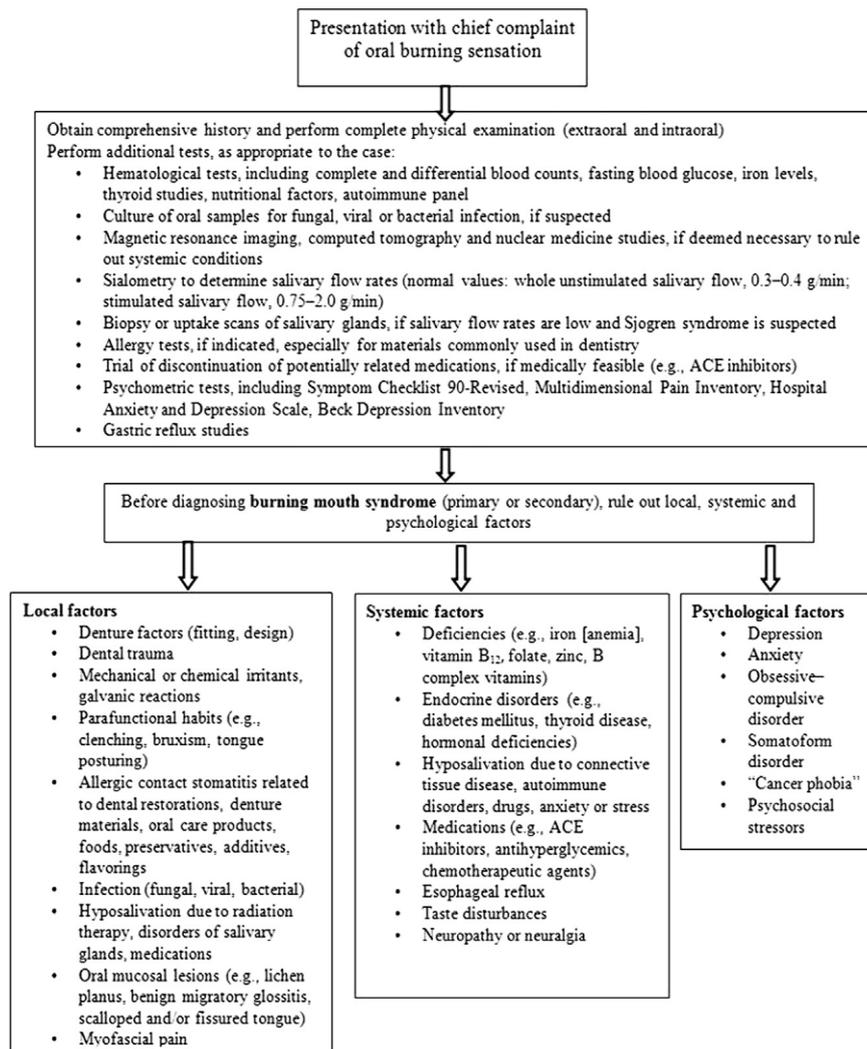
BMS is defined as a burning painful sensation in the mouth (oral dysesthesia) with normal clinical examination and no obvious organic cause. BMS is thus a diagnosis of exclusion, made only after excluding all other causes of mouth pain. Evidence suggests that this disorder has a multifactorial cause, with neurologic, psychogenic, and hormonal factors all contributing to the disease. Many names have been given to this condition, including orodynia and glossodynia being the 2 most common.<sup>32</sup>

Symptoms—Sensory, Chemosensory Abnormalities	
Persistent or constant oral mucosal pain daily <sup>13</sup>	<ul style="list-style-type: none"> <li>• Burning, scalding, numb feeling, tingling                             <ul style="list-style-type: none"> <li>◦ Location (one or more)—tongue, oral mucosa, oropharyngeal areas, lips, nasal mucosa</li> <li>◦ Intensity—variable, weak to intense</li> <li>◦ Pattern/timing—continuous, not paroxysmal</li> <li>◦ Localization—often bilateral, symmetric, independent of nervous pathways.</li> </ul> </li> </ul> <p>Types: Three patterns of oral pain have been identified<sup>23</sup>:</p> <p>Type 1: pain absent on waking and developing during the day</p> <p>Type 2: pain present day and night</p> <p>Type 3: intermittent pain, with pain-free days</p>
Dysguesia 70% <sup>13,24,25</sup>	Persistent taste, altered taste, metallic taste, bitter taste <sup>11</sup>
Xerostomia 46%–67% <sup>9,26</sup>	With or without salivary gland hypofunction



**Fig. 29 Clinical Features of Burning Mouth Syndrome.**

## Diagnostic Modalities<sup>32</sup>



## Management<sup>32</sup>

- **Behavioural strategies:** cognitive behavioural approaches and/or group psychotherapy.
- Diagnose and manage local and systemic cofactors related to secondary BMS
  - Local: Oral examination, Salivary hypofunction/xerostomia, Parafunctional habits, Contact allergies
  - Systemic: Haematological parameters, Nutritional deficiencies, Hormonal disturbances, Side effects from medications
  - Psychological factors

• **Topical medication**<sup>32</sup>

Medications	Specific Examples	Dose	Directions
Benzodiazepines	Klonazepam wafer/orally disintegrating tablets <sup>58</sup>	0.25 mg–2 mg/d	0.25 mg at bedtime; increase dosage by 0.25 mg every 4 to 7 d until oral burning is relieved or side effects occur; as dosage increases, medication is taken as full dose or in 3 divided doses
Anesthetic	Lidocaine 2% viscous gel	Variable	Applied PRN on the oral mucosa/tongue
Atypical analgesic	Capsaicin cream	Variable	Rinse mouth with 1 teaspoon of a 1:2 dilution (or higher) of hot pepper and water; increase strength of capsaicin as tolerated to a maximum of 1:1 dilution.
Anti-depressant	Doxepin 5% cream	Variable	Q4–6 h
Nonsteroidal anti-inflammatory	Benzydamine oral rinse	Variable	Dispense 5 mL, swish for 30 s, and spit, TID
Antimicrobial	Lactoperoxidase oral rinse	Variable	Dispense 5 mL, swish for 30 s, and spit, BID
Mucosal protectant	Sucralfate oral rinse	Variable	Dispense 5 mL, swish for 30 s, and spit, TID

• **Systemic medications**<sup>32</sup>

Medications	Specific Examples	Dose	Directions
Benzodiazepine (low dose)	Clonazepam	0.5–2 mg/d	0.25 mg at bedtime; increase dosage by 0.25 mg every 4 to 7 d until oral burning is relieved or side effects occur; as dosage increases, medication is taken as full dose or in 3 divided doses
	Chlordiazepoxide	10–30 mg/d	5 mg at bedtime; increase dosage by 5 mg every 4 to 7 d until oral burning is relieved or side effects occur; as dosage increases, medication is taken in 3 divided doses
Anticonvulsants	Gabapentin	300 to 1600 mg/d	100 mg at bedtime; increase dosage by 100 mg every 4 to 7 d until oral burning is relieved or side effects occur; as dosage increases, medication is taken in 3 divided doses
	Pregabalin	25 to 300 mg	25 mg at bedtime; increase dosage by 25 mg every 4 to 7 d until oral burning is relieved or side effects occur; as dosage increases, medication is taken in 3 divided doses

<i>(continued)</i>			
Medications	Specific Examples	Dose	Directions
Selective norepinephrine reuptake inhibitors	Milnacipran	100 mg/d	50 mg BID, start with 12.5 mg, then 12.5 BID every 4 to 7 d until oral burning is relieved or side effects occur, max. 200 mg/d
	Duloxetine <sup>65,66</sup>	60 mg–120 mg/d	60 mg–120 mg PO QD
Antioxidant	$\alpha$ -Lipoic acid	600 mg–1200 mg	300 mg/600 mg BID
Atypical antipsychotic	Olanzapine	5–20 mg/d	5–20 mg PO QPM
Dopamine agonist	Pramipexole	0.125–0.5 mg PO QPM	Start 0.125 mg PO QPM, may increase 0.125 mg/d q4–7 d max. 0.5 mg/d, 2–3 h before bedtime
Herbal supplement	Hypericum perforatum (St John's wort)	300 mg to 1800 mg/d in divided doses	300 mg TID
Salivary stimulants	Pilocarpaine	15–40 mg/d	5 mg/10 mg TID/QID
	Cevimeline	90–120 mg/d	30 mg TID/QID

## 9.10 Eagle's Syndrome

It is an uncommon condition resulting from compression of the glossopharyngeal nerve by an elongated styloid process or an ossified stylohyoid ligament. The condition is more prevalent among females. The chief signs and symptoms include dull and persistent neck and throat pain, dysphagia, otalgia, and a foreign body sensation. The pain may have a neuralgic component, mimicking glossopharyngeal neuralgia, and it is usually exacerbated by rotation of the head to the contralateral side, swallowing, extending the tongue and yawning.<sup>33</sup>

It is suggested that abnormal bone formation, leading to an elongated styloid process or an ossified stylohyoid, may be secondary to soft tissue injury, such as tonsillectomy. However, most patients report no previous history of trauma or tonsillectomy.<sup>33</sup>



**Fig. 30 Eagles Syndrome: OPG Revealing Elongation of Styloid Process**

Surgical resection of the styloid process or the calcified stylohyoid ligament, through an intraoral or extraoral approach, results in resolution of the symptoms in most patients. Concurrent treatment with NSAIDs is advocated, in order to prevent re-ossification following the surgical procedure.<sup>33</sup>

# Chapter 10

## Intraoral Pain Disorders

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Those experiencing intraoral pain associated with dental and oral diseases of various causes are likely to pursue treatment from medical and dental providers. A range of causes for intraoral pain include odontogenic, periodontal, oral mucosal, or contiguous hard and soft tissue structures to the oral cavity. Dentists should be vigilant when diagnosing these, as they should be among the first in their differential diagnoses to be ruled out.<sup>46</sup>

### 10.1 Dental and Pulpal

Dental and pulpal pain occurs when there is noxious stimulation of the teeth or disease affecting the enamel, dentin, or pulpal structures. This pain may be attributable to trauma, attrition, abrasion, erosion, or iatrogenic or bacteria causing caries.<sup>46</sup>

There is typically a continuum of symptoms based on the severity of disease ranging from short, sharp pain that can progress to a persistent, dull pain indicating the presence of inflammation, infection, and disease.<sup>46</sup>

Because enamel is avascular, noninnervated, and nonporous, loss of structure due to demineralization, mechanical means, or caries isolated in the enamel is usually painless. However, once lesions breach the dentinoenamel junction, pain can be experienced through stimuli affecting the dentinal tubules.<sup>46</sup>

#### **Caries<sup>46</sup>**

Bacterial invasion leads to subsequent acid metabolite formation on tooth structures, leading to damage of tooth structure. Symptoms are a result of lost enamel and exposure of dentin, cementum, and pulp.

- Symptoms and features: Patients may report sensitivity to thermal changes, sweet, or acidic foods. Pain is sharp, localized, and dissipates immediately after removal of the stimuli.



**Fig. 43 Deep Caries Noted on Adjacent Premolars Radiographically.<sup>46</sup>**

- **Diagnosis:** Caries are detected both clinically and radiographically
- **Management:** If a lesion is asymptomatic and incipient involving only the enamel, monitoring and topical fluoride placement are usually adequate. However, if the lesion is symptomatic, extends into dentin, and is not arrested, removal of the decayed tooth structure and placement of a dental restoration is indicated.

#### **Exposed Cementum or Dentin<sup>46</sup>**

Gingival recession leading to exposed cementum commonly results from heavy pressure from aggressive tooth brushing. Abrasion of enamel leading to exposed dentin can also occur from aggressive tooth brushing, bruxism, or abnormal or traumatic occlusion.

- **Symptoms and features:** Tooth sensitivity to thermal stimuli generally results in sharp, localized pain that dissipates immediately after removal of stimuli.



**Fig. 44 Exposed Cementum of the Upper Left Canine Due to Gingival Recession.<sup>46</sup>**

- **Diagnosis:** Diagnosis is made clinically through evaluation and testing exposure of cold stimuli to the exposed root surface.
- **Management:** Treatment measures are directed toward limiting dentinal fluid movement by covering the exposed dentin or cementum with desensitizing agents or restorations. Oral hygiene instruction is also important to improve toothbrushing technique and prevent further recession.

## Pulpal Disease<sup>46</sup>

Caries, trauma, fracture, exposed dentin or cementum, or premature or traumatic occlusal contact can all result in inflammation with or without infection that causes pulpal pain. There may be continuous, dull, aching pain and episodes of pulsing, throbbing, and sharp pain, representing stimulation of the C fibres and Ad fibres, respectively. Intermittent pulpal pain can be stimulated by heat, cold, pressure, and head positioning. Teeth that only have pulpal disease are not sensitive to percussion of the affected tooth.

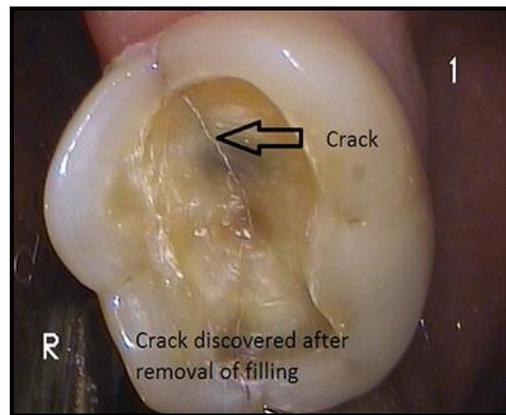
- Normal pulp<sup>46</sup>
  - **Symptoms and features** include a short response to cold stimuli that is mildly uncomfortable and subsides almost immediately on removal.
  - **Diagnosis** is made clinically, as there is no evidence of loss of tooth structure or periapical abnormalities on radiographs.
  - **Management:** In the absence of tooth abnormality, no treatment indicated.
- Reversible pulpitis<sup>46</sup>
  - **Symptoms and features** include an exaggerated quick, sharp response to cold stimuli, followed by a dull ache that dissipates. There is no complaint of spontaneous pain.
  - **Diagnosis** is primarily made based on clinical features and pulp testing to cold and heat stimuli. There usually is not any radiographic evidence of periapical abnormalities.
  - **Management** entails removal of the pain-causing stimulus, usually removal of carious lesion, and/or restoration of lost tooth structure.

- Irreversible pulpitis<sup>46</sup>
  - **Symptoms and features** include spontaneous, lingering dull ache or a constant, severe, unrelenting pain; increased pain intensity to noxious stimuli; and positive response to cold and heat stimuli
  - **Diagnosis:** Radiographically, there may or may not be a thickening of the PDL or periapical radiolucencies at the tooth's apex.
  - **Management:** Treatment requires either root canal therapy or tooth extraction.
  
- Pulpal necrosis<sup>46</sup>
  - **Symptoms and features:** There is no pain or response to heat, cold, or electronic pulp testing.
  - **Diagnosis:** Radiographs may or may not reveal the presence of a widened PDL at the apex or periapical radiolucency. If the infection has extended beyond the apex of the tooth in the surrounding bone, a percussion test may be positive.
  - Treatment requires either RCT or extraction.

### **Cracked Tooth Syndrome<sup>46</sup>:**

Cracked tooth syndrome is when tooth fractures become symptomatic and is defined as incomplete fracture of the dentin that may or may not extend to the pulp.

- **Symptoms and features:** Complaints include sharp, transient pain that is stimulated by biting or releasing or resulting from exposure to cold food or drinks that can be easily localized. Pain may sometimes linger minutes after chewing.
- **Diagnosis:** Transillumination on the tooth is best performed with the use of magnification to better illustrate colour changes and clinically significant cracks. Detection of a cracked tooth on a radiograph is rare. Tooth percussion seldom elicits pain with percussion in the apical direction. Pain on biting is more commonly noted with release of biting, owing to fluids within dentinal tubules moving toward the pulp.



**Fig. 45 Mesiodistal Crack Across tMolar Seen After Removal of Restoration.**

- **Management:** Treatment of cracked tooth syndrome may include stabilization with an orthodontic band, a crown, or onlay. RCT or extraction of the tooth may be indicated depending on the extent of the crack or lack of resolution or severity of symptoms.

## 10.2 Periodontal

Periodontal pain is a localized pain, owing to the mechanoreceptors and proprioceptors in the periodontium. Pain caused by chronic periodontal conditions may be mild, persistent, or episodic dull pain. Periodontal pain caused by local factors is localized to affected teeth in which there is inflammation or infection involving the gingiva, periodontium, alveolar bone, or pericoronal tissue.<sup>46</sup>

### **Gingival/Periodontal Abscess<sup>46</sup>:**

This abscess is a localized collection of pus within the tissues of the gingiva and periodontium adjacent to a vital tooth. This abscess occurs when bacteria within a periodontal pocket continually finds their way into the soft tissues, with abscess formation representing a decreased local or systemic resistance of the host.

- **Symptoms and features:** The main symptom is sudden onset of pain, which is made worse by biting on the involved tooth. The tooth may be mobile, and the lesion may contribute to destruction of the PDL and alveolar bone, noted. The pain is deep and throbbing, and the surface may be shiny because of stretching of the mucosa.

Before pus has formed, the lesion will not be fluctuant and there will be no purulent discharge. There may be regional lymphadenitis. Such abscesses are classified primarily

- Gingival abscess is a localized, purulent infection that involves only the soft tissue near the marginal gingiva or the interdental papilla.
- Periodontal abscess is a localized, purulent infection involving a greater dimension of tissue, extending apically and adjacent to a periodontal pocket.
- Pericoronal abscess is a localized, purulent infection within the tissue surrounding the crown of a partially or fully erupted tooth.
- Combined periodontal/endodontic abscess is a periodontal abscess that occurs in conjunction with a tooth that has infected pulp.



**Fig. 46 Periodontal Bone Loss Noted Radiographically<sup>46</sup>**

- **Diagnosis:** Clinical features as described earlier, in addition to radiographic evidence of periodontal disease, are sufficient to obtain a diagnosis.
- **Management:** It involves pain relief and control of the infection. This management entails obtaining drainage, either through incision at the area of fluctuance or in the gingival margin or through the socket if the tooth is extracted. Removal of the source of infection is indicated whether it is bacteria or a foreign body, which can be accomplished through root debridement in the cases of periodontal abscesses. A history of recurrent periodontal abscesses and significantly compromised periodontal support indicate that the prognosis for the involved tooth is poor and it should be extracted.

## Periapical Inflammatory Lesions Periapical Periodontitis<sup>46</sup>

This lesion is an acute or chronic inflammatory lesion around the apex of a tooth root, representing the bacterial invasion from a necrotic tooth. This lesion can be considered a sequela in the natural history of dental caries, irreversible pulpitis, and pulpal necrosis. Periapical periodontitis is classified as acute periapical periodontitis, chronic periapical periodontitis and periapical granuloma.

- **Symptoms and features:** In acute periapical periodontitis, pain may be continuous, aching, and/or throbbing or only elicited through percussion of the involved tooth. Chronic periapical periodontitis and periapical granuloma may be painless.

## Periapical Abscess<sup>46</sup>

Periapical periodontitis may develop into a periapical abscess whereby a collection of pus forms at the tooth apex, with the consequence of spread of infection from the tooth pulp.

- **Symptoms and features:** Symptoms are similar to that described for gingival and periodontal abscesses earlier. Pain may be continuous, aching, and/or throbbing, with percussion sensitivity of the involved tooth. The associated tooth is necrotic and nonvital.



**Fig. 47** Periapical Radiolucencies Noted Radiographically on Adjacent Teeth.<sup>46</sup>

- **Diagnosis:** The radiographic features of periapical inflammatory lesions vary depending on the time or course of the lesion. Because very early lesions may not show any radiographic changes, diagnosis of these lesions relies solely on the clinical symptoms. More chronic lesions may show lytic (radiolucent) or sclerotic (radiopaque) changes or both.
- **Management:** Definitive treatment is targeted toward addressing the source of infection, which is the necrotic

### Alveolar Osteitis (Dry Socket) <sup>46</sup>

Alveolar osteitis is an inflammation with or without infection of the alveolar bone, which occurs as a postoperative complication of tooth extraction. This complication is a result of bare alveolar bone being exposed to bacteria and/or debris.

- **Symptoms and features:** Signs may include an empty socket, which is partially or totally devoid of blood clot or shows denuded bone walls. Symptoms may include dull, aching, throbbing pain in the area of the socket that is moderate to severe and may radiate to other parts of the head, such as the ear, eye, temple, and neck. Intraoral halitosis and bad taste in the mouth may also occur.
- **Diagnosis:** Diagnosis is made clinically, in conjunction with the history of a recent tooth extraction.
- **Management:** Treatment is usually symptomatic with analgesic medications and removal of debris from the socket by irrigation with saline or chlorhexidine, with local anaesthetic. Medicated dressings are also commonly placed in the socket. Although there is concern that these will act as a foreign body and prolong healing, they are usually needed because of the severe pain.

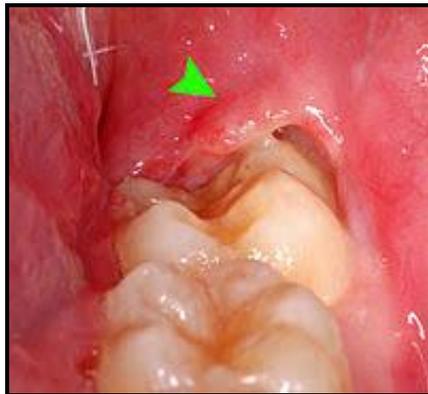


**Fig. 48 Clinical Presentation of Dry Socket**

## Pericoronitis<sup>46</sup>

Pericoronitis, also known as operculitis, is inflammation of the soft tissues surrounding the crown of a partially erupted tooth, including the gingiva and the dental follicle. This inflammation may occur as a result of trauma or bacterial infection and commonly occurs in impacted third molars.

- **Symptoms and features:** Pain in the affected area is continuous and often severe. Other signs and symptoms depend on the severity and include halitosis, bad taste, pus exudate, signs of trauma on the operculum, dysphagia, cervical lymphadenitis, facial swelling etc.
- **Diagnosis:** Diagnosis is made based on clinical features, associated with an impacted tooth.
- **Management:** Initial treatment involves prescription of analgesic and antibiotics. Prevention and/or definitive treatment can be achieved by extraction of the associated impacted tooth.



**Fig. 49 Pericoronitis Seen with Erupting Third Molar.**

### 10.3 Oral Mucosal Pain

Oral pain related to mucosal disorders is a direct manifestation of changes of the mucosal epithelium. These changes are seen intraorally as vesicle formation, ulcerations, erosions, erythema, pseudomembranous, and/or hyperkeratosis, with hyperalgesia of the affected mucosal tissue. Pain of mucosal origin is continuous and usually described as raw, stinging, aching, and burning. Painful oral mucosal disorders may develop as a result of infection, reactive processes, systemic disorders, or dysplasia.<sup>46</sup>

## Oral Candidiasis<sup>46</sup>

Oral candidiasis is a mycosis of *Candida* species occurring on the oral mucosal surfaces. Causes of fungal proliferation are thought to be multiple, attributed to one or a combination of hyposalivation, change in oral bacterial flora, immune compromise, immune suppression, diabetes, or topical corticosteroid use.

- **Symptoms and features:** A continuous burning sensation in affected areas may occur in the presence or absence of lesions. Three main clinical appearances of candidiasis are generally recognized: pseudomembranous, erythematous, and hyperplastic. Other specific variants include the following:
  - Angular cheilitis is inflammation at the corners of the mouth, very commonly involving *Candida* species, when sometimes the terms “*Candida*-associated angular cheilitis” or, less commonly, “monilial perleche” are used. Denture-related stomatitis refers to a mild inflammation and erythema of the mucosa beneath the denture surface.
  - Median rhomboid glossitis is an elliptical or rhomboid lesion in the centre of the dorsal tongue, just anterior of the circumvallate papillae. The area is depapillated, reddened (or red and white), and rarely painful.
  - Linear gingival erythema is a localized or generalized linear band of erythematous gingivitis. It was first observed in HIV–infected individuals and termed HIV-gingivitis, but the condition is not confined to this group.



**Fig. 50 Hyperplastic Oral Candidiasis of the Left Buccal Mucosa.**<sup>46</sup>

- **Diagnosis:** Diagnosis is mostly made based on clinical features, history, and symptoms. Low-grade fungal infections in the absence of clinical signs can sometimes be misdiagnosed as burning mouth syndrome. If diagnosis is uncertain, a cytologic smear or culture may be performed.
- **Management:** Oral candidiasis can be treated with topical antifungal drugs, such as nystatin, clotrimazole, or miconazole. In cases of persistent recurrent oral candidiasis, antifungal therapy alone does not permanently resolve these lesions, but rather the underlying predisposing factors (eg, hyposalivation, immunosuppression, immunocompromised, diabetic control) must also be addressed.

### Herpes Simplex Virus<sup>47</sup>

Herpes simplex virus 1 and 2 (HSV-1 and HSV-2) are two members of the herpes virus (Herpesviridae) family. The ubiquitous and contagious HSV-1 and HSV-2 are associated with oral and genital lesions, respectively, but not exclusively. They can be transmitted when an infected person is producing and shedding the virus during active episodes and can be spread through contact with saliva, such as sharing drinks.

- **Symptoms and features:** Reactivation and recurrent lesions typically present as painful vesicle eruptions on keratinized tissue, often preceded by prodromal tingling or burning sensations in the affected area. Vesicles are short lived, quickly rupturing, resulting in a yellow ulceration with erythematous borders. Healing occurs within 1 to 4 days.



**Fig. 51 Herpes Simplex Lesions of the Palate.**<sup>46</sup>

- **Diagnosis:** Diagnosis is often based on clinical presentation and history. If the diagnosis is uncertain, viral cultures are obtained by swabbing a fresh vesicle.
- **Management:** No method completely eradicates herpes virus, as it remains latent or dormant in the trigeminal ganglion; but antiviral medications can reduce the frequency, duration, and severity of outbreaks, for eg. acyclovir, valacyclovir, famciclovir, and penciclovir. Certain dietary supplements and alternative remedies are claimed to be beneficial. Systemic analgesics and topical anaesthetic treatments (eg, prilocaine, lidocaine, benzocaine, or tetracaine) are used to relieve pain.

### **Herpes Zoster (Shingles) <sup>47</sup>**

Herpes zoster is an infection resulting from reactivation of the varicella-zoster virus that affects peripheral or cranial nerves, usually occurring years after primary infection with the varicella (chickenpox) virus or receipt of the live, attenuated varicella vaccine.

- **Symptoms and features:** The disease manifests as painful vesicular eruptions over a single dermatome or 2 or more contiguous dermatomes in the mucous membranes and/or skin. They are invariably unilateral and do not cross the midline. Concern after resolution of condition is postherpetic neuralgia, which is a continuous, intractable, burning pain in the previously involved affected sites.
- **Diagnosis:** Diagnosis is usually made by history and clinical presentation.
- **Management:** Treatment is with higher doses and extended regimens of systemic antiviral medications, such as acyclovir, valacyclovir, and famciclovir. Systemic steroids have been noted to decrease the severity and duration of pain and are also used as a prophylactic measure to prevent postherpetic neuralgia.



**Fig. 52 Herpes Zoster Lesions of the Skin Following the Mental Nerve Distribution.**

### **Necrotizing Periodontal Diseases<sup>46</sup>**

Necrotizing periodontal diseases are inflammatory periodontal diseases thought to be caused by bacteria (spirochetes, fusiform bacteria) and triggered by other factors (eg, stress, impaired immunity).

- **Symptoms and features:** These diseases usually have a sudden onset and are characterized by continuous moderate pain, fetid odour, and systemic symptoms (eg, malaise, low-grade fever).
  - Necrotizing ulcerative gingivitis is characterized by erythematous and edematous gingiva, with punched-out papillae.
  - Necrotizing ulcerative periodontitis (NUP) has soft tissue necrosis, rapid bone loss involving the gingiva, PDL, and alveolar bone.
  - Necrotizing stomatitis occurs when NUP progresses into the tissue beyond the mucogingival junction.
- **Diagnosis:** Diagnosis is made based on history and clinical features.
- **Management:** Treatment entails local debridement, topical antimicrobials (eg, chlorhexidine rinse), analgesics, and oral antibiotic therapy in the event of systemic manifestations.

### **Recurrent Aphthous Stomatitis<sup>46</sup>**

Aphthous stomatitis is a relatively common condition characterized by the repeated formation of benign and noncontagious oral ulcers (aphthae) in otherwise healthy individuals, with no detectable systemic symptoms or signs outside the mouth.

- **Symptoms and features:** Generally, symptoms may include prodromal sensations such as burning, itching, or stinging, which may precede the appearance of any lesion by some hours; and pain, which is often out of proportion to the size of the ulceration. It is worsened by physical contact especially with certain foods and drinks (eg, acidic). Ulcerations are yellow with erythematous borders, typically appearing on nonkeratinized mucosa.
  - Minor aphthae is the most common type of aphthous stomatitis, accounting for about 80% to 85% of all cases.
  - Major aphthae, making up about 10% of all cases of aphthous stomatitis, are similar to minor aphthous ulcers but are more than 10 mm in diameter and the ulceration is deeper.
  - Herpetiform ulceration is a subtype of aphthous stomatitis so named because the lesions resemble a primary infection with HSV.



**Fig. 53 Recurrent Aphthous Stomatitis Lesions on the Floor of Mouth.<sup>46</sup>**

- **Diagnosis:** Diagnosis is made based on history and clinical presentation. Other potential underlying causes for similar lesions (eg, hematinic deficiency, Behcet disease, celiac disease, inflammatory bowel disease) are ruled out through laboratory studies.
- **Management:** Treatment is palliation (eg, with topical anaesthetics or topical or systemic analgesics) until lesions resolve. Topical anti-inflammatory medications (eg, steroids, chlorhexidine rinse, tetracyclines) may be used, with immune modulators (eg, oral steroids, pentoxifylline, dapsone, colchicine) used for severe, refractory cases or in the immunocompromised.

## Lichen Planus<sup>46</sup>

Lichen planus (LP) is an inflammatory disease of the skin and/or mucous membranes thought to be the result of a T cell–mediated immune process targeting an unknown self-antigen in the epithelium, with an unknown initial trigger.

- **Symptoms and features:** Six clinical forms of oral LP are recognized:
  - **Reticular:** The most common variant is characterized by the classic netlike or spider weblike appearance of lacy white lines, known as Wickham striae. This variant is usually asymptomatic and painless.
  - **Erosive/ulcerative:** This form is characterized by oral ulcers presenting with persistent, irregular areas of redness, ulcerations, and erosions covered with a yellow slough. Ulcerations are usually continuously significantly painful, with sensitivity to acidic or mechanical stimuli.
  - **Papular:** This form is characterized by white papules that are usually asymptomatic.
  - **Plaquelike:** This form appears as white patches that may resemble leukoplakia and are usually painless.
  - **Atrophic:** Atrophic oral LP may also manifest as desquamative gingivitis, with some areas of pain and sensitivity.
  - **Bullous:** This form appears as fluid-filled vesicles that project from the surface and are painful.



**Fig. 54 Erythema, White Plaques, and Ulcerative Lesions on the Left Buccal Mucosa and Lips Due to Erosive LP.<sup>46</sup>**

- **Diagnosis:** Diagnosis may be made clinically for the reticular variant. Other variants may resemble other mucosal disorders; thus, biopsy of representative tissue may provide a histopathologic diagnosis.
- **Management:** There is no cure, but many different medications and procedures have been used to control the symptoms. Treatment is only required if lesions are symptomatic, usually involving topical corticosteroids and analgesics. If these are ineffective and the condition is severe, intralesional or systemic corticosteroids may be used. Calcineurin inhibitors (eg, tacrolimus) are sometimes used.

### Vesiculobullous Diseases<sup>46</sup>

A vesiculobullous disease is a type of mucocutaneous disease that is characterized by vesicles and bullae. These diseases occur when autoantibodies target components of the epithelium and underlying connective tissue. Examples of vesiculobullous diseases include pemphigus vulgaris, cicatricial pemphigoid, dermatitis herpetiformis, linear immunoglobulin A disease, and epidermolysis bullosa.

- **Symptoms and features:** These diseases are characterized by blisters, erosions, and ulcerations affecting the oral mucosa, with some exhibiting extraoral manifestations (eg, skin, eyes, genitals). Affected intraoral areas may be continuously painful, sensitive to foods, or only mildly painful.



**Fig. 55 Pemphigus Vulgaris Lesions of the Lower Lip.**<sup>46</sup>



**Fig. 56 Cicatricial (Mucous Membrane) Pemphigoid Lesions Involving the Gingiva.<sup>46</sup>**

- **Diagnosis:** Diagnosis is made by biopsy of lesional and perilesional tissue and serum studies, with the last two being used for direct immunofluorescence and indirect immunofluorescence, respectively, for autoantibodies.
- **Management:** Treatment is varied depending on the exact diagnosis and composed of one or a combination of topical steroids, systemic steroids, or other systemic immune modulators.

### **Squamous Cell Carcinoma<sup>46</sup>**

Squamous cell carcinoma (SCC) accounts for upwards of 90% of intraoral malignancies. Risk factors for the development of oral SCC include chronic exposure of oral mucosa to tobacco and/or alcohol.

- **Symptoms and features:** Lesions initially present as areas of leukoplakia, erythroplakia, exophytic lesions, and/or ulceration that persists. There may or may not be the presence of pain; but when present, it is continuous in the affected areas. Pain can be due to the ulcerations themselves, secondary infection, and/or encroachment of adjacent peripheral nerves. Hypoesthesia and/or paraesthesia may also accompany lesions.



**Fig. 57 Oral SCC on the Right Lateral Tongue.<sup>46</sup>**

- **Diagnosis:** Diagnosis is made histopathologically. Incisional biopsies should be made of indurated leukoplakic lesions, erythroplakic lesions, and/or long-standing ulcerations in the absence of apparent sources of irritation or trauma.
- **Management:** Composed of one or a combination of surgical removal, chemotherapy, and radiation therapy.

### Oral Mucositis Related to Cancer Therapy<sup>46</sup>

Patients may develop oral mucositis as a result of therapies targeted toward treating cancer due to radiation or chemotherapy or hematopoietic stem cell transplantation for hematologic malignancies.

- **Symptoms and features:** This condition is characterized by erythema, edema, pseudomembrane formation, mucosal shedding, and ulcer formation. Mucosal pain usually coincides with the onset of erythema and ulceration.



**Fig. 58 Oral Mucositis in a Patient Undergoing Cancer Chemotherapy.**<sup>46</sup>

- **Diagnosis:** Diagnosis is made based on the appearance of lesions coinciding with treatment. For radiation therapy, severity is dose dependent, with erythema and ulceration occurring after a cumulative dose of 30 Gy. In chemotherapy with mucotoxic regimens, changes begin 2 to 4 days after initiation of chemotherapy, with ulceration occurring 5 to 8 days after initiation.
- **Management:** Treatment is generally for analgesia, composed of topical analgesics, oral and parenteral analgesics, in addition to nutritional and fluid support. Signs and symptoms persist for 2 to 6 weeks following the completion of radiation therapy and 7 to 10

days during chemotherapy, as long as patients do not develop secondary infection or remain granulocytopenic or immunocompromised.

### **Immunocompromised States (Transplantation Medicine, Human Immunodeficiency Virus)<sup>46</sup>**

Oral lesions occurring in the immunocompromised, either due to an inherent condition (eg, HIV) or due to immunosuppressive medications (ie, after transplantation), are due to opportunistic oral infections, such as HSV, oral candidiasis, and other uncommon viral and fungal infections. In addition, aphthous ulcers may form.

- **Symptoms and features:** Clinical appearance and symptoms are dependent on the actual condition; however, infectious lesions may present with a more atypical or severe appearance than those found in immunocompetent patients.
- **Diagnosis:** Diagnosis is based on clinical appearance. If the actual nature is unclear, culture through swab or with tissue samples or biopsy for histopathologic analysis may be performed.
- **Management:** In addition to analgesia, management is specific to the exact nature of the lesion, with systemic antimicrobials for fungal and viral lesions and topical and/or systemic steroids for ulcerative (non-infectious) lesions.

## **10.4 Bone**

### **Osteomyelitis<sup>46</sup>**

Osteomyelitis occurs when an infectious inflammatory process spreads through the medullary spaces of the bone.

- **Symptoms and features:** An acute osteomyelitis causes significant pain and swelling in the affected area of the jaw, along with fever, lymphadenopathy, and leukocytosis. They may also present with paraesthesia and exfoliation of bony sequestra. Chronic osteomyelitis may present with swelling, pain, sinus formation, and intermittent periods of pain.
- **Diagnosis:** Diagnosis is obtained clinically and radiographically with ill-defined radiolucencies evident in the affected bone.

- **Management:** Treatment entails abscess drainage if present and antibiotic therapy. For refractory chronic osteomyelitis, surgical intervention is required, involving removal of affected bone through curettage and, in more severe cases, resection.

## Osteonecrosis<sup>48</sup>

Osteonecrosis occurs as formation of necrotic bone in the oral cavity from hypoxia, hypovascularity, and hypocellularity. Osteoradionecrosis (ORN) occurs as a result of radiation therapy exposure. The risk for ORN increases with radiation doses greater than 60 Gy, dental disease, post radiation dental extractions, and previous cancer resection. Medication-related osteonecrosis of the jaw (MRONJ) is associated with various medications used for osteoporosis or cancer therapy (eg, bisphosphonates, antiangiogenics, and Receptor activator of nuclear factor kappa-B ligand receptors). The risk for bisphosphonate associated MRONJ is increased by intravenous administration of the medication, longer duration periods of treatment, compromised immune status, concomitant steroid therapy, dental disease, and invasive oral procedures.

- **Symptoms and features:** Osteonecrosis is typically characterized by the presence of nonhealing areas of exposed bone present for at least 6 months. Affected areas may remain painless, with clinical symptoms including continuous pain, swelling, reduced jaw mobility, bony destruction, and purulent drainage when there is a secondary osteomyelitis.



**Fig. 59 MRONJ Involving the Right Maxillary Buccal Plate with Exposed Necrotic Bone.<sup>46</sup>**

- **Diagnosis:** Diagnosis is made by clinical findings and history of previous exposure to radiation therapy to affected areas or implicated medications.
- **Management:** Treatment of both ORN and MRONJ is challenging because of the nonhealing nature, and there is no established effective treatment regimen. Analgesia, long-term topical and systemic antibiotic therapy for secondary infections, pentoxifylline, and hyperbaric oxygen therapy are current treatment options. Surgical considerations include removal of affected bone by curettage or resection and vascularized bone containing a pedicle flap, although surgery may exacerbate the condition.

### Maxillary Sinusitis<sup>46</sup>

The most common causes of maxillary sinusitis are upper respiratory tract infections and allergic rhinitis. Most common bacteria implicated are *Streptococcus pneumoniae* and *Haemophilus influenzae*. As the maxillary sinus is in close proximity to the maxillary posterior teeth, 10% of maxillary sinusitis cases may result from odontogenic sources, including infection of manipulation of posterior teeth.

- **Symptoms and features:** Patients with acute sinusitis may present with headache, fever, facial pain over affected sinus, nasal or pharyngeal discharge, pain over cheekbone, toothache and tenderness to percussion of multiple maxillary teeth, periorbital pain, and pain during positional changes. Patients with chronic sinusitis may experience facial pressure and pain, sensation of obstruction, headache, sore throat, light-headedness, and generalized fatigue.
- **Diagnosis:** Clinical features and imaging studies (eg, computed tomography [CT] or Water's view radiograph) showing increased radio-opacities in the sinus aid in obtaining a diagnosis.
- **Management:** Symptom relief is typically the goal of treatment and includes decongestants, antihistamines, mucolytic agents,  $\alpha$ -adrenergic agents, corticosteroids, analgesics, and antibiotics for cases of more than 1-week duration.

## 10.5 Salivary Gland Abnormalities

### Oral Sialoliths<sup>46</sup>

Sialolithiasis is a condition whereby a calcified mass or sialolith forms within a salivary gland, usually in the duct of the submandibular gland. Less commonly, the parotid gland or rarely the sublingual gland or a minor salivary gland may develop sialoliths. Sialadenitis (infectious and noninfectious) of the gland may develop as a result. Sialolithiasis may develop because of existing chronic infection of the glands, dehydration, hyposalivation, and changes in fluid and electrolyte makeup in the gland, such as increased local levels of calcium.

- **Symptoms and features:** Usual symptoms are pain and swelling of the affected salivary gland, both of which get worse when salivary flow is stimulated (eg, with the sight, thought, smell, or taste of food or with hunger or chewing). The development of infection in the gland also influences the signs and symptoms, which include intermittent swelling of the gland, tenderness of the involved gland, palpable hard lump, lack of saliva coming from the duct, erythema of the duct, purulence discharge from the duct, and cervical lymphadenitis.
- **Diagnosis:** Diagnosis is usually made by characteristic history and physical examination and can be confirmed by radiographic imaging, sialogram, or ultrasonography.
- **Management:** The condition is usually managed by removing the sialolith. Other treatments include includes hydration, moist heat therapy, analgesics, Shock-wave therapy, and sialendoscopy.



**Fig. 60 Oral Sialolith Associated With Left Wharton Duct on the Floor of Mouth.<sup>46</sup>**

## Bacterial Sialadenitis<sup>46</sup>

Bacterial sialadenitis occurs when there is bacterial infection of the salivary gland. Hyposalivation due to various causes (eg, dehydration, medications, or Sjogren's syndrome [SS]) may lead to increased bacterial colonization of salivary gland ducts.

- **Symptoms and features**
  - Acute: Painful swelling, reddened skin, edema of the cheek, low-grade fever, malaise, serum studies showing raised erythrocyte sedimentation rate, raised c-reactive protein, leucocytosis, purulent exudate from duct openings.
  - Chronic: Unilateral, mild pain/swelling, symptoms common after meals, parotid or submandibular gland enlargement, intermittent recurrent painful swelling associated with salivary flow stimulation
- **Diagnosis:** Diagnosis is primarily made through observation of clinical features.
- **Management:** For acute bacterial sialadenitis, initial management involves empirical antibiotic therapy for oral flora coverage, with appropriate cultures obtained. In chronic recurrent sialadenitis or chronic sclerosing sialadenitis, symptomatic periods are managed with conservative therapies, such as hydration, analgesics, sialogogues to stimulate salivary secretion, and regular, gentle gland massage. If episodes occur more than 3 times per year or are severe, surgical excision of the affected gland may be considered.

## Mumps<sup>46</sup>:

Mumps (paramyxovirus) primarily affects both parotid glands and is highly contagious and can spread rapidly, transmitted by respiratory droplets or direct contact with an infected person. Viral parotitis may also be a result of infection due to HIV, Epstein-Barr virus, coxsackievirus, and influenza A and parainfluenza viruses.

- **Symptoms and features:** Prodromal symptoms include low-grade fever, headache, and malaise, followed by swelling of one or both parotid glands. Patients may also have a sore face and ears and

difficulty talking.<sup>43</sup> In the case of mumps, symptoms typically occur 16 to 18 days after exposure.

- **Diagnosis:** Diagnosis is mostly based on clinical symptoms, with blood testing showing leukopenia with relative lymphocytosis and elevated serum amylase.
- **Management:** Treatment is symptomatic and involves analgesics and antipyretics. Symptoms resolve after 7 to 10 days.



**Fig. 61 Parotid Gland Swelling Seen in Mumps.**

### **Sjogren's Syndrome<sup>49</sup>**

SS is a chronic autoimmune inflammatory disorder primarily affecting exocrine glands, such as salivary and lacrimal glands, due to lymphocytic infiltration but can also have extraglandular organ involvement.

- **Symptoms and features:** In addition to primary complaints of xerostomia and/or dry eyes, pain symptoms in patients may vary, with patients with SS showing a higher incidence of burning mouth, glossodynia, and bilateral distal neuropathies. Other features include fatigue, myalgia, and mild cognitive dysfunction; some may present with parotitis.
- **Diagnosis:** Diagnosis is based on clinical symptoms, specific answers to a set of validated questions on symptoms, and serology for anti-Sjogren's antibodies (anti-Ro/SSA and/or anti-La/SSB). Other tests may include scintigraphy and minor salivary gland lip biopsy to evaluate for lymphocytic infiltrate.
- **Management:** Treatment measures are targeted toward alleviating individual symptoms. For oral symptoms, focus is on moistening of the mouth, measures for salivary stimulation (both local and systemic), and analgesia for pain.

## Salivary Gland Neoplasms<sup>46</sup>

Salivary gland neoplasms, both of the benign and malignant varieties, are relatively rare. Most common benign tumours include pleomorphic adenoma and papillary cystadenoma lymphomatosum. Among the most common malignant salivary gland neoplasms are mucoepidermoid carcinoma and adenoid cystic carcinoma.

- **Symptoms and features:** Most major salivary gland neoplasms arise as a slowly enlarging painless mass in an otherwise normal appearing gland. Minor salivary gland tumours vary in presentation, with painless masses on the palate or floor of mouth being the most common presentation. Pain, numbness, and nerve paralysis may be a feature in adenoid cystic carcinoma because of its nature of infiltrating around nerves.



**Fig. 62 Adenocarcinoma on the Palate.**<sup>46</sup>

- **Diagnosis:** If suspicion for such neoplasms arises through signs and symptoms, imaging studies (eg, CT, MRI, ultrasound) and biopsy to obtain definitive histologic diagnosis are warranted.
- **Management:** In the case of both benign and malignant tumours, surgical excision is indicated. Malignant tumours may require subsequent radiation and/or chemotherapy depending on the staging and type of tumour.

## Differential diagnosis of intraoral pain<sup>23</sup>

Condition	Signs and Symptoms
Dental caries	<ul style="list-style-type: none"> <li>Decay present clinically and on radiograph</li> <li>If extending to the pulp, can lead to more severe sharp, shooting pain</li> </ul>
Dental abscess	<ul style="list-style-type: none"> <li>Possible periapical radiolucency noted on radiograph</li> <li>Cariou or periodontal defect noted</li> <li>Possible swelling and/or purulence in adjacent soft tissues</li> </ul>
Cracked tooth	<ul style="list-style-type: none"> <li>History of parafunction</li> <li>Large restoration present</li> <li>Presence of craze lines</li> <li>Pain on release and biting</li> </ul>
Sensitivity	<ul style="list-style-type: none"> <li>Galvanic effects due to proximity of metal restorations</li> <li>Can occur postoperatively after a restoration due to proximity to the pulp or leakage between the tooth and restoration seal</li> <li>Presence of dentin exposure or root exposure</li> </ul>
Premature bite/occlusal interferences	<ul style="list-style-type: none"> <li>Clear marking of an occlusal discrepancy with articulating paper</li> <li>Resolution with adjustment</li> </ul>
Dry socket	<ul style="list-style-type: none"> <li>1–3 d after extraction</li> <li>Loss of blood clot</li> <li>Limited relief with conventional pain medication</li> </ul>
Periodontal (gingivitis and periodontitis)	<ul style="list-style-type: none"> <li>Gingival erythema and/or edema with possible bleeding</li> <li>Poor hygiene</li> <li>Accumulation of plaque and calculus</li> <li>Presence of deep periodontal pockets</li> <li>Horizontal or vertical bone loss noted on radiograph</li> <li>Pain is in general more dull and throbbing</li> <li>Pain sometimes correlates with amount of stimulus</li> </ul>
Pericoronitis	<ul style="list-style-type: none"> <li>Inflamed tissue surrounding an unerupted third molar</li> </ul>
Mucosal pain	<ul style="list-style-type: none"> <li>Presence of vesiculoerosive conditions (eg, lichen planus, pemphigoid, pemphigus), soft tissue pathology, infection, trauma, xerostomia/dry mouth</li> </ul>

## Intraoral Pain Disorders With Selected Imaging Modalities and Radiographic Appearance<sup>50</sup>

Common Pain Disorders	Selected Imaging Modality	Radiographic Appearance
<b>Odontogenic pain</b>		
Dental caries, fracture of crown or root	Intraoral/panoramic radiography	Radiolucent
Apical periodontitis	Intraoral/panoramic radiography/CBCT	Radiolucency at the apex of a tooth with caries or a large restoration, or radiopacity at the apex of a tooth with a large restoration
Periodontal pain (periodontal abscess)	Intraoral/panoramic radiography	Intercrestal and furcal bone loss
Pericoronitis	Cannot be diagnosed by radiograph alone, intraoral/panoramic radiography	A bony defect with sclerosing osteitis associated with the crown of an unerupted third molar
Pulpal and periodontal pain secondary to fractured teeth	Intraoral/panoramic radiography	Without displacement of tooth fragments, diagnosis is difficult
Odontogenic cyst or tumor	Depending on lesion size: intraoral/panoramic radiography/CBCT/CT	Radiolucent/radiopaque, displacement/resorption of teeth, expansion/perforation of cortical bone
<b>Nonodontogenic pain</b>		
Musculoskeletal, neurovascular, neuropathic, psychogenic	Panoramic radiography/CBCT/CT, MRI	Bone and soft tissue variations
<b>Painful oral soft tissue lesions</b>		
Localized mucogingival and glossal pain, infections, mucosal trauma, pain associated with cancer, geographic tongue, immune-mediated inflammatory conditions	Panoramic radiography/CBCT/CT to rule out osseous involvement	No radiographic evidence without osseous involvement

## Conclusion

Orofacial pain disorders are highly prevalent and debilitating conditions involving the head, face, and neck. These conditions represent a challenge to the clinician since the orofacial region is complex and therefore, pain can arise from many sources. The clinician needs to have solid knowledge of the pain conditions that arise from these structures for proper diagnosis and a multidisciplinary approach of management is strongly recommended.<sup>41</sup>

The orofacial pain classification as outlined by Okeson is divided into physical (Axis 1) and psychological (Axis 2) conditions. Physical conditions comprise temporomandibular disorders (TMD), which include disorders of the temporomandibular joint (TMJ) and disorders of the musculoskeletal structures (eg, masticatory muscles and cervical spine); neuropathic pains, which include episodic (eg, trigeminal neuralgia [TN]) and continuous (eg, peripheral/centralized mediated) pains and neurovascular disorders (eg, migraine). Psychological conditions include mood and anxiety disorders.<sup>41</sup>

Basic and clinical research support that neuroplastic changes involving the peripheral and central nervous system as well as immune mechanisms are involved in the development and maintenance of chronic neuropathic pain. Commonly, neuropathic pain conditions in the orofacial region are divided into episodic pain disorders, including trigeminal neuralgia (TN) and glossopharyngeal neuralgia, and continuous pain disorders that frequently result from deafferentation after injury in the peripheral and central nervous system, which is the case in neuromas and idiopathic trigeminal neuropathic pains such as atypical odontalgia (AO). There is considerable variability in prevalence, cause, and treatment of these disorders.<sup>41</sup>

Trigeminal neuropathic pain conditions can arise from injury secondary to dental procedures, infection, neoplasia, or disease or dysfunction of the peripheral and/or central nervous system. Anticonvulsant medications are the first-line treatment choice for the management of neuralgic type of pains. Tricyclic antidepressants and serotonin noradrenaline reuptake inhibitors, as well as topical medications such as capsaicin and lidocaine are used for the more continuous type of pain.<sup>41</sup>

A temporomandibular disorder (TMD) defines a number of clinical problems that involve the masticatory musculature, the TMJ, and associated structures. TMD is the most prevalent condition for which patients seek treatment. The careful evaluation of these facial structures in conjunction with clinical symptoms is crucial in forming a proper differential diagnosis. The patient may present with jaw ache, earache, toothache, facial pain, and/or headache; however, the complaint may be as benign as general facial fullness or pressure.<sup>41</sup>

Treatment planning depend on various factors, including the chief complaint, medical history, presenting symptoms, examination, and diagnosis. In the past, TMD cases have sometimes been considered to be difficult to diagnose and problematic to treat; however, thanks to ongoing research in orofacial pain and pain management, clinicians are able to use a more standardized classification and better diagnostic and therapeutic methods to offer patients a wide range of treatment modalities with higher success rates.<sup>41</sup>

Another source of nonodontogenic toothaches and orofacial pains may present as a disturbance of the neurovascular system. Migraine is commonly thought of as a headache that is unilateral and that causes pain behind the eye, neck, and cranium; however, migraine headaches can also present in the lower part of the face, particularly in the teeth. It is very important that the orofacial pain clinician is aware of the possibility of this localization in addition to the clinical features that a migraine presents to avoid misdiagnosis as an odontogenic toothache or other type of orofacial pain, leading to improper management.<sup>41</sup>

Those experiencing intraoral pain associated with dental and oral diseases of various causes are likely to pursue treatment from medical and dental providers. A range of causes for intraoral pain include odontogenic, periodontal, oral mucosal, or contiguous hard and soft tissue structures to the oral cavity. Providers should be vigilant when diagnosing these, as they should be among the first in their differential diagnoses to be ruled out.<sup>46</sup>

Together, these disorders of the trigeminal system impact the quality of life of the sufferer dramatically. Orofacial pain management can be challenging and the clinician should be aware of the different etiologies and characteristics of the diverse disorders of the orofacial region. The

orofacial pain specialist has the experience and the knowledge to provide a correct diagnosis and management of these conditions. A multidisciplinary approach is ideal in the management of orofacial pain disorders.<sup>41</sup>

Understanding the pain neurobiology of the trigeminal system is key to the development of better and safer therapeutics. It is necessary to evaluate the efficacy of current and new therapies for the management of orofacial pains. New and exciting discoveries from the bench to the bedside will hopefully put an end to the burden of chronic orofacial pain conditions in the near future.<sup>41</sup>

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# Study about Unique, Cost-effective and Retentive Removable Prosthesis to Rehabilitate Long Span Kennedy's Class I Edentulism with Custom Attachment System

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## ABSTRACT

**Aim:** This case study discusses a unique custom-made attachment on the abutment teeth that was used to improve the retention and stability of a removable partial denture. It also sheds light on a low-cost method for changing the abutment teeth with the help of crowns and custom-made attachments.

**Background:** Achieving retention in Kennedy's class I bilateral edentulism usually has an impact on the periodontal health of the abutment teeth, and eventually the retention is compromised. The patient's masticatory efficiency is also impacted by distal extension edentulism. The rehabilitation of a patient with the long span Kennedy's class I condition is complicated by the lack of a sufficient number of abutments to support the prosthesis. For the same reason, conventional removable prostheses with clasps and cantilever fixed partial prostheses are not recommended in this situation.

**Case Description:** A case involving the Kennedy class 1 modification 1 partially edentulous arch with missing 1st and 2nd molars, as well as central incisors, was rehabilitated with a low-cost custom attachment that used a die-pin and sleeve to provide a fixed prosthesis on abutment teeth and a removable prosthesis with missing teeth.

**Conclusion:** This procedure has the following advantages: better retention than traditional RPDs, protection of abutment health by repairing it with a crown, ease of placement and removal, and low cost.

**Clinical Significance:** The entire technique demands less skill compared to semi-precision and precision attachments.

**Keywords:** *Cantilever fixed partial dentures (FPDs); custom attachment; die pins and sleeves; distal extension removable partial denture (RPDs); Kennedy's class 1 edentulism.*

## 1. BACKGROUND

Tooth erosion/loss is a big issue that affects a person in every way. An edentulous space, which can be partial or entire, indicates tooth loss [1]. There are numerous classifications that are advised for classifying edentulous arches in order to identify tooth-to-ridge pairs. Kennedy's classification for partially edentulous arches is currently the most widely accepted classification. Kennedy's

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classification allows for instant visualisation, recognition of prosthesis support, and evaluation of removable partial denture design aspects [2,3,4].

The patient's satisfaction with removable partial denture (RPD) therapy has become an increasingly important factor in prosthetic treatment [5-7]. Rehabilitation options for the partially edentulous patient with a single tooth or multiple missing teeth include interim acrylic resin removable partial denture (RPD), conventional cast partial denture, partial denture with attachment, fixed partial denture, or implant retained prosthesis. Clinical decision making is critical in deciding the most suitable treatment option for a patient [8].

Removable partial dentures are considered a widely acceptable means of replacing missing natural teeth for restoring aesthetics and function in partially edentulous patients [9]. The widespread use of acrylic partial denture is attributed to advantages like the ease of fabrication and modification [10]. Practitioners and researchers have shown that when a removable partial denture is placed into a healthy oral environment, when the design is developed by a dentist to meet specific needs of the patient, and when good oral hygiene is maintained, long-term success with removable partial denture treatment can be expected [11]. Different methods to control the load delivered from Kennedy Class I RPDs to both teeth and residual ridges were suggested by Lammie and Laird [12]. These methods include reducing the load, distributing the load between teeth and residual ridges, and distributing the load widely.

This case report discusses about the cost-effective method to increase the retention and enhance the stability of the removable partial denture by modifying the abutment teeth with the help of crowns and custom-made attachments (consisting of matrix made of sleeve and patrix made of die pin).

## **2. CASE DESCRIPTION**

A 58-year-old male patient reported to the Department of Prosthodontics, KAHER Vishwanath Katti Institute of Dental Sciences, Belgaum, Karnataka with a complaint of unaesthetic appearance and difficulty in chewing and swallowing food because of the completely edentulous mandibular arch and multiple missing upper anterior and posterior teeth due to decay. On examination of the maxillary arch, there was a Kennedy class 1 modification 1 partially edentulous arch with 1<sup>st</sup> and 2<sup>nd</sup> molars missing along with central incisors (Figs. 1 and 2a).

Diagnostic impressions were made using irreversible hydrocolloid impression material (Tropicalgin; Zhermack, Italy). Casts were prepared using type III dental stone (Kalstone; Kalabhai Karson Pvt. Ltd., Mumbai, Maharashtra, India). Tentative jaw relation was recorded to assess the interarch space, which was found to be satisfactory. A complete mandibular denture and a maxillary removable partial denture was fabricated without clasps in heat cure acrylic resin (Meliodent heat cure, Kulzar Mitsui Chemicals Group).

Four maxillary premolars were prepared with shoulder finish line to restore them with porcelain fused to metal crowns. Final impression was made using two stage technique with putty and light body consistency of polyvinyl siloxane impression material (Aquasil Ultra Monophase; DENTSPLY, Germany). Cast was poured with die stone (Ultrarock; Kalabhai Karson Pvt. Ltd., Mumbai, Maharashtra, India).

A mold of die pin (Crosspin; Nordin, Switzerland) was made with the help of putty consistency polyvinyl siloxane and was replicated with pattern resin wax (Pattern Resin; GC Corporation, Tokyo, Japan). Four straight die pin replicas were made. These die pin replicas were attached to the horizontal extension of wax in continuation with wax coping of the prepared premolar crowns as shown in (Fig. 3a). Parallelism of these die pin replicas were checked with a surveyor. Entire assembly was then invested and casted with cobalt chromium alloy. Casted assembly was finished and polished and was tried intra orally for evaluating the fitting of prosthesis before ceramic layering.

After this, the ceramic layering was carried out on the crowns (Fig. 3b). Total thickness of maxillary removable prosthesis was measured and then the die pin extensions were trimmed based on the

thickness of the prosthesis and die pin sleeves were tried on it to achieve perfect fit (Fig. 4). The entire framework was placed in patient's mouth (Fig. 5) and with the help of articulating paper (Deepti Dental Products India Pvt. Ltd; M.I.D.C. Ratnagiri) the 4 points were marked on the intaglio surface of removable partial denture where the sleeves will be placed eventually. Holes were made on these 4 points wide enough to fit the sleeves and in a manner, which won't perforate the overlying acrylic teeth. Trial of denture was done along with sleeves placed on the die pin extensions. Retention was achieved and proper occlusion of maxillary RPD was established with mandibular complete denture.

Prepared assembly is cemented on the 4 prepared premolars with GIC luting cement (GC Luting and Lining Cement; GC Corporation, Tokyo, Japan). Hard liner (Kooliner- Hard chairside denture reliner; GC America Inc. ALSIP IL 60803) was applied on the holes of RPD and petroleum jelly was applied on the die pin extensions for easy removal. Sleeves were placed on the extensions and the RPD with hard liner was placed and the patient was asked to bite in centric occlusion. After the setting of hard liner, the RPD was removed and it was observed that sleeves were incorporated in the intaglio surface of denture (Fig. 6). The excess was trimmed off from the tissue-fitting surface of the prosthesis. Prosthesis was inserted with oral hygiene instructions and patient was intimated about the importance of recall visits.



**Fig. 1. Pretreatment Intraoral View**

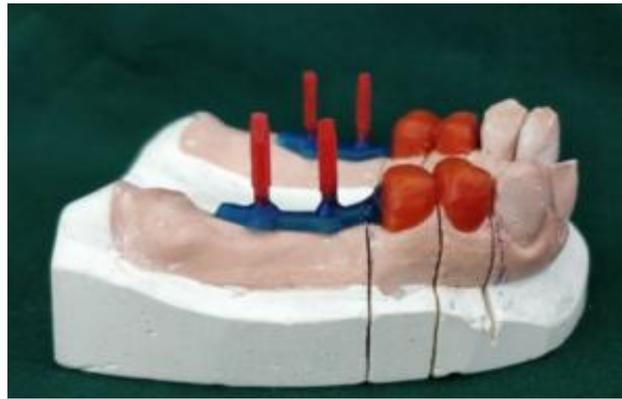


(a)



(b)

**Fig. 2. Pretreatment extra oral view Post treatment extra oral view**



**(a) Wax pattern with pattern resin index**



**(b) PFM crowns with customized attachment**

**Fig. 3.**



**Fig. 4. Reduction of attachments according to the thickness measured**



**Fig. 5. Intraoral view of cemented crowns with attachment**



**Fig. 6. Sleeves picked up in the RPD**

### **3. DISCUSSION**

Distal extension removable partial dentures have long been implicated in the increase in mobility and the destruction of the supporting structures of the primary abutment teeth. Various clasping systems have traditionally been used to retain distal extension removable partial dentures, and other designs have been proposed to minimize torqueing forces on the abutment teeth. Movement of the abutment teeth is influenced by many factors, such as the location of rests, the contour and rigidity of connectors and the extension of the denture base [13].

Status of the abutment teeth in distal extension situation were affected by removable partial denture (RPD) wearing. According to a study by Mahmood WA almost 30% of the abutments progressed to periodontal disease, 16.9% developed caries and 12.4% had to be extracted when the denture was used for a mean of 2 – 6 years. Caries activity and extraction of the abutments were observed more in the third to ninth years of denture wearing [14].

Displacement of the denture, especially in the area of the distal extension, is more likely. To prevent displacement of the denture, precision attachments or conventional clasps have been widely used. In addition, denture bases are usually fitted to the surrounding tissue as accurately as possible.

However, the rotational tendency of the RPD after long-term use cannot be eliminated completely, regardless of design and fit of the denture.

Dental implants are not considered in all patients due to systemic conditions and as many patients cannot afford them, particularly those with large edentulous areas. For reconstruction among these patients, fixed-type prostheses usually require more implants for support than removable prostheses. In addition, these patients may require several surgeries to increase bone mass, thus making the entire treatment complicated. However, if a traditional removable partial denture (RPD) is used, insufficient retention may induce problems [15].

In this case FPD was contraindicated due to a long edentulous span and the cost factor which contraindicated implant supported prosthesis. This custom attachment was then designed with inexpensive materials like straight die pins and sleeves making it affordable for the patient. The unique yet not at all technique sensitive design was easy to understand by the lab technician also as compared to semi-precision and precision attachments. Periodontal health of the abutment teeth was preserved, and retention achieved was snap fit as seen in cast partial denture. Flexible nature of sleeves helped to distribute the occlusal forces and will lead to less resorption. Retention was increased so as the stability of the overall prosthesis. Occlusal efficacy was also increased. Prosthesis was cost effective.

Periodic recalls are a must in this case. Maintaining good oral hygiene will make this prosthesis last for a very long time by not affecting the periodontal health of the abutments.

#### **4. CONCLUSION**

Case report describes about a novel technique of custom made attachment restoring the lost teeth in Kennedy class I by taking into consideration the disadvantages of treatment options like - conventional RPD (hampering the periodontal health of abutment teeth) and Implant supported prosthesis (with its limitation) and having advantages of retention better than conventional RPDs, protection of abutment health by restoring it with crown, easy to place and remove and very cost effective.

#### **CLINICAL SIGNIFICANCE**

The entire technique demands less skill compared to semi-precision and precision attachments.

#### **COMPETING INTERESTS**

Authors have declared that no competing interests exist.

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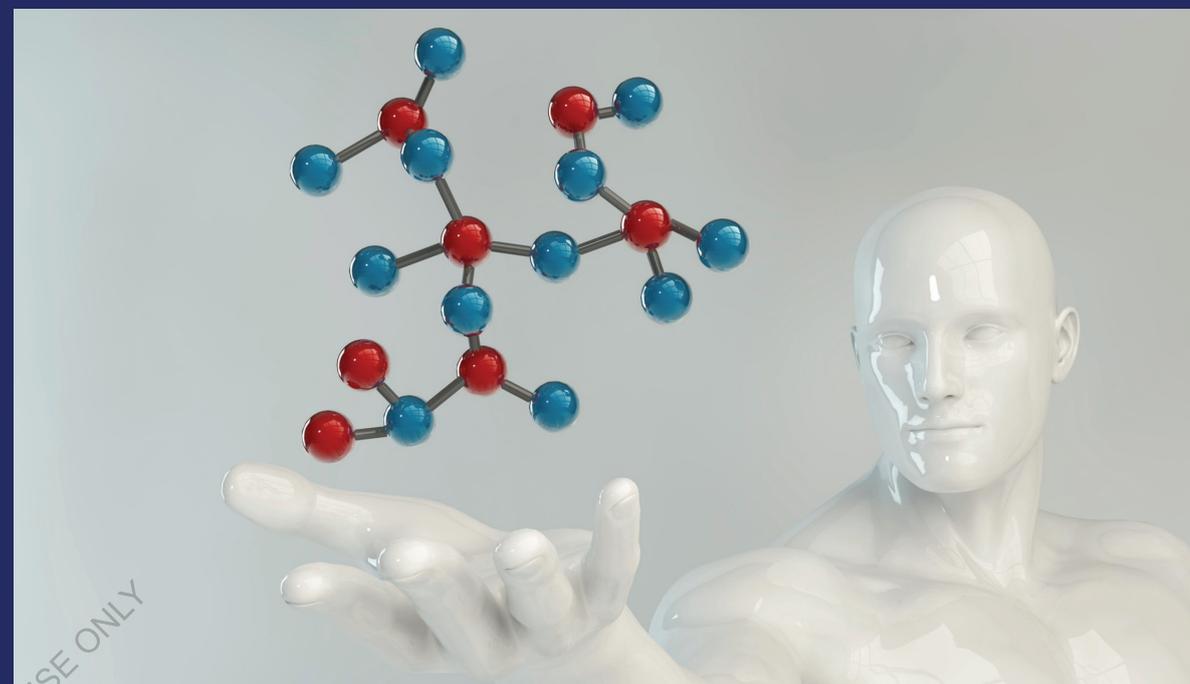
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Oral cavity acts as a niche for numerous microorganisms. Among them, some are pathogenic and cause infections. Hence to control and prevent such infections, a lot of researches are conducted on different materials using various advanced techniques. Nanotechnology and nanoscience have emerged in the recent years exploring the antimicrobial effects of metal nanoparticles. Distinct physical, biologic and chemical properties of metallic oxide nanoparticles make them efficient antimicrobial agents. Application of this nanotechnology in dentistry termed as Nanodentistry, has brought many effective changes in the dental materials.



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HEMA KANATHILA  
ASHWIN PANGI  
RAHUL JAISWAL

# METALLIC OXIDE NANOPARTICLES AS ANTIMICROBIALS

APPLICATIONS IN DENTISTRY



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**METALLIC OXIDE NANOPARTICLES AS  
ANTIMICROBIALS AND THEIR  
APPLICATIONS IN DENTISTRY**

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# CHAPTER -1

## INTRODUCTION

Nanotechnology is a rapidly growing entity in the modern science. The impact of nanotechnology has brought many changes in treatment aspects in healthcare sector. Nano sized materials show different properties. Colour, conductivity, strength etc change in case of nanosized materials. This nanotechnology in dental field, “Nanodentistry” is a multidisciplinary field of science and technology, that uses nanomaterials and devices in diagnosing, treating and preventing oral and dental diseases, relieving pain and improving dental health using nanosized material.

Bacterial infections remain as a gross reason for morbidity and mortality in this world. The main concern is about multi drug resistant bacterial strains and biofilm-associated infections. Despite the innumerable potent antibiotic drugs and other existing modern antibacterial means, bacterial infections remain as a challenge. Antimicrobials used in the clinical field at present have shortfalls like risk of microbial resistance, weak antimicrobial activities, difficulty in functioning in a dynamic environment etc. Long-term effective antibacterial and biofilm-preventing materials account for a prompt need in medicine and dentistry. Hence a gross change in the antimicrobial therapy was required and the attention was moved to nanotechnology. The new and emerging nanoparticle-based biomaterials in healthcare field brought a good change in various materials as well as therapies applied.

Nanotechnology has been applied widely in medical as well as dental field. This has brought immense changes in research as well as in the application field, bringing a lot of improvements in diagnosing, preventing and treating oral and dental pain and diseases. Metallic oxide nanoparticles have been applied in biomedical field such as drug delivery, anticancer, antifungal, antibacterial etc.

Due to the increase in the number of microorganisms and their resistance to antimicrobials, scientists have researched on materials that can be effective against microorganisms as well as cost effective. Decreasing the size of the particle has been found to be an efficient tool in improving the biocompatibility. Nanoparticles of metals have various applications in industry, agriculture and healthcare. Antimicrobials in the form of nanoparticles have been studied, and suggested their use as bactericidal materials. In various research works, metals and metallic oxides have proved to show antimicrobial activity at low concentrations.<sup>1,2,3</sup>

Nanotechnology has become an integral part in dental research. The antimicrobial activity of different metals like silver (Ag), gold (Au), titanium (Ti), copper (Cu) and zinc (Zn), which are considered to be safe for human beings, have been used in various areas since a long time<sup>4</sup>. As years passed, Metallic oxide nanoparticles such as silver oxide (Ag<sub>2</sub>O), titanium dioxide (TiO<sub>2</sub>), zinc oxide (ZnO), calcium oxide (CaO), copper oxide (CuO) and magnesium oxide (MgO) were identified to display antimicrobial activity.

Oral cavity has numerous microorganisms which can cause many infections. Dental and periodontal diseases have multiple etiological factors, but the common being bacteria. Oral infections can influence the progression and pathogenesis of many systemic diseases like cardiovascular disease, bacterial pneumonia etc. Hence, maintaining oral health is a major goal in dentistry. Nanomaterials along with nanotechnology in dentistry help in bringing down the microbial infections.

The accurate mechanism of action of nanometals is still being studied. The mechanism of action thought to be behind its antimicrobial activity is that they act by deactivating the cellular enzyme and DNA by engaging the electron donating groups such as carboxylates, Amides, Thiols, Indoles, Hydroxyles, etc. They cause pores in bacterial cell walls, thus leading to increased permeability leading to cell death. Certain possibilities which have been put forward

include free metal ion toxicity due to the dissolution of metals from the surface of nanoparticles or oxidative stress caused by generating reactive oxygen species (ROS) on the surfaces of nanoparticles.<sup>5</sup>

Antimicrobial effectiveness depends on the kind of the materials used for preparing the nanoparticles and its particle size.<sup>6,7</sup> Reducing the particle size of the materials is considered to be an efficient tool for improving biocompatibility.<sup>5</sup> Nanotechnology at present gives a good platform for changing the physical and chemical properties of various metals to transform them into effective antimicrobials. Hence antimicrobial efficacy of various nanometals are dedicated to their morphology and physicochemical properties.<sup>6,8</sup>

The antimicrobial efficacy of nanoparticles are found to be greatly influenced by its shape.<sup>9,10</sup> Nanoparticles when compared to their own larger particles show different characteristic features. This can be credited to the fact that the surface/volume ratio of the nanoparticles increase with the decrease in the particle size.<sup>11,12</sup> Because of this small particle size, nanoparticles have a better penetration into cells and tissues, showing strong bactericidal effect.<sup>13,14,15</sup> It is believed that, the positively charged surface of the metallic nanoparticles help in their attachment to the negatively charged surface of the bacteria thus resulting in a higher bactericidal effect.<sup>6</sup>

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# CHAPTER 2

# HISTORY

A few researchers think nanotechnology as a newer form of science that did not develop until the late 1980s or early 1990s. But some others have traced it back to the 1950s.

**1867** - In 1867 by James Clerk Maxwell proposed that a tiny entity known as Maxwell's Demon shall be able to handle individual molecules in the time ahead.

**1914** - During the first decade of the 20th century, the first observations and size measurements of nano-particles was made. Richard Adolf Zsigmondy did a research of gold sols and other nanomaterials with sizes down to 10 nm or less. He was the first person who used the term "nanometer" for specifying the size of a particle.

**1959** - The Nobel prize winning physicist Prof. Richard Feynman described atomic scale fabrication of nanomaterials. Prof Feynman suggested that nanomachines, nanorobots and nanodevices could be utilized to develop a wide variety of precise microscopic instruments and tools.

**1974** - Norio Taniguchi, coined the term "nanotechnology" in his article and the name gained popularity.

**1977**- Many researchers accept to the fact that the term "Nanotechnology" was coined by Prof. Kerie E. Drexler, researcher at Massachuehettes Institute of Technology. Researchers claim that that Prof. Drexler also introduced molecular nanotechnology concepts in the late 1970's.

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# **CHAPTER 3**

**SILVER(Ag) AND SILVER OXIDE**

**NANOPARTICLES (Ag<sub>2</sub>O)**

Of all the metal nanoparticles, silver nanoparticles have been effectively used as antimicrobial agent against bacteria, fungi, and viruses. Applications of Silver and its compounds have been used for disinfection of various medical devices and in water purification. Among nanometals, with antimicrobial properties, silver is being used against microbial infections since many years. Silver compounds are commonly used to treat wounds and a number of infectious diseases. Silver was reported to be an efficient antibacterial agent against different pathogens in various studies.

Silver nanoparticles are the most popular inorganic nanoparticles employed as antimicrobial agents in numerous products and has vast biomedical applications. The antibacterial activity of silver nanoparticles reduces patient infection, antibiotic dependence as well as associated costs. Besinis et al. in their study concluded that the antibacterial effectiveness of Ag nanoparticles against *S. mutans* was high-up than that of chlorhexidine.<sup>16</sup>

Hernández-Sierra et al, in their comparative study on the antimicrobial activity of Ag nanoparticles, ZnO, and Au against *Streptococcus mutans* (*S. mutans*) showed that Ag exhibited the highest activity against *S. mutans*. They also suggested that as *S. mutans* being responsible for dental caries, Ag nanoparticles may be considered helpful.<sup>17</sup>

Properties based on the shape of nanoparticles have also been investigated by various researchers. Bera et al stated that the size as well as the shape of the fluorescent Ag nanoparticles (1–5 nm) controlled its antimicrobial activity against *Staphylococcus epidermidis* and *Bacillus megaterium* and *Pseudomonas aeruginosa*.<sup>18</sup>

Ag<sub>2</sub>O nanoparticles were found to have good antimicrobial activity. Sondi and Salopek-Sondi in their study suggested the antimicrobial efficacy of Ag<sub>2</sub>O nanoparticles against *E. coli*.<sup>19</sup>

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# **CHAPTER 4**

## **TITANIUM DIOXIDE(TiO<sub>2</sub>)**

### **NANOPARTICLES**

TiO<sub>2</sub> nanoparticles are considered as advanced materials because of their impressive optical, photo-catalytic and dielectric, properties. Titanium dioxide (TiO<sub>2</sub>) is used as a disinfecting and cleansing material. It is used for environmental purification which can be attributed to its photo induced super-hydrophobicity as well as antifogging results.<sup>20</sup> These properties are very well utilized in eliminating bacteria and harmful agents from air and water.<sup>21</sup> These nanoparticles are also used for sterilizing surfaces in healthcare centres.

Antimicrobial property of TiO<sub>2</sub> is attributed to its crystal structure, shape and size .<sup>22</sup> The oxidative stress via the generation of reactive oxygen species (ROS) may be an important mechanism for TiO<sub>2</sub> nanoparticles. The ROS causes site specific DNA damage.<sup>23,24</sup> Haghghi et al. in their research on the antifungal effect of TiO<sub>2</sub> nanoparticles against fluconazole resistant standard strains of *Candida albicans*, showed that the synthesized TiO<sub>2</sub> nanoparticles had improved antifungal effect on the fluconazole resistant strain of *C. albicans* biofilms. Therefore, it was suggested that TiO<sub>2</sub> nanoparticles could be used effectively to inhibit the fungal biofilms especially those formed on the surface of medical devices.<sup>22</sup>

TiO<sub>2</sub> nanoparticles have the potential to produce ROS under UV light. Photocatalytic properties of the TiO<sub>2</sub> nanoparticles make them efficient in eradicating bacteria. But, the use of TiO<sub>2</sub> nanoparticles under UV light can cause genetic damage in human cells and tissues, hence restricted. It has been found that, doping of TiO<sub>2</sub> nanoparticles with metal ions can be a good idea to solve this problem. <sup>25</sup>Carré et al. noted that the antibacterial activity was accompanied by lipid peroxidation that causes the disruption of the cell integrity.<sup>26</sup>

*Main characteristics as antimicrobial agent-*

- Photocatalytic activity
- High stability
- Bactericidal effects on both Gram-positive and Gram-negative bacteria
- High stability
- Effective antifungal for fluconazole resistant strains.

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# **CHAPTER 5**

## **ZINC OXIDE NANOPARTICLES(ZnO)**

Zinc oxide is a bio safe material which exhibit antibacterial properties. The white color, UV-blocking, and ability to prevent biofilm formation makes them suitable for fabric and glass industries as coating materials for medical and other equipment. ZnO nanoparticles were shown to have broad range of antimicrobial activity against various microorganisms, and it was dependent on the concentration and particle size. Emami-Karvani et al.<sup>27</sup> studied the antimicrobial activity of ZnO nanoparticles against *E. coli* and *S. aureus* bacteria, by using different concentrations and reducing the particle size. They concluded that the antibacterial activity of ZnO nanoparticles increased by changing the concentrations and by reducing the particle size. This improved antibacterial activity of ZnO nanoparticles compared to its microparticles was mainly attributed to the surface area enhancement.

ZnO nanoparticles are of low cost. They are effective size- dependent antimicrobial against *Klebsiella pneumonia*, *Listeria monocytogenes*, *Salmonella enteritidis*, *Streptococcus mutans*, *Lactobacillus* and *E. coli* and with low toxicity to human cells. ZnO nanoparticles exhibit high photocatalytic properties which enhance their antimicrobial efficiency. These nanoparticles generate ROS under UV light as well.

#### ***Proposed mechanism of antimicrobial action-***

By ROS generation on the surface of the particles and zinc ion release leading to membrane dysfunction and internalization of nanoparticles into cell.

Azam et al. in their comparative investigation of antimicrobial activity of ZnO, CuO, and Fe<sub>2</sub>O<sub>3</sub> nanoparticles against Gram negative and Gram-positive bacteria reported ZnO as the most bactericidal.<sup>28</sup> Some studies have demonstrated that metal ion doped nanoparticles can increase antimicrobial properties of metallic nanoparticles. Sun et al. from their studies

suggested that the titanium doped ZnO powders showed antimicrobial action against E. coli and S. Aureus.<sup>29</sup>

The treatment using zinc was approved by the FDA and an added point is nowadays Zn is available as a food additive.

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# **CHAPTER 6**

## **COPPER (Cu) AND COPPER OXIDE (CuO)**

### **NANOPARTICLES**

Copper nanoparticles have unique biological, chemical and physical properties, antimicrobial activities as well as the low cost of preparation. Eventhough copper oxide (CuO) nanoparticles are found to be effective against various bacterial pathogens, their antibacterial efficacy has been inferior to that of Ag or ZnO. Hence, a higher concentration of nanoparticles is required to achieve the same good results. Cu is much less expensive than other nanosized metal particles, it can be utilized for efficacy enhancement like the other metallic nanoparticles, to express their antibacterial activity by membrane disruption and ROS production.

Mahapatra et al.investigated the antibacterial activity of CuO nanoparticles and reported that copper oxide nanoparticles showed good antibacterial activity against the tested bacteria.<sup>30</sup>

Azam et al investigated the antibacterial activities of CuO nanoparticles against *S. aureus* and *B. subtilis* and *Pseudomonas aeruginosa* and *E. coli*. According to their study, nanoparticles exhibited size dependent -inhibitory effects against both groups of the mentioned bacteria. These nanoparticles prevent bacterial growth by entering the nano- pores existing on the cellular membranes of most of the bacteria.<sup>31</sup>

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# **CHAPTER 7**

## **NANOMETALS AS ANTIMICROBIALS IN DENTISTRY**

Nanomaterials have been considered as materials in which the shape as well as the molecular composition can be controlled at nanometre scale. Hence, they have extraordinary properties which are useful for the development of new and improved applications in dentistry. In dentistry, several research efforts are being carried out, for the improvement of the properties of materials used in dentistry.

Various studies done on the different nanoparticles were applied into different aspects of dentistry starting from the biomaterial aspect to the treatment level considerations. Silver, titanium dioxide and zinc oxide nanoparticles have been extensively studied and applied in various dental materials.

Nanomaterials are used in various dental applications –

- **Tissue regeneration**
- **Reinforcement of polymeric composites**
- **Endodontics application**
- **Implants as coatings.**

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# **CHAPTER 8**

**NANOMETALS AS ANTIMICROBIALS IN**

**DENTAL MATERIALS**

## **MATERIAL ASPECTS**

Dental health care standards has been enhanced due to the development of newer nano-biomaterials and also by changing the properties of the existing materials.

These promising materials will find wider dental applications with improved therapeutic application.

### **Impression Materials-**

Dental impressions form vital part of all specialities of dentistry. The most commonly used impression material in dentistry is the hydrocolloid alginate impression material. Impressions get contaminated with saliva as well as blood during clinical procedures and there are chances of cross infection. The incorporation of different antimicrobial agents into impression materials could be effective in decreasing cross-infection.

Alginate powder can be incorporated into water containing silver hydrosol to provide an antimicrobial effect, which will prevent the contamination of stone cast from the infected impression.<sup>32,33</sup> Wangchuk et al, in their study, evaluated the *in vitro* antimicrobial efficacy of silver nanoparticles incorporated to alginate against *Staphylococcus aureus*. According to this study, silver nanoparticles (AgZrPO<sub>4</sub>) at different concentrations added to the powder of impression material showed inhibitory effect against pathogenic bacteria.<sup>34</sup>

**Dental cements-**

Dental cements play a key role in restorations as well as cementation of crowns and bridges. So antimicrobial activity of dental cements has become an important criteria, to prevent the pathogenic microorganisms from gaining access to the cavity or the prepared tooth after cementation. The antibacterial activity of the dental luting cements is important considering the microleakage after cementation. Considering this, studies were carried on the efficacy of nanometals in inhibiting microorganisms. Silver nanoparticles show good antimicrobial activity, which is mainly due to the release rate of silver ions. These reactive ions act on the bacterial cell wall and results in the structural changes by binding to the tissue protein and causing cell death. Magalhaes et al in their study,<sup>35</sup> incorporated silver nanoparticles into glass ionomer cement, endodontic cement and resin cement and the antimicrobial activity against *S. mutans* was studied. These cements doped with silver nanoparticles presented significant antimicrobial properties compared to cements without nanoparticles.

Glass ionomer-containing TiO<sub>2</sub> nanoparticles possessed antibacterial activity against *S. mutans* in contrast to the unmodified glass ionomer.<sup>36</sup> A study evaluating the antibacterial activity of zinc oxide nanoparticles incorporated self cured GIC and light cured resin reinforced GIC on *S. mutans* biofilms, concluded that ZnO nanoparticles incorporated into GIC, at concentrations of 1% and 2% by weight did not help in their antibacterial action.<sup>37</sup>

## Dental Composites-

The resin based dental composites are commonly used in dental restorations due to their aesthetic superiority and strong bonding ability and strength. Plaque accumulations on these materials can cause recurrent caries and ultimately failure of restorations. Silver and titanium particles were incorporated into dental composites to provide antimicrobial properties as well as to improve the biocompatibility. To reduce the biofilm accumulation over composite, antimicrobial restorative materials have been developed by the incorporation of silver nanoparticles to composite resins. Cheng et al reported that silver nanoparticles incorporation into composite resins enabled good mechanical properties along with notable antimicrobial effect, at lower concentrations.<sup>38</sup> Reham et al evaluated antimicrobial efficacy of ZnO nanoparticles incorporated into resin composites against organisms causing caries and the results show 85% reduction in growth of different kinds of bacteria which tested under study.<sup>39</sup> In a study conducted by Shahin Kasraei et al, antibacterial properties of composite resins with zinc oxide and silver nanoparticles concluded that it can inhibit the growth of *S.mutans* and *Lactobacillus*.<sup>40</sup>

Light cured flowable composite resin material can function as an effective antimicrobial by adding silver hydrosol. This silver hydrosol that gets leached from the composite resin matrix can help to decrease the incidence of dental caries.<sup>41</sup> Such studies showing antimicrobial properties of silver nanoparticles-containing composite resin might reduce the development of secondary or recurrent caries by reducing the bacterial biofilm formation on the teeth and thereby increasing the longevity of the restorations.

**Endodontic materials-****Guttapercha-**

Success of endodontic care is connected to the bacterial elimination, to a large extent. Many materials have been used as root canal fillings, among which gutta-percha being the most widely used. The zinc oxide component present in gutta-percha makes it have its own antimicrobial property. Iranian researchers, Dianat and Ataie had introduced nanosilver-gutta-percha, to enhance the antibacterial effectiveness of gutta-percha. The new material demonstrated significant antimicrobial effect against *Enterococcus faecalis*, *Staphylococcus aureus*, *Candida albicans*, and *Escherichia coli*.<sup>42</sup>

**Mineral trioxide aggregate (MTA)-**

Mineral trioxide aggregate is a well-known dental root repair material. MTA is used for an apical plug formation during apexification, in case of any root perforations during root canal treatment and in cases of internal root resorption. Also used as root-end filling material and pulp capping material. Samiei et al modified MTA by incorporating silver nanoparticles and it was found to act against oral bacteria and fungi species. They concluded that a group-containing MTA possesses higher antimicrobial action compared to unmodified MTA.<sup>43</sup> Eventhough AgNP is a potent antimicrobial, there are only a few studies incorporating it in endodontic materials.

**Dental adhesives-**

Dental adhesives are materials which help in the adhesion and cohesion of two different materials or between material and natural teeth. Li et al, in their study incorporated silver nanoparticles (AgNPs) to an adhesive system in order to evaluate the bacterial inhibition. According to their results, AgNPs reduced Colony forming units (CFU) number and lactic acid production on biofilms suggesting their antibacterial potential.<sup>44</sup>

Melo et al in their study evaluated antimicrobial efficacy by incorporating silver nanoparticles to an adhesive system and results showed a reduced metabolic activity on biofilm, compared to control group without AgNPs.<sup>45</sup> Mahshid S et al, studied the effect of adding zinc oxide nanoparticles to dental adhesives on their antimicrobial activity and bond strength. According to their results, adding zinc oxide nanoparticles to dental adhesives inhibited the formation of *Streptococcus mutans* colonies, without compromising the bond strength.<sup>46</sup>

**Acrylic resins-**

Dentures are fabricated by poly (methyl methacrylate) (PMMA) acrylic resin. Various factors can contribute to the roughness of their inner surface which can act as a niche for microbial (*Candida* species) colonization, which can cause denture stomatitis in denture wearers.<sup>47</sup> Due to the smaller size, silver nanoparticles possess greater dispersion in PMMA matrix and produce larger area for oxidation. The release of silver ions act by rupturing the cell wall and denaturing the protein and ultimately leading to microbial death, thus explaining the antimicrobial action and effectiveness of silver nanoparticles.

Acosta-Torres et al in their research observed that PMMA- AgNPs specimens showed less *Candida albicans* adherence compared to unmodified PMMA, thus reporting the antifungal potential of AgNPs incorporated to acrylic resin.<sup>48</sup>

**Tissue conditioners or Soft liners-**

Tissue conditioners are used in denture patients who present inflamed or abused mucosa and getting them back to normal health. It is mainly used to aid in the treatment of chronic soreness caused by dentures. Tissue conditioners are susceptible to microbial colonization. Many studies were conducted by addition of metallic and metallic oxides in tissue conditioners to study its antimicrobial activity. Nam in his study, incorporated AgNPs into a commercial tissue conditioner, in the following concentrations: 0.1%, 0.5%, 1.0%, 2.0%, and 3.0%. Their inhibitory effect was evaluated against *Staphylococcus aureus*, *Streptococcus mutans*, and *Candida albicans*. He reported that the modified tissue conditioner presented antimicrobial properties even at lower concentrations, that is, 0.1% (for *S. mutans* and *S. aureus*) and 0.5% (for *C. albicans*).<sup>49</sup>

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# **CHAPTER 9**

## **NANOMETALS AS ANTIMICROBIALS**

### **IN IMPLANT DENTISTRY**

Dental implants have become an integral part of reconstructive dentistry. Bacterial invasion can occur during surgery or post operatively. Infection being one of the most important complications in Implantology, various measures have been considered in order to avoid bacterial contamination. Nanotechnology is increasingly used for the surface modifications of dental implants.

It has been reported in various literatures that titanium dioxide nanoparticles coating on titanium implants can increase antimicrobial efficacy of implants. Singaravel et al in their study, evaluated the antifungal effect of titanium, zirconium and aluminium nanoparticles coated titanium oxide plates. Titanium oxide nanoparticles coated titanium plates showed greater antifungal effect against *Candida albicans*, compared to zirconium oxide and aluminium oxide.<sup>50</sup>

Flores et al suggested that incorporation of silver nanoparticles on titanium implants as a method to guard implant surface against the pathogen. And they also reported that silver nanoparticles showed bactericidal action at lesser concentration which does not interfere with the osseointegration process.<sup>51</sup>

Zhao et al in their study, incorporated silver nanoparticles into titania nanotubes (TiO<sub>2</sub>-NTs) on Ti implants. The antibacterial effect against *Staphylococcus aureus* was evaluated. According to this study, Ti implants incorporated with silver nanoparticles showed its ability to prevent bacterial adhesion for a time period of 1 month.<sup>52</sup>

Zhang et al, in their study coated TiO<sub>2</sub> implants by silver nanoparticles using Micro Arc Oxidation (MAO) and their results showed enhanced antimicrobial activity which was attributed to the interaction between silver nanocrystals and bacterial cell membrane.<sup>53</sup> A study conducted by Xiaojing He et al suggested that the Micro Arc Oxidation (MAO) technique effectively introduces inorganic antibacterial metals (eg: Ag, Cu, Zn) into biomedical implants, thus successfully solving the issue of periimplant infection. Flores et al studied the antibacterial

activity of silver nanoparticles (AgNPs) against *Pseudomonas aeruginosa* and suggested that the incorporation of AgNPs on Ti implants as an effective approach to guard the surface of implants against microbial colonization.<sup>54</sup>

Miguel A et al, studied antimicrobial activity of metal oxide nanoparticles against pathogens causing periimplantitis. In their study they considered six metal (Ag) and metal oxides [cuprous oxide (Cu<sub>2</sub>O), cupric oxide (CuO), zinc oxide (ZnO), titanium dioxide (TiO<sub>2</sub>), tungsten oxide (WO<sub>3</sub>)] and two of their composites[(Ag+CuO), (Ag+ZnO)] against bacterial pathogens. The antimicrobial activity of the nanoparticles tested showed silver showing the most and tungsten oxide the least antimicrobial effect. And they suggested that composites of nanoparticles should also be considered as antimicrobial agents. In this study, bacteriostatic activity showed by the composites were greater than that of nanoparticles alone.<sup>55</sup>

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# **CHAPTER 10**

## **NANOMETALS AS ANTIMICROBIALS IN MAXILLOFACIAL PROSTHETIC MATERIALS**

## **MAXILLOFACIAL PROSTHESIS**

Maxillofacial deformities negatively affect patient's physical and mental health affecting their family and social life. Maxillofacial prostheses repairs and replaces artificially the lost or missing parts in the maxillofacial region. Maxillofacial prosthesis has a crucial role on the patient's self-confidence and quality of life, as it's an instant corrective way that can help the patient get back to his normal social life.

Maxillofacial reconstruction involves using artificial substitutes for intraoral as well as extraoral parts like eyes, ears, nose, cranial bones, jaw bones etc. A variety of materials, procedures and clinical approaches are used in maxillofacial prosthetic reconstruction. Maxillofacial prostheses are basically fabricated of acrylic resin or silicone based on the facial structure of the patient in need. These prostheses are retained by various types of retentive mechanism like anatomic, mechanical and chemical.

Maxillofacial prosthesis can be classified as restorative or complementary. In these, restorative prostheses substitute for repair deformities of facial contour or for bone loss. They can be either internal within the tissue or external like oral, ocular or facial prostheses. Whereas, the complementary prostheses help with plastic surgery, during pre, trans or post operative time frame or in radiotherapy sessions. Maxillofacial prostheses are more prone for contamination and thereby can cause infections.

Maxillofacial prostheses fabricated from silicone material are more prone to fungal infection caused by *Candida albicans*. Coating silicone materials with silver nanoparticles could be advantageous to the patients using maxillofacial prostheses, to prevent or reduce fungal infection. Silver nanoparticles have been incorporated in maxillofacial prosthesis and it showed reduced adherence of *Candida albicans* to maxillofacial prosthesis surface.<sup>56</sup>

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# CHAPTER 11

## A NOTE ON CYTOTOXICITY

## A NOTE ON CYTOTOXICITY OF METAL AND METALLIC OXIDE NANOPARTICLES

Mechanism behind the toxicology of nanomaterials and their hazardness extent are still unknown. The toxic effects they pose can be attributed to various factors. The generation of ROS is considered the main determinant for both their *in vitro* and *in vivo* cytotoxicity.<sup>57</sup> Many cellular events are driven by low levels of ROS. An increase beyond certain limits lead to oxidative stress causing cell death via oxidation.<sup>57</sup>

Nanoparticles of Ag, ZnO, and TiO<sub>2</sub>, show moderate to high levels of cytotoxicity against a variety of animal cells. In addition, some nanoparticles like SiO<sub>2</sub>, Au, Fe<sub>2</sub>O<sub>3</sub>, and TiO<sub>2</sub> have shown good biocompatible properties. This cytotoxic nature of nanoparticles has been converted into biocompatible materials by introducing slight changes in their surface structural features. Nanoparticles have a wider level of biological properties that are dependent upon their structure, size, quantity and receptor cell type.

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# **CHAPTER 12**

## **ADVANTAGES AND DISADVANTAGES OF NANODENTISTRY**

## **ADVANTAGES**

Advantages of nano-dentistry include

- Superior flexural strength, hardness, translucency, modulus of elasticity and durability of nano-dental materials.
- Faster and apt diagnosis of many oral diseases with small diagnostic machineries.
- Less treatment time and faster healing
- Better aesthetics
- Better treatment outcome
- Reduced number of visits for the patient
- More economical

## **DISADVANTAGES**

Disadvantages of nano-dentistry include

- Toxicity associated with nanomaterials can affect the humans
- Ethical issues /social acceptance

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## **SUMMARY AND CONCLUSION**

Many microorganisms and antimicrobial resistant microorganisms pose a real threat to human life. Certain bacterial strains are resistant to the antibiotics now in use and pose a serious public health concern. This demands newer materials against such strains, in order to overcome such issues. Nanotechnology has been successful in creating many novel bactericidal antimicrobial materials and strategies. Advances in the field of nano-structures and nanomaterials with suitable properties led to an increase in the making of stable nanoparticles that are capable of biomedical applications. Nanoparticles of metals have shown great potential as fungicidal and bactericidal agents in treating many medical issues. Applications of metal and metallic oxide nanoparticles, and their surface modifications, with good antimicrobial activity in lesser concentration locally destroy pathogens, without being toxic. The efficacy of these nanoparticles varies with their size, shape, and concentration. As the size of the particle reduces, the percentage of atoms on the surface increases, thus enhancing the effectiveness of action.

Different nano- metals and metallic oxides show good biocompatibility as well as antimicrobial pathogenic activity against different viral and bacterial species in small measures. These nanoparticles of metallic oxides offer extended antimicrobial activity with minimal toxicity. Hence metallic oxide nanoparticles might be considered as a new alternative to most of the antibiotics and if applied in drug delivery systems in medical and dental field can be a boon to the human race, where antibiotic resistant pathogens have aroused to be alarming. More researches and application in this field will bring many newer results and advances in different fields.

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# ***Advances in Dental Sciences***

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# **Chapter - 1**

## **Dental Practice during Covid-19: Challenges and Safety Measures**

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# Chapter - 1

## Dental Practice during Covid-19: Challenges and Safety Measures

Dr. Hema Kanathila, Dr. Ashwin Pangi, Dr. Bharathi Poojary, Dr. Rahul Jaiswal and  
Dr. Karuna Patwardhan

### Abstract

Covid-19 has created a panic all over the world pausing everyone's normal social and economic life. At present all treatment procedures are carried out starting from regular oral check-ups to all complicated surgical procedures following a strict dentist as well as patient protective measures, vigilantly and meticulously. Apart from the basic safe care protocols, advanced protocol when followed helps in enhancing the working efficiency. This chapter is in detail about the safety challenges and measures adopted by dental professionals during the Covid -19 time period.

**Keywords:** COVID 19, coronavirus, dental professionals, transmission, personal protective equipment, challenges

### Introduction

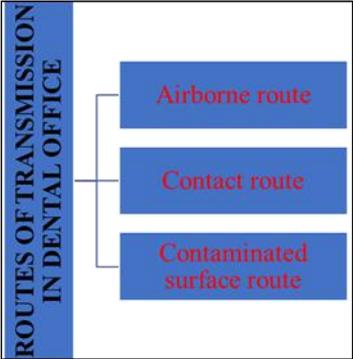
COVID-19 pandemic has brought many challenges for the mankind and humans have started finding significant opportunities to bring out their best in such a difficult time frame. The super-fast spreading deadly pandemic Covid-19 has created a panic all over the world pausing everyone's normal social and economic life. This novel corona virus with human-to-human transmission has put the world to halt and has become a major public health concern for all healthcare professionals.

Coronavirus disease (Covid-19) started in Wuhan, Hubei (China) towards the end of the year 2019 <sup>[1, 2]</sup>. Individuals affected with SARS-CoV-2 can be asymptomatic with no detectable manifestations or can be symptomatic with mild to moderate symptoms. Salivary gland dysfunction, xerostomia, taste alterations, oral mucosal lesions are the most common oral cavity manifestations in individuals with coronavirus disease. Some patients present with severe viral pneumonia showing myalgia, fever, dry cough, shortness of breath <sup>[2, 3]</sup> and death as the last consequence of this deadly disease.

Initially the outbreak shut down the normal workflow of all dental surgeons thus disrupting the routine dental care. After the recommencement of routine dental practice, self-care of dental professionals as well as patient care became a challenge to the dental practitioners considering the virulence of Corona virus and its different emerging variants. At present all treatment procedures are carried out starting from regular oral check-ups to all complicated surgical procedures following a strict dentist as well as patient protective measures, vigilantly and meticulously.

The routes of transmission of SARS-CoV-2 are very important to be known to safeguard the health professionals from contracting the disease.

**Transmission routes in dental office**



**Fig 1:** Routes of transmission

A person with Covid 19, likely infects his primary contacts via contact with droplets and contaminated surfaces. It infiltrates the human body via mucosal surfaces of eyes, nose and oral cavity. In dental offices, the novel coronavirus Covid - 19 can be transmitted via three different routes: airborne route, direct contact, or contaminated surfaces [4].

**Transmission via air borne route**

Studies have identified Covid 19 virus in patient’s saliva. To el at, in his viral culture study confirmed the presence of Corona virus in saliva [5, 6]. Dental procedures involve close contiguity with patient’s oral cavity, and involves production of aerosols, dental professionals are at a greater risk of getting infected and transmitting the virus to the assistants and next patients as the air remains contaminated with aerosolized coronavirus particles [7, 8]. Restorative, scaling, tooth preparation and surgical procedures require the use of aerotors and it becomes impossible to bypass the generation of aerosols and microdroplets fused with blood and saliva, which can easily settle down and

contaminate hard surfaces as well as enter the human respiratory tract in cases of personal protection negligence.

**Transmission via contact route**

Transmission via contact route can either be direct or indirect [5,9]. Dental professionals are most of the time in direct or indirect contact with saliva or blood. They have to handle the dental materials used in patient’s oral cavity as well as the dental instruments used for dental procedures. They come in contact with the surfaces touched by patients in the dental office which can be a possible way of contracting the coronavirus disease.

**Transmission via contaminated route**

Investigations on Human coronaviruses, SARS-CoV, endemic human coronaviruses (HCoV) or Middle East Respiratory Syndrome coronavirus (MERS-CoV), have proved frequently contacted contaminated surfaces in hospitals as a cause for coronavirus transmission. Coronaviruses are said to be active on different surfaces such as glass, metal and plastic. Studies have shown HCoV to be infectious from 2 hours till 9 days at room temperature.<sup>10,11</sup> Hence it is a fact to be accepted that salivary/respiratory droplets and aerosolized particles from Covid 19 infected patients can easily contaminate the surfaces in dental office.

For dental clinical procedures, the standard protective protocol followed may not be helpful in overcoming the threat of getting infected with coronavirus. The dental practitioners have been suggested to take necessary personal and patient protective care. Hence personal and patient safety measures are given utmost priority, which has made the dental professionals bloom up in this tough time period of economic and professional challenges.

<b>Challenges in dentistry during COVID-19</b>		
<b>Personal Protection Challenges</b>	<b>Patient Safety Challenges</b>	<b>Economic Challenges</b>

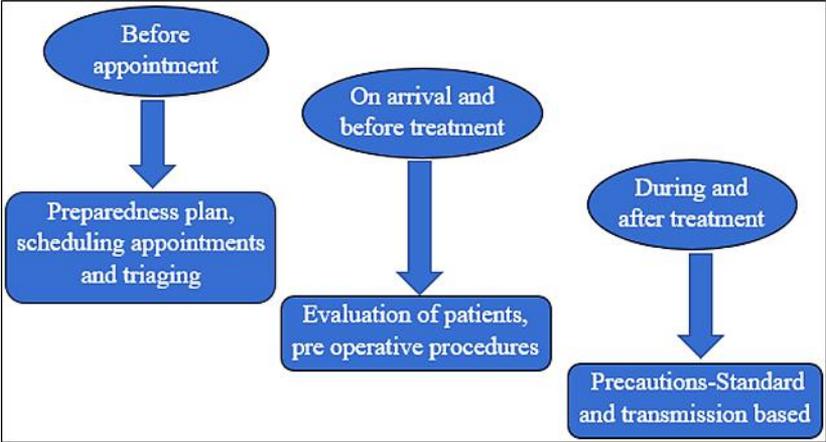
**Fig 2:** Challenges in dentistry

**Dentist’s personal and patient safety challenges and protection strategies**

Dental professionals always follow standard precautionary measures for reducing the spread of infection directly or through cross-infection. But, in case of SARS-CoV-2, new and strict protective measures have to be followed that differs from the usual protocol to manage other diseases. As vaccination is being done and many variants are emerging, most of the individuals have

mild symptoms or asymptomatic, thus becoming undiagnosed. But these asymptomatic patients are potential carriers who can transmit the virus and therefore it has to be noted to execute routine screening for the staffs in dental office as well as the patients to ensure complete safety. Various treatment guidelines have been put forward by the Centers for Disease Control (CDC) and Occupational Safety and Health Administration (OSHA) to prevent the transmission of infection.

Patients have to be treated based on their complaints, considering it as whether emergency and non-emergency complaints [8]. Patients who don't require emergency dental treatments can be communicated and instructed via Teledentistry. Teledentistry should be incorporated in routine dental practice which can be applied in various situations during this pandemic, as it offers various applications such as triaging, teleconsultation and telemonitoring [12]. And patients who need emergency treatment must be categorised as potentially infected and treated with extra protective protocol. When a dental practitioner attends a patient, a thorough medical, social and travel history has to be taken prior to any dental procedures. It must include fever, cough and respiratory problems apart from the routine questionnaire. Social contacts and travel history also to be noted if it is of concern [8].

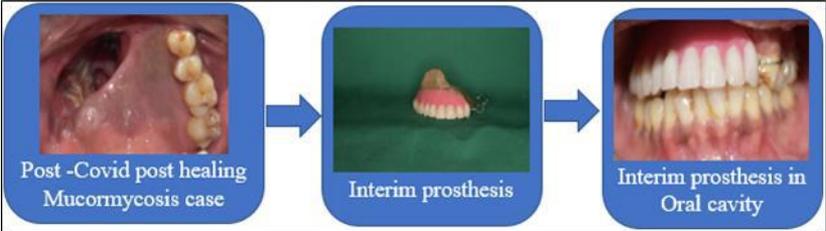


**Fig 3:** How to schedule and work?

Even more challenging situation was when a scenario occurred during SARS-CoV-2 outbreaks in Indian states, making the Government of India to announce a mucormycosis epidemic, a rare but life-threatening fungal infection, causing complications and raising alarming bells all over. This was seen in immunocompromised hosts, risk factors being cancer, organ or bone marrow transplantation and treatment with corticosteroids, uncontrolled

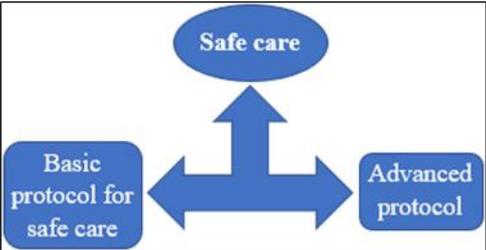
diabetes etc. The cascade of events which occurs during and post Covid-19 infection, promotes secondary bacterial and fungal infections in critically ill, prolonged hospital stay or medically compromised patients. The infection can start in the nose and paranasal sinuses because of inhalation of fungal spores, and then spread to orbital and cranial structures via blood vessels or by direct invasion. In such cases, treatment has been mainly antifungal agents combined with surgical debridement or resection <sup>[13]</sup>, which has led to challenging medical and dental conditions for the patient as well as the dental practitioners. Surgical and prosthetic treatment being the treatment option, prosthetic rehabilitation and psychological support improving the quality of life was provided by the dental professionals to many patients.

Prosthetic rehabilitation of a mucormycosis case (Post Covid complication)-



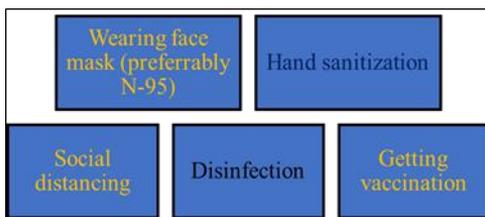
**Fig 4:** Prosthodontic management of mucormycosis

**What are the opportunities to overcome the threat (safe care) and enhance working efficiency?**



**Fig 5:** Self care protocol

Basic protocol to be followed by all includes-



**Fig 6:** Basic safety measures

Apart from these above mentioned basic safe care protocols, advanced protocol when followed helps in enhancing the working efficiency. Below are the safety challenges and measures adopted by dental professionals during the Covid-19 time period.

### **Hand hygiene**

The dental professionals should make it a habit of handwashing as well as using hand sanitizer frequently. The patient should be motivated to use hand sanitizer and directed to avoid touching surfaces in dental office and their nose, eyes and oral cavity. Hand washing techniques lasting 20 seconds should be followed which reduces the spread of disease <sup>[8]</sup>.

### **Reception area modifications**

Certain rules have to be highlighted and followed in the reception area. Rules like no usage of appointment cards, only online/digital transactions, social distancing from each other and patients coming for treatment must be followed. Clerical staff should be well trained and asked to wear mouth mask. Waiting room must be organized with chairs arranged at a distance to each other and should be well ventilated. All the magazines and products that can harbour virus should be removed. At the reception desk, the patient should be given hand sanitizer and instructed not to touch surfaces as well as face, eyes, nose and mouth. These instructions can be put on the notice board in the reception area and strictly asked to be followed by the patients and their companions. Appointments should be minimized as well as minimal companions should be allowed with patients in the waiting room. Least number of people should be allowed in the working area. This helps in avoiding the exposure to other people as well as it helps in zeroing their exposure to aerosols and microdroplets in the dental office.

### **Personal protective equipment**

All extra protective measures should be strictly considered because of the risk involved in treating patients. Considering the possibility of transmission

of Covid 19, three-level protective care for dental professionals are recommended [4].

1) Standard protection for dental practitioner in dental office.

– Using disposable working head cap, disposable surgical mask, and working clothes (white apron), wearing protective eye wear or face shield, and disposable latex gloves or nitrile gloves.

2) Advanced protection for dental practitioners in dental office.

– Using disposable head cap, disposable surgical mask/N-95, protective eye wear, face shield and working clothes with disposable isolation clothing or surgical clothes outside and disposable latex gloves.

3) Strengthened protection

– In case of unavoidable close contact with Covid 19 suspected or infected patient, special protective outwear is mandatory, i.e. Personal Protective Equipment.

Personal Protective Equipment includes garments worn in order to protect the health care workers or any persons from getting infected. In case of unavailability, extra protective cloth over white apron should be used. Also, disposable head cap, eye wear, face shield, disposable latex gloves, disposable surgical gloves and impermeable shoe cover must be attired.

### **Use of mouth rinse, rubber dam isolation and anti-retraction hand piece**

Antiseptic mouth rinses are considered to reduce the viral load in the oral cavity. Usage of hydrogen peroxide or povidone iodine solutions is highly recommended [4, 14, 15, 16]. The patient must be asked to rinse as well gargle using betadine mouth wash for 30-40 seconds before the start of any dental clinical procedures. Use of mouthwash in between the treatment procedure also should be encouraged to decrease the viral load, thus minimizing the spread of infection.

Samaranayake *et al.* in their study concluded that the use of rubber dam gets down the airborne particles in 3-foot diameter of the operational field by 70%. So, usage of rubber dam in restorative procedures minimize the contact with oral fluids (saliva and blood droplets), while working with high-speed hand piece and ultra-sonic scalars [17]. Carisolv can be considered for caries removal and hand scalar for scaling, in cases where rubber dam cannot be used.

High speed hand piece with anti-retraction valves must be used during clinical procedures, in order to minimize cross infection. A study on anti-

retraction high-speed dental hand piece has shown to reduce the backflow of oral bacteria and viruses into the tubes of the hand piece as well as dental unit when compared with the hand piece without anti-retraction valve <sup>[18]</sup>. Thus hand piece with anti-retraction valve will be of great use minimizing cross infection.

High or low volume saliva ejectors reduce aerosol and droplets to a great extent. Dental professionals must use extraoral dental suctions which helps to remove aerosol particles and droplets generated during most of the clinical procedures. These also help in filtering the blood, fluids, viruses & dust that would contaminate operatory atmosphere.

### **Sterilization of instruments and surface disinfection**

Sterilization of instruments and surface disinfection is crucial considering the patient safety protocol. All the instruments must be cleaned thoroughly and autoclaved on a daily basis based on the count of patients and instruments needed for different clinical procedures. High touch surfaces like door handles, dental chair, light switches must be frequently sterilized, using sodium hypochlorite solution <sup>[8]</sup>. The suction and spittoon should be drained with hypochlorite solution. Fumigation of the dental office must be carried out regularly. All these procedures help in safeguarding the patient to a large extent from cross infection.

### **Additional safety measures**

- a) **Negative pressure room or using Air purifiers:** Performing aerosol generating procedures in a negative pressure room (AIIR or Airborne Infection Isolation Room) can be a good option to control infection. Otherwise, usage of air purifiers in dental clinic helps to create fresh and safe inhaling air in the working environment <sup>[19, 20, 21]</sup>.
- b) Use of resorbable sutures is a way to eliminate the patient follow up appointment thus considering patient safety <sup>[19, 22]</sup>.
- c) Considering extra oral radiographs or minimizing the number of radiographs must be thought of by dental practitioners in order to minimize the chance of gag reflex and further transmission of virus particles <sup>[22]</sup>.
- d) **Waste management:** The medical waste in the dental offices of patients with suspected or confirmed Covid 19 patients are considered under infectious medical waste and needs to be cleared or disposed in a proper way following all the necessary protocols. Double-layer yellow coloured medical waste bags with “gooseneck” ligation must be used to dispose the waste <sup>[8]</sup>.

## Economic challenges

Most of the people all around the world have faced great economic loss. This challenge was not less for the dental practitioners as well. The prices of all materials starting from gloves, masks and dental materials was hiked. Apart from this, the price of disposable PPE which was the need of the time period also was in the expensive list. Hence, the treatment charges had to be raised in a reasonable way which had to be affordable for the patient as well.

## Conclusion

Covid-19 has brought vast changes in everyone's life, and especially those in medical and dental fields. Following all safety measures not only safeguards the dental professionals, it also helps in the safety of patients. This helps in enhancing the working efficiency by providing good dental care facility thereby bringing a lot of future opportunities. Technological innovations to provide oral care for patients will be helpful in future dental practice.

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## **Chapter - 2**

### **Universal Immunization Programme**

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# Chapter - 2

## Universal Immunization Programme

Dr. Saundarya Priyadarshini, Dr. Swati Sharma, Dr. Neetu Garg,  
Dr. Debarghya Bhattacharya and Dr. Siddharth J David

### Abstract

The benefits of vaccination extend beyond prevention of specific diseases in individuals. They enable a rich, multifaceted harvest for societies and nations. Vaccination makes good economic sense, and meets the need to care for the weakest members of societies. Reducing global child mortality by facilitating universal access to safe vaccines of proven efficacy is a moral obligation for the international community as it is a human right for every individual to have the opportunity to live a healthier and fuller life. Vaccinations are important to health care professionals because many of these infections can present occupational risks. Oral health professionals who are directly and indirectly involved in care can be exposed to infectious agents that can be transmitted to and from clinicians and patients. As such, practitioners and other team members should be vaccinated to protect against exposure to infectious agents and minimize the risk of cross infection. Dental teams should familiarize themselves with vaccination recommendations to reduce the risk of infectious diseases and better educate patients about the importance of immunizations.

**Keywords:** Immunization, vaccination, uip, universal immunization program, mission indradhanush

### Introduction

- Under Global Smallpox Eradication Program, it was experienced that immunization is the most powerful and cost- effective weapon for the prevention and control and even eradication of a disease.
- In 1974, WHO officially launched a global immunization program, known as Expanded Program of Immunization for the prevention and control of six killer diseases of children, namely tuberculosis, diphtheria, pertussis, tetanus, poliomyelitis and measles, all over the world.

- It was called Expanded because: Adding more disease controlling antigens of vaccination schedules, extending coverage to all corners of a country and Spreading services to reach the less privileged sectors of the society
- The primary health care concept as enunciated in the 1978 Alma-Ata Declaration included immunization as one of the strategies for reaching the goal of “Health for All” by the year 2000.
- The Government of India launched Expanded Program of Immunization in 1978 with objective of reducing mortality and morbidity resulting from vaccine-preventable diseases of childhood and to achieve self-sufficiency in the production of vaccines.

## History

- In October 1985, UNICEF emphasized the goal of achieving universal immunization by 1990 so the global program was renamed as ‘Universal Child Immunization’.
- On 19 November 1985, GOI renamed Expanded Program of Immunization program, modifying the schedule as ‘Universal Immunization Program’ dedicated to the memory of Late Prime Minister Mrs Indira Gandhi.
- Universal Immunization Program has two vital components: immunization of pregnant women against tetanus, and immunization of children in their first year of life against the six Expanded Program of Immunization target diseases.
- The aim was to achieve 100 per cent coverage of pregnant women with 2 doses of tetanus toxoid (or a booster dose), and at least 85 per cent coverage of infants with 3 doses each of DPT, OPV, one dose of BCG and one dose of measles vaccine by 1990.
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## **Objective**

The stated objectives of Universal Immunization Program are:

- 1) To rapidly increase immunization coverage.
- 2) To improve the quality of services.
- 3) To establish a reliable cold chain system to the health facility level.
- 4) To introduce a district-wise system for monitoring of performance.
- 5) To achieve self-sufficiency in vaccine production Universal Immunization Program was given the status of a one of the five 'National Technology Missions' in 1986.

## **Current structure for immunization service delivery India**

The MoHFW comprises of four departments, each of which is led by a Secretary to the GoI.

These include:

- i) Department of Health & Family Welfare.
- ii) Department of Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homoeopathy.
- iii) Department of Health Research.
- iv) Department of AIDS Control.

The MoHFW is responsible for implementing various national health programs in all states of India.

The Directorate General of Health Services renders technical advice on all medical and public health matters and is involved in the monitoring of implementation of various health services.

All states are required to submit in advance a program implementation plan (PIP) for a financial year, along with complete projections of funds required to implement the PIP.

## **Guiding principles of universal immunization program**

The services provided through the Universal Immunization Program shall be guided by the following principles.

- 1) **Universal immunization coverage:** Sustaining demand and ensuring that all pregnant mothers, children and adolescents are immunized as per national schedule in line with the principles of universal health coverage
- 2) **Equitable access:** Ensuring that the immunizations services reach out to the underserved, needy and most vulnerable populations while addressing regional inequalities across states
- 3) **High quality services and innovation:** Maintaining highest possible quality in vaccine procurement, storage, distribution and delivery services in an innovative and safe manner.
- 4) **Sustainability and Partnerships:** Committing resources-financial, human and technical, that sustain immunization benefits to the people at all times and promoting partnerships across different sectors and organizations build synergies and expand the overall coverage of the program.
- 5) **Governance:** Decentralized planning through a bottoms up approach to improve operational efficiency
- 6) **Management excellence and accountability:** Implementation, oversight and accountability of interventions that optimize efficient use of resources

### **Pulse polio immunization programme**

- Pulse Polio is an immunisation campaign established by the government of India to eliminate poliomyelitis (polio) in India by vaccinating all children under the age of five years against the polio virus.
- The project fights polio through a large-scale, pulse vaccination programme and monitoring for poliomyelitis cases.
- Vellore, (Tamil Nadu) was the first Indian state to become 100% polio-free through the pulse strategy, and rest of India adopted the strategy in 1995.
- IN India, vaccination against polio started on 1978 with Expanded Programme of Immunization.
- By 1999, it covered around 60% of infants, giving three doses of OPV to each.
- In 1985, the Universal Immunization Programme was launched to cover all the districts of the country. Universal Immunization Program became a part of child survival and safe motherhood

program (CSSM) in 1992 and Reproductive and Child Health Program (RCH) in 1997. This program led to a significant increase in coverage, up to 5%.

- The number of reported cases of polio also declined from thousands during 1987 to 42 in 2010.
- In 1995, following the Global Polio Eradication Initiative of the World Health Organization (1988), India launched Pulse Polio immunization program with Universal Immunization Program which aimed at 100% coverage.
- The last reported cases of wild polio in India were in West Bengal and Gujarat on 13 January 2011.
- On 27 March 2014, the World Health Organization (WHO) declared India a polio free country, since no cases of wild polio been reported in for five years.
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### **Introduction of hepatitis-b vaccine**

- Infection with the hepatitis B virus can lead to lifelong chronic infection and serious liver damage.
- Symptoms are variable and include yellowing of the eyes, abdominal pain and dark urine. Some people, particularly children, don't experience any symptoms. In chronic cases, liver failure, cancer or scarring can occur.
- Dental professionals are in frequent contact with blood, saliva and other bodily fluids that increase their risk of contracting hepatitis B through percutaneous or mucosal exposure.
- The hepatitis B vaccination is the most effective measure of prevention.

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- Dental professionals are in frequent contact with blood, saliva and other bodily fluids that increase their risk of contracting hepatitis B through percutaneous or mucosal exposure.
- The hepatitis B vaccination is the most effective measure of prevention.

### **Introduction of Japanese encephalitis vaccine**

- Japanese encephalitis (JE) is an infection of the brain caused by the Japanese encephalitis virus (JEV).
- While most infections result in little or no symptoms, occasional inflammation of the brain occurs.
- In these cases, symptoms may include headache, vomiting, fever, confusion and seizures. This occurs about 5 to 15 days after infection.
- There are currently three vaccines available: SA14-14-2, IXIARO (IC51, also marketed in Australia, New Zealand as JESPECT and India as JEEV) and ChimeriVax-JE (marketed as IMOJEV).
- The programme was introduced in 2006 to cover 104 endemic districts in phased manner, using SA 14-14-2 vaccine, imported from China.

- Single dose of JE vaccine was given to all children between 1 to 15 years of age through campaigns.
- The JE vaccine is being integrated into routine immunization in the districts where campaign had already been conducted to immunize the new cohort of children by vaccinating with two doses at 9-12 months and 16-24 months.

### **Introduction of measles vaccine second opportunity**

- In order to accelerate the reduction of measles related morbidity and mortality, second opportunity for measles vaccination is being implemented.
- The National Technical Advisory Group on immunization recommended introduction of 2nd dose of measles vaccine to children between 9 months and 10 years of age through supplementary immunization activity (SIA) for states where evaluated coverage of first dose of measles vaccination is less than 80 per cent.
- In states, with coverage of measles vaccination more than 80 per cent, the second dose of vaccine was given through routine immunization at 16-24 months.
- Common Side Effects of Vaccine are Sore arm from the shot, Fever, Mild rash and Temporary pain and stiffness in the joints, mostly in teenage or adult women who did not already have immunity to the rubella component of the vaccine.

### **Introduction of pentavalent vaccine (DPT + *Hep-B* + *Hib*)**

- India introduced pentavalent vaccine containing DPT, hepatitis B and Hib vaccines in two states viz. Kerala and Tamil Nadu under routine immunization programme from December 2011.
- DPT and hepatitis B vaccination require 6 injections to deliver primary doses.
- With the introduction of pentavalent vaccine, a new antigen, i.e., Hib has been added which protects against *Haemophilus influenzae* type B (associated with pneumonia and meningitis) and the number of injections are reduced to 3.
- The vaccine has been expanded to 6 more states, i.e., Haryana, Jammu and Kashmir, Gujarat, Karnataka, Goa and Puducherry in 2012-13. Now pentavalent vaccine is being given in all states.

## **Rotavirus vaccine**

- Rotavirus is a contagious virus that can cause gastroenteritis (inflammation of the stomach and intestines).
- Symptoms include severe watery diarrhea, often with vomiting, fever, and abdominal pain.
- Infants and young children are most likely to get rotavirus disease. They can become severely dehydrated and need to be hospitalized and can even die.
- Common Side Effects of Rotavirus Vaccine
- Irritability, Mild, temporary diarrhea or vomiting
- India became the first country in Asia to launch Rotavirus vaccine in the Universal Immunization Program (Universal Immunization Program) in March 2016.
- The vaccine, ROTAVAC, was developed by Bharat Biotech in collaboration with the Government of India's Department of Biotechnology.
- ROTAVAC, an oral vaccine, would be administered to infants in a three-dose course at the ages of 6, 10 and 14 weeks.
- According to the Indian government's media release, ROTAVAC reduces severe diarrhea by 56% during the first year of life, with protection continuing into the second year of life.

## **Rubella vaccine**

- Rubella is a contagious disease caused by a virus. It is also called "German measles," but it is caused by a different virus than measles. For some people-especially pregnant women and their unborn babies-rubella can be serious.
- Young children who get rubella usually have a mild illness, with symptoms that can include a low-grade fever, sore throat, and a rash that starts on the face and spreads to the rest of the body.
- Older children and adults are more likely to have a headache, pink eye, and general discomfort before the rash appears.
- Rubella can be prevented with MMR vaccine. This protects against three diseases: measles, mumps and rubella.
- CDC recommends children get two doses of MMR vaccine, starting with the first dose at 12 through 15 months of age, and the second dose at 4 through 6 years of age.

- February 2017, India began introducing rubella-containing vaccine (RCV) into the public-sector childhood vaccination programme.

### **Mission Inradhanush**

- The Government of India launched Mission Inradhanush on 25<sup>th</sup> December 2014, to cover children who are either.
  - Unvaccinated or partially vaccinated against seven vaccine.
  - Preventable diseases, i.e., diphtheria, whooping cough, tetanus, polio, tuberculosis, measles and hepatitis B.
  - The goal was to vaccinate all under-fives by the year 2020.
  - 201 high focus districts were covered in the first phase. Of these 82 districts are from Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan. These 201 districts have nearly 50 per cent of all
    - Unvaccinated children of the country. The drive was through a
      - “catch-up” campaign mode. The mission was technically
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    - The goal was to vaccinate all under-fives by the year 2020.

- 201 high focus districts were covered in the first phase. Of these 82 districts are from Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan. These 201 districts have nearly 50 per cent of all
- Unvaccinated children of the country. The drive was through a
- “catch-up” campaign mode. The mission was technically
- Supported by WHO, UNICEF, Rotary International and other donor partners.

### **Intensified mission indradhanush 2.0**

- To boost the routine immunisation coverage in the country, the minister of Health and Family welfare Dr. Harsh Vardhan introduced Intensified Mission Indradhanush 2.0 to ensure reaching the unreached with all available vaccines and accelerate the coverage of children and pregnant women in the identified districts and blocks from December 2019-March 2020.
- This aims to achieve the Sustainable Development Goal of ending preventable child deaths by 2030.
- It aims at immunizing 272 districts in 27 States and at block level (652 blocks) in Uttar Pradesh and Bihar because of its hard to reach and tribal populations.
- Ministry of Women and Child Development, Panchayati Raj, Ministry of Urban Development, Ministry of Youth Affairs and others have come together to ensure the benefits of vaccines reach the last mile.

### **Intensified mission indradhanush 3.0 scheme**

- The Intensified Mission Indradhanush (IMI) 3.0 scheme has been rolled out to cover children and pregnant women who missed routine immunisation during the Covid-19 pandemic.
- The Objective was to reach the unreached population with all the available vaccines under Universal Immunisation Programme (UIP) and thereby accelerate the full immunization and complete immunization coverage of children and pregnant women.
- It will have two rounds this year which will be conducted in 250 pre-identified districts/urban areas across 29 States/UTs.
- The districts have been classified to reflect 313 low risk, 152 medium risk and 250 high risk districts.

- Beneficiaries from migration areas and remote areas would be targeted as they may have missed their vaccine doses during the pandemic.
- It will foster India's march towards the Sustainable Development

## Barriers

- Infrastructure issues include poor infrastructure of vaccine stores and transportation systems; there is a lack of standards for vaccine stores at different levels and insufficient temperature monitoring system at all vaccines storage points from GMSDs to last cold chain point level. State and regional stores. There exist difficulties in procuring the right quality of cold chain eq Universal Immunization Programment on time with adequate after sale support.
- **Poor social mobilization:** Low levels of awareness, communication and information sharing amongst frontline workers as well as poor HR capacity for BCC in government institutions as a whole contributes to the problem of high lefts outs and drop outs.
- **Poor data management and analysis for evidence generation:** A robust system for data management and evidence generation is crucial to support informed decision making for the creation of realistic goals and strategies for improvement of current coverage levels and introduction of new antigens in Universal Immunization Program.
- **Weak human resource capacity:** In a study of HR needs assessment in Universal Immunization Program by Mavlankar *et al.* (IIM Ahmedabad)<sup>14</sup>it was found that there is limited technical and operational human resource capacity and quality at various levels in Universal Immunization Program.
- **Evidence synthesis for informed policy making:** The NTAGI was formed in 2001 and tasked with advising the MoHFW on issues related to the program, policy and implementation of the national immunization program.

## Conclusion

- The benefits of vaccination extend beyond prevention of specific diseases in individuals. They enable a rich, multifaceted harvest for societies and nations. Vaccination makes good economic sense, and meets the need to care for the weakest members of societies. Reducing global child mortality by facilitating universal access to

safe vaccines of proven efficacy is a moral obligation for the international community as it is a human right for every individual to have the opportunity to live a healthier and fuller life. With the changing lifestyle people have started using Air conditioner and living in a box with closed windows and doors which does not allow proper ventilation.

Emergence of COVID 19 brought us back to our Indian culture of opening doors and window which led to proper ventilation and healthy lifestyle.

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**Chapter - 3**  
**Biochemical Changes in Periodontitis**

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# Chapter - 3

## Biochemical Changes in Periodontitis

Dr. Shubham Kumar

### Abstract

Periodontitis is a multifactorial inflammatory disease affecting the structures supporting the tooth. Though there have been considerable advances in the surgical and non-surgical management of periodontitis, the diagnostic part still remains obscure with clinicians relying mainly on radiographic findings and periodontal probing. This chapter tries to explain the biochemical changes in periodontitis with focus on biomarkers in periodontal disease, their role as chair side diagnostic kits with their existing limitations and future directions in the diagnosis of periodontitis.

**Keywords:** Periodontitis, collagen, biomarkers

### Introduction

- Periodontitis is an inflammatory disease of bacterial origin that results in the progressive destruction of the tissues that support the teeth.
- There has been significant advances in the understanding of pathogenesis of disease over the past years.
- However, the traditional methods by which clinicians diagnose periodontal disease still holds true in routine clinical practice.

### Extracellular matrix

- The extracellular matrix may be defined as the substance that underlies all epithelia and endothelia and surrounds all connective tissue cells, providing mechanical support and physical strength.
- Most connective tissues can be divided into fibrous and non-fibrous elements.
- The collagens and elastin comprise the fibrous components.
- Non-fibrous components include a variety of Proteoglycans, Glycoproteins (Fibronectin, Laminin, Osteocalcin etc) as well as mineral, lipids, mineral-bound growth factors and water.

## 1. Collagen

- The collagen superfamily consists of 27 types of collagens that are encoded by 25 separate genes dispersed among at least 12 chromosomes.
- The most abundant protein found in body and consists of 3 polypeptide  $\alpha$ -chain coiled around each other to form triple-helix configuration.
- Synthesized by Fibroblasts, Chondrocytes, Osteoblasts, Odontoblasts and Cementoblasts.
- Variations arise due to differences in polypeptide assembly, length of triple helix, interruptions in helix and termination of helical domain.

## 2. Proteoglycans

- Proteoglycans are macromolecules composed of a core protein to which one or more highly anionic glycosaminoglycan chains are attached (Aggrecan, Syndecan etc).
- Proteoglycans may contain one, or several types of glycosaminoglycan on the same core protein.
- They have been ascribed a variety of functions including tissue hydration, regulation of collagen fibril formation, growth factor binding, cell adhesion and growth.

## 3. Glycosaminoglycans

- Glycosaminoglycans are defined as linear polysaccharide units consisting of repeating disaccharide units of hexosamine and hexuronic acid.
- They are covalently bound to core proteins and they are all sulphated (ex-Hyaluronan).
- Seven species of glycosaminoglycan exist & the sulphate and carboxyl groups that are present, render these macromolecules highly negative charge under normal conditions.

## 4. Glycoproteins

- Glycoproteins are a heterogeneous group of molecules that collectively contain carbohydrates covalently attached to a core protein.

- Key features of many of these molecules lie in their ability to interact not only with cells, but also with other macromolecules in the matrix.
- The adhesive glycoproteins (RGD motif) influence cell behaviour by facilitating the attachment and migration of cells.
- The glycoproteins found in skeletal tissues are thought to be important in influencing ion concentrations, although some are able to influence bone cell metabolism directly.

### Composition of periodontal connective tissue

Tissue	Collagen	Proteoglycans	Glycoproteins
<b>Gingiva</b>	Type – I, III, IV, V & VI	Decorin Biglycan Versican Syndecan	Fibronectin Tenascin Osteonectin Laminin
<b>Periodontal Ligament</b>	Type – I, III, V & VII Type – VI	Decorin Versican Fibromodulin Heparan Sulphate	Fibronectin Osteopontin
<b>Cementum</b>	Type – I & III Type – V & VI	Fibromodulin Lumican Biglycan Versican Chondroitin 4 Sulphate	Bone Sialoprotein Osteopontin Osteonectin Fibronectin
<b>Alveolar Bone</b>	Type – I & III	Chondroitin 4 Sulphate Decorin Biglycan	Osteopontin BSP - II

### Alterations in periodontal connective tissue

- Periodontitis, being an inflammatory disease, brings about many pathognomonic qualitative and quantitative changes in the periodontal connective tissue.
- As soon as gingival plaque accumulates adjacent to the gingival margin, an inflammatory infiltrate becomes apparent within the subjacent connective tissue.
- By 3<sup>rd</sup>-4<sup>th</sup> day, the inflammatory response is sufficient to initiate connective tissue degradation with up to 70% of the collagen within the foci of inflammation being lost.

### Changes in gingiva

- The Gingival collagen becomes more soluble.

- Ratio of Collagen types also changes with increase in the amount of Type-V Collagen.
- Degradation of Proteoglycan Core Protein and Hyaluronic Acid.
- If not contained, the inflammatory response and associated tissue destruction expands deeper towards the periodontal ligament and alveolar bone.

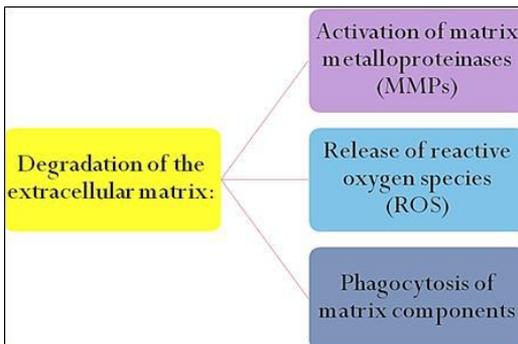
### Changes in cementum

Exposure of cementum to oral cavity or pocket environment brings about loss of collagenous attachment	
<u>Areas of increased mineralization:</u> <ul style="list-style-type: none"> <li>• Arise due to exchange of minerals from saliva</li> <li>• <math>\uparrow</math> <math>\text{Ca}^{++}</math>, <math>\text{Mg}^{++}</math>, <math>\text{K}^+</math> &amp; F</li> <li>• <math>\uparrow</math> Tooth resistance to decay</li> </ul>	<u>Areas of decreased mineralization:</u> <ul style="list-style-type: none"> <li>• Proteolysis of Sharpey's Fibers – Cavitation – Root Caries</li> <li>• <i>Actinomyces viscosus</i>, <i>Actinomyces naeslundii</i>, <i>S. mutans</i>, <i>S. Salivarius</i>, <i>S. Sanguis</i> &amp; <i>Bacillus cereus</i></li> </ul>

### Changes in junctional epithelium

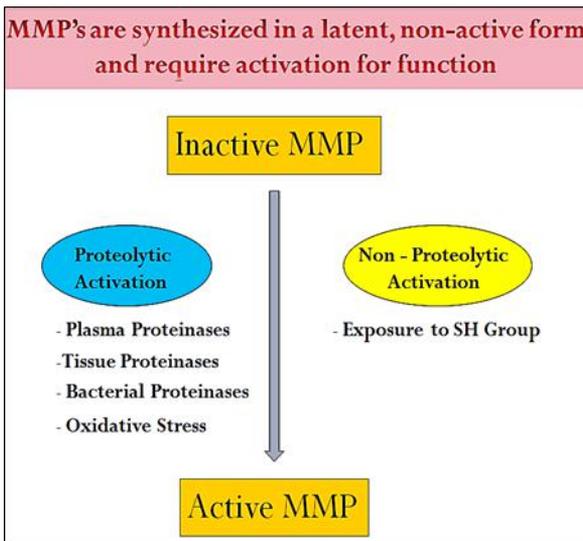
- Apical migration of Junctional Epithelium.
- Epithelial cell proliferation and migration over the modified connective tissue substratum.
- Expression of Integrins and other cell surface adhesion molecules at the epithelial connective tissue interface.
- Changes in distribution of Type-VII collagen, Laminin-5, Fibronectin, Tenascin &  $\beta$ 1 Integrin.

### Mechanism of degradation



## Matrix Metalloproteinases (MMP)

- The matrix metalloproteinase (MMP) gene family encodes a total of 24 homologous proteinases.
- They are classified into collagenases, gelatinases, stromelysins, membrane type matrix metalloproteinases and other matrix metalloproteinases depending on their substrate specificity and molecular structure.
- Matrix metalloproteinases play a major role in connective tissue breakdown.
- MMP-1,-2,-3,-8,-9 and-13 have been identified in inflamed periodontal tissues.



MMP activity is controlled *in vivo* by three ways:

- MMP's are synthesized and secreted as inactive precursors, and conversion to the active form requires activation.
- Production of MMP's can be regulated by growth factors and cytokines.
- Matrix metalloproteinase activity can be neutralized by endogenous serum and tissue inhibitors.

## Reactive Oxygen Species (ROS)

- ROS and Free Radicals have been implicated in the pathogenesis of many chronic inflammatory conditions including periodontitis.

## Sources of Free Radicals and ROS:

### Exogenous:

- Heat
- Trauma
- Ultraviolet light
- Ozone
- Smoking
- Radiation
- Infection & Therapeutic drugs

### Endogenous:

- By-products of metabolic pathways, electron leakage from mitochondrial electron transport chain
- Functional generation by host defence cells

- Oxygen derived free radicals (Superoxide, Hydroxyl, Peroxyl etc) are products of normal cellular metabolism.
- These species are capable of extracting electron and thereby oxidizing a variety of biomolecules vital to cell and tissue functions.
- At low concentrations, these free radicals stimulate the growth of fibroblasts and epithelial cells *in vitro* but results in tissue injury at higher concentrations.
- Their effect is nullified by ANTIOXIDANTS present in the body that comprises of-Vitamin A, C, E,  $\beta$ -Carotene, superoxide dismutase, catalase and myeloperoxidase.
- Dental Plaque harbours a number of bacterial pathogens which causes inflammatory changes in the periodontium & stimulates the host cells to release various interleukins and TNF- $\alpha$ .
- These pro-inflammatory cytokines (IL-1, IL-6, TNF- $\alpha$ ) attract PMN's to the site of injury.
- PMNs encounter this bacterial challenge by producing proteolytic enzymes and ROS by oxidative burst.
- These ROS not just damages the cell but also invoke other biomolecules to form free radicals-Nitrogen (NO) & Chlorine (HOCl).
- PMN's produce ROS by metabolic pathway of the respiratory burst catalyzed by NADPH Oxidase (Phagocytosis).
- HOCl is generated by azurophilic enzyme myeloperoxidase (Phagocytic Degranulation).
- NO is produced by macrophages via nitric oxide synthase (Vascular Endothelium).

- ROS thus results in disruption of cellular proteins, nucleic acids, membrane lipids and depolymerization of matrix components- collagen, proteoglycans & glycoproteins.

### **Phagocytosis**

- Phagocytosis is a significant pathway of collagen degradation in the physiological turnover and remodelling of periodontal connective tissues (Tewari *et al.* 1996).
- It is responsible for physiological turnover and remodelling of periodontal connective tissue.
- Phagocytosis of collagen takes place within the lysosomal apparatus of Fibroblast.
- Recognition followed by partial digestion of the collagen fibrils by proteinases such as gelatinases (MMP-2,-9) and final degradation by lysosomal enzymes Cysteine Proteinases such as Cathepsin B or L.

### **Current diagnostic strategies**

- Assessment of Etiological Factors.
- Assessment of Gingival Inflammation.
- Assessment of Loss of Periodontal Attachment.
- Radiographic Evaluation.

### **Biochemical analysis as a part of periodontal diagnosis**

- This approach of periodontal diagnosis involves identification of specific mediators in oral fluids (GCF, Saliva) and/or Blood.

This approach aims at recognition of following:

- a) Sub Gingival Bacteria and their products.
- b) Host Inflammatory and Immune products.
- c) Proteolytic and Hydrolytic enzymes released by inflammatory cells.
- d) Enzymes released from dead cells.
- e) Connective Tissue degradation products.

### **Biomarkers**

- A characteristic that can be measured and evaluated as an indicator of normal biological processes, pathological processes or pharmacologic responses to therapeutic interventions” (NIH Biomarkers Definitions Working Group, 1998).

- It provides useful information regarding present disease activity, disease susceptibility, future disease progression and response to periodontal therapy.
- Considering the multifactorial etiology of periodontitis, identification of a single diagnostic marker for all forms of periodontitis seems illusory (Seibel, 2006).

## **Biomarkers in periodontitis**

### **1. Host response & inflammatory biomarkers**

- Bacteria induce tissue destruction indirectly by activating host defence cells, which in turn produce and release mediators that stimulate the effectors of connective tissue break down.
- These mediate the inflammatory process and acts as markers of inflammation (Offenbacher *et al.*, 2010).
- The Interleukins (IL-1 $\alpha$ , IL-1 $\beta$ , IL-6), Prostaglandins (Pg E2), Tumour Necrosis Factor (TNF- $\alpha$ ) and Matrix Metalloproteinases (MMP-8, MMP-9) play major role in the pathogenesis of periodontal diseases.

#### **A. Cytokines**

- Cytokines are the low molecular weight polypeptides (5-70 kD) produced by cells to regulate or modify the activity of other cells.
- Proinflammatory Cytokines (IL-1 $\alpha$ , IL-1 $\beta$ , IL-6 & TNF- $\alpha$ ) appear to have a central role in periodontal tissue destruction (Graves, 1999).
- IL-1 is found in two active forms-IL-1 $\alpha$  & IL-1 $\beta$  and were once known as Osteoclast Activating Factor.
- IL-1 & TNF- $\alpha$  is produced primarily by activated macrophages in response to bacterial LPS.

These proinflammatory cytokines bring about:

- 1) Stimulation of Endothelial cells to express Selectins.
  - 2) Activation of Macrophage IL-1 production.
  - 3) Induction of PgE2 by macrophages and fibroblasts.
- IL-1 is a potent stimulant of Osteoclast proliferation, differentiation and activation.

- Both IL-1 and TNF- $\alpha$  induce production of proteinases in the mesenchymal cells including MMPs (Graves, 1999).
- Reduction in IL-1 concentration are associated with successful treatment (Macuh & Tanner, 2000).
- Elevated levels of IL-6 in GCF are associated with sites that do not respond well to non-surgical initial therapy (Masada *et al.* 1990).
- Elevated levels of TNF- $\alpha$  & IL6 are known risk factors for periodontitis (Page, 1991).
- The amount of IL-1 $\alpha$ , IL-1 $\beta$  and IL-1ra (IL-1 receptor antagonist) was significantly higher in GCF from diseased site compared to healthy site (Holmlund *et al.* 2004).

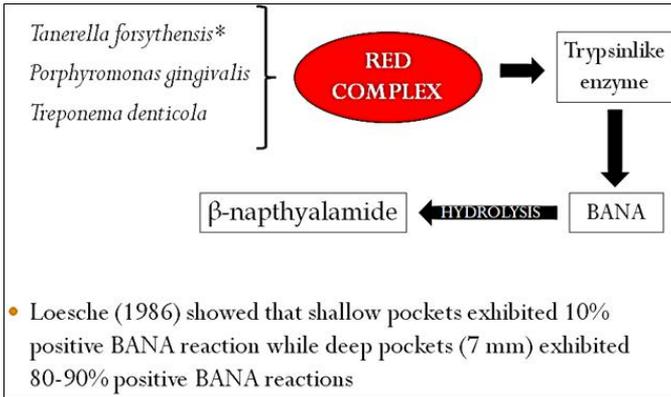
## **B. Prostaglandins**

- Prostaglandins are Arachidonic Acid metabolites generated by Cyclooxygenases (COX-1 & COX-2).
- The activity of COX-2 is upregulated by the action of IL-1 $\beta$  and TNF- $\alpha$  thereby resulting in increased production of PGE2 by Macrophages and Fibroblasts.
- Increased level of PGE2 is associated with increased production of MMPs by fibroblasts and osteoclasts (Airilia-Mansson *et al.* 2006).
- Use of NSAIDs in human subjects with advanced periodontitis are associated with less amount of bone loss compared to placebo (Williamia *et al.* 1989).

## **C. MMP's**

- MMPs are a family of proteolytic enzymes that mediate the degradation of extracellular matrix molecules, including interstitial and basement membrane collagens, fibronectin, laminin, and proteoglycan core protein (Christgau *et al.* 2006).
- The enzymes are secreted or released in latent form and become activated in the pericellular environment by disruption of a Zn<sup>++</sup>.
- Neutrophils are the major cells responsible for release of MMP-8 (Collagenase) and MMP-9 (Gelatinase) at the site of inflammation.
- Increased level of MMP-8 in saliva has been demonstrated in patients with periodontal disease (Herr *et al.* 2007).

## 2. Microbial biomarkers



## 3. Proteolytic & hydrolytic enzyme biomarkers

S. No.	Enzymes	Author	Year	Findings
01.	Aspartate aminotransferase	Oringer	2001	Associated with periodontitis severity.
02.	Alkaline phosphatase	Bartold Gibert	1998 2003	Positively correlated with pocket depth but not with bone loss. Indicator of future periodontal breakdown.
03.	Collagenase-2 (MMP-8)	Rai	2008	Elevated levels in periodontitis subjects compared to control.
04.	Collagenase-3 (MMP-13)	Ma	2000	Expressed during bone formation and gingival wound healing.
05.	Gelatinase (MMP-9)	Teng	1992	Twofold increase in patients with recurrent attachment loss.
06.	Cathepsin B	Eley & Cox	1996	Predictor of attachment loss.
07.	Myeloperoxidase	Cao & Smith	1989	Higher concentration at disease site & the conc reduces after t/t.
08.	Lysozyme	Jalil	1993	Subjects with lower levels are more susceptible to plaque formation.

## 4. Bone related biomarkers

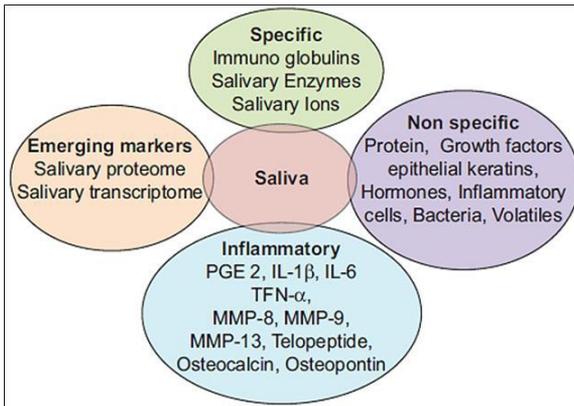
S. No.	Marker	Author	Year	Findings
01.	Osteocalcin	Nakashima	1996	Increased levels are evident during increased disease activity.
02.	Osteopontin	Sharma	2006	Conc. increased proportionally with disease progression.

03.	Calprotectin	Kido	1999	Higher levels in subjects with periodontitis than controls.
04.	Osteonectin	Bowers	1989	Sensitive marker for detection of periodontal disease status.
05.	Pyridinoline cross linked carboxy terminal telopeptide of type I Collagen	Giannobile	1999	Predictor of future alveolar bone and attachment loss. Conc. Reduces significantly after therapy.

## 5. Markers of cell death and connective tissue degradation

S. No.	Marker	Author	Year	Findings
01.	Fibronectin	Huynh	2002	Marker for periodontal disease status
02.	Glycosaminoglycans	Giannobile	1999	Raised level reflects active periodontal destruction
03	Lactate dehydrogenase	Wong	2006	Higher activity in patients with increased probing depth

## 6. Salivary biomarkers



## Chairside diagnostic kits

### Ideal requirements for periodontal diagnostic test (Chapple I., 1997)

- Quantitative.
- Highly sensitive method capable of analyzing a single periodontal site in health as well as disease.
- Reproducible
- Highly specific
- Simple to perform

- A rapid, one or two stage procedure
- Non-invasive
- Versatile in terms of sample handling, storage and transport
- Amendable to chairside use
- Economical
- Dependent upon simple and robust instrumentation

Chairside periodontal test kits can be categorized as:		
<b>Microbiological Kits</b> <ul style="list-style-type: none"> <li>• Omnigene</li> <li>• Evalusite</li> <li>• PerioScan</li> </ul>	<b>Biochemical Kits</b> <ul style="list-style-type: none"> <li>• Perio 2000</li> <li>• Prognos-Stik</li> <li>• Perio-Check</li> <li>• PerioGard</li> <li>• Pocket Watch</li> </ul>	<b>Genetic Kits</b> <ul style="list-style-type: none"> <li>• Periodontal susceptibility test (PST)</li> </ul>

### 1. Omnigene

- DNA Probe system for known pathogens.
- Paper point subgingival plaque is sent.

Detects:

- i) *A. actinomycetemcomitans*
- ii) *P. gingivalis*
- iii) *P. intermedia*
- iv) *F. nucleatum*
- v) *C. rectus*
- vi) *T. denticola*

- Reports are provided within few hours to few days



## 2. **Evalusite**

- ELISA based test for Aa, Pg & Pi.

## 3. **Perioscan**

- Utilises BANA (n-Benzoyl-DL-Arginine-2-Naphthylamide).
- Pg, Td & Tf-RED Complex.



## 4. **PERIO2000**

- Pg, Pi & Tf produce Volatile Sulphur Compounds.
- Degradation of aa-Cysteine & Methionine.
- Probe is inserted subgingivally to measure the level of VSCs.

## 5. **Prognos-stik**

- Released in 1993.
- Detects the elevated levels of MMP in GCF.

## 6. **Perio check**

- Most rapid chairside test for neutral proteases in GCF-Elastases, Collagenases.

## 7. **Periogard**

- Based on detection of enzyme Aspartate Aminotransferase (AST).
- AST is released from cell upon its death.
- Increased AST level in GCF signifies early periodontal destruction.
- Complex procedure involving multiple steps.

## 8. **Pocket watch**

- Based on detection of enzyme Aspartate Aminotransferase (AST).

## 9. Periodontal Susceptibility Test (PST)

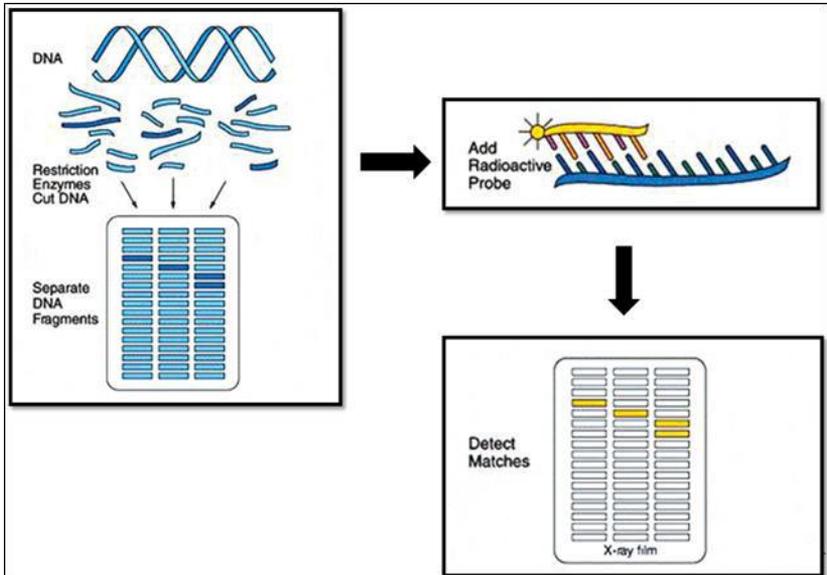
- First genetic test for periodontal diagnosis.
- Kornmam *et al.* (1997) found polymorphism in the genes encoding for IL-1 $\alpha$  & IL-1 $\beta$ .
- Individuals identified as genotype positive are more likely to have the phenotype of over expression of this gene.

### Future directions

#### 1. Near Infrared (NIR) Spectroscopy

- This test can distinguish different molecules by measuring vibrations of their chemical bonds and can use this molecular profile to differentiate between diseased and healthy tissues.
- It provides a measure of oxygen saturation of the tissues, degree of tissue perfusion and measure of tissue oedema (Xiang *et al.*, 2010).
- Liu *et al.* (2009) demonstrated decreased tissue oxygenation at periodontitis site compared to healthy site using NIR Spectroscopy.
- NIR Spectroscopy of GCF, unlike traditional biochemical analysis may provide more diagnostic and prognostic results.

#### 2. DNA Probes in periodontal diagnosis



## **Limitations**

- Lack of a single biomarker indicating periodontal status.
- Lack of easy sampling method with minimal discomfort.
- False Positive and False Negative results.
- Lack of acceptance in clinical practice.
- Cost Factor.

## **Conclusion**

- Early diagnosis by diagnostic kits using biomarkers can be instrumental in individualised and targeted periodontal treatment.
- Given the complex nature of periodontal disease, combination of two or more markers may provide an accurate assessment.
- Despite the presence of many important biomarker, the use of GCF as sample for diagnostic test is not well accepted among dental professionals due to difficulty in sampling.
- A more practical approach to biochemical diagnosis of periodontal disease is offered by saliva, however unlike GCF, it lacks site specificity.
- Application of latest techniques will definitely establish GCF as an important oral fluid for diagnosing periodontal disease and prognosticate the treatment outcome in near future.

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**Chapter - 4**  
**Cementum in Health and Disease**

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# Chapter - 4

## Cementum in Health and Disease

Dr. Shubham Kumar

### Abstract

Cementum is the calcified, avascular mesenchymal tissue that forms the outer covering of the anatomic root. Though avascular & aneural in structure, it is a dynamic tissue that is deposited throughout our lives. The cementum is composed of both Organic and Inorganic constituents. Hydroxyapatite  $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$  is the main inorganic constituent of cementum while the organic constituent is composed mainly of Collagen. This chapter tries to describe the detailed review of cemental physiology in health and disease with its clinical implications.

**Keywords:** Cementum, collagen, cemento-enamel junction, root planing

### Introduction

In humans and other mammals, the teeth are not directly attached to the Alveolar Bone. A soft connective tissue, referred to as the Periodontal Ligament is present between the tooth root and the alveolar bone. The principal fibers of the periodontal ligament are attached to the alveolar bone on one side and cementum on the other side. Due to its intermediary position between the radicular dentin and the periodontal ligament, cementum being a part of tooth, is functionally a part of the dental attachment apparatus, that is, the Periodontium.

Cementum has been defined as:

- Cementum is the calcified, avascular mesenchymal tissue that forms the outer covering of the anatomic root-*Carranza, 10<sup>th</sup> Edition (2007)*.
- Cementum is a specialized mineralized tissue covering the root surfaces and, occasionally, small portions of the crown of the teeth-*Jan Lindhe, 5<sup>th</sup> Edition (2008)*.
- Cementum is a hard-avascular connective tissue that covers the root of teeth-*Ten Cate's, 8<sup>th</sup> Edition (2012)*.

Cementum is a dynamic tissue that is deposited throughout our lives. It is pale yellow in color as compared to dentin. It is softer than dentin and has KNOOP HARDNESS NUMBER (KHN) 40 as reported by the *Biomaterials Properties Database, University of Michigan, 1996*. Cementum is Avascular & Aneural, that is, it is devoid of any blood supply and neural innervations. Cementum is permeable at young age, however the permeability of cementum decreases with the advancing age. Continuous deposition of cementum throughout life leads to the formation of *Incremental Lines of Salter*. It denotes the rhythmic activity of cemental deposition. These annulations in the cementum have proved to be a moderately reliable means for age detection in humans irrespective of sex, age & periodontal disease as reported by *Aggarwal et al., Incremental Lines in Root Cementum of Human Teeth: An approach to their role in age estimation using Polarizing Microscopy, IJDR, Volume 19, Issue 4, 2008, Page 326 -330*.

### **Biochemical composition**

The cementum is composed of both Organic and Inorganic constituents. Hydroxyapatite  $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$  is the main inorganic constituent of cementum and makes approximately 45-50% of cemental mass. Apart from Hydroxyapatite, cementum also contains traces of Fluoride, Magnesium and Sulphur. *Röckert* found that the concentration of Ca varied within a wide range, from 0.10 to 0.83 mg Ca/mm<sup>3</sup> (*Carranza 10th edition, Chapter 5, Ref No-156, Periodontology 2000, Vol. 13, 1997, Page 41-75*)

The organic constituents (50-55%) of cementum is composed mainly of Collagen. Other than collagen, the organic matrix of cementum also contains Non Collagen Proteins, Cells, Ground Substance, Adhesion Molecules and Others.

### **Collagen**

*Type I Collagen* comprises 90% of all collagen found in cementum. *Type III Collagen* (5%) is also found which less cross linked and is found in high concentration during development, repair and regeneration of mineralized tissues. However, its amount gets reduced with tissue maturation. *Type XII Collagen (FACIT-Fibril Associated Collagen with Interrupted Triple helices)* bind to type I collagen and also to non-collagenous proteins. Trace amount of *Type V Collagen, Type VI Collagen* and *Type XIV Collagen* is also found and is thought to be of periodontal origin.

## Non-collagen proteins

The non-collagen proteins found in cementum are Osteocalcin, Osteonectin and Osteopontin. They are thought to promote cell attachment and cell migration. They also stimulate protein synthesis of gingival fibroblasts and periodontal ligament cells. They portray major role in the differentiation of cementoblast progenitor cells to cementoblasts.

## Cells

Cemental matrix has two different types of cells. They are Cementoblasts, the formative cells and Cementoblasts, the resorptive cells.

### A) Cementoblast

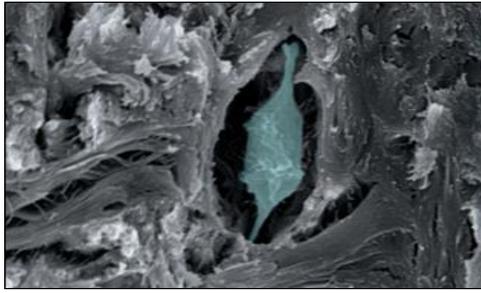
They arise from the Cementoprogenitor Cells derived from the cells of Dental Follicle. Some researchers also suggest the epithelial origin of cementoblast and are thought to be derived from Hertwig's Epithelial Root Sheath (HERS). They synthesize Collagen & Proteoglycan that make the organic matrix. These cells have numerous Mitochondria, well-formed Golgi apparatus and large amount of Granular Endoplasmic Reticulum.

According to the Embryonic Origin, Cementoblasts can be classified as (*Orban's Histology & Embryology, 12<sup>th</sup> Ed*)

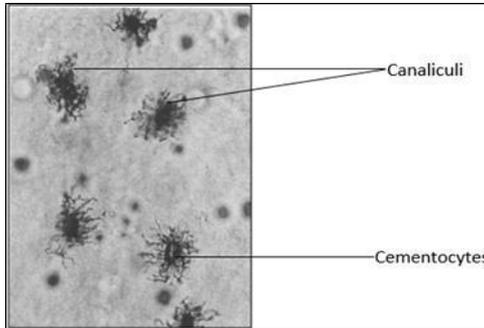
Cementoblasts producing Cellular Cementum	Cementoblasts producing Acellular Cementum
Derived from Dental Follicle	Derived from HERS
E 11 antibody strongly reacts with this cementoblast	E 11 antibody does not strongly react with this cementoblast
Cementoblast express receptors for Parathormone	Receptors for Parathormone are not expressed
Cementoblast express Osteopontin and Osteocalcin	Cementoblast express only Osteopontin

### Cementocytes

They are the cementoblasts that get trapped in rapidly calcifying cemental matrix. They are usually seen in apical 3<sup>rd</sup> of root. These are located in spaces termed lacunae. Cementum that is formed rapidly generally possesses wider lamellae & more cementocytes. Cementocytes have numerous cytoplasmic processes coursing in canaliculi. Adjacent canaliculi of neighboring cells communicate with each other and exchange of nutrients take place through this system of canaliculi by the process of diffusion.



**Cementocytes (blue cell) residing in lacunae. (Linde 5<sup>th</sup> Edition, Page-32)**



## **B) Cementoclast**

They are the multinucleated giant cells that are indistinguishable from osteoclasts. They are normally not seen in a healthy tooth. They cause cemental resorption that leads to:

- Exfoliation of primary teeth.
- Root resorption of Permanent Teeth.

## **Ground substance**

The ground substance of cementum is composed of Proteoglycans and Glycoproteins.

- **Proteoglycan:** Chondroitin Sulfate, Dermatan Sulfate & Hyaluronic Acid.
- **Glycoprotein:** Fibronectin & Tenascin.

They regulate cell-cell & cell-matrix interactions, both in normal development as well as in cemental repair. Immunohistochemical studies suggest that the distribution of Proteoglycan is closely associated with cementoblasts and cementocytes.

## Adhesion molecules

They are the proteins with RGD (Arginyl-Glycyl-Aspartic Acid) motifs that help in cell adhesion. Cementum Adhesion Molecules (CAP) is also found in the cemental matrix.

- **Bone sialoprotein:** Promotes mineral formation on root surface.
- **Osteopontin:** Regulates mineral growth on root surface.

Cementum Adhesion Molecules have a role to play in chemotaxis and differentiation of cementoblasts. They also play important role in attachment of Periodontal Ligament (PDL) fibers to root surface.

It is believed that the balanced activities of these two molecules may contribute to establishment and maintenance of unmineralized Periodontal Ligament (PDL) between cementum and alveolar bone.

## Others

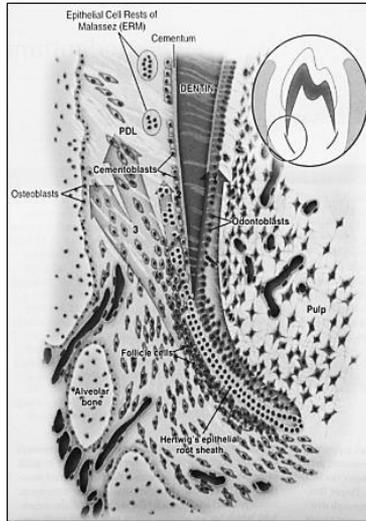
*Ikezawa et al.*, (1996) demonstrated the presence of Cementum-derived Growth Factor (CGF) in the Cemental matrix of bovine teeth. It is an Insulin-like Growth Factor-I (IGF-I). It is thought to enhance the proliferation of gingival fibroblast and PDL cells.

## Cementogenesis

Cementogenesis is one of the complex biochemical phenomena taking place during tooth development that involves the synchronized interplay of various factors and cell signaling molecules. Root formation commences when the enamel organ has reached its final size.

The inner and outer cell layers of the enamel epithelium, which delineate the enamel organ, proliferate from the cervical loop to form Hertwig's Epithelial Root Sheath (HERS). Initiation of Cementum formation takes place at the advancing root edge.

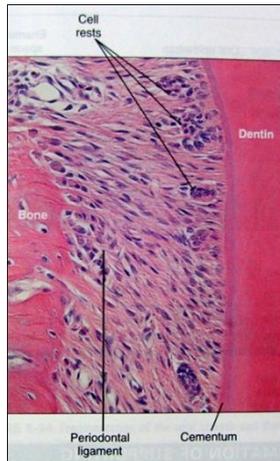
The cells of Hertwig's Epithelial Root Sheath (HERS) induce the Ectomesenchymal Cells of Dental Papilla to differentiate into Odontoblast. The newly formed Odontoblasts lay down the layer of Predentin. As soon as the first layer of predentin is laid, Odontoblast reciprocally induces the cells of Hertwig's Epithelial Root Sheath (HERS) causing it to disintegrate. Hertwig's Epithelial Root Sheath (HERS) at this stage becomes interrupted, thereby facilitating the Ectomesenchymal Cells of Dental Sac to come in direct contact with predentin. These cells differentiate into Cementoblast and lay down the Cementum.



### Fate of Hertwig's Epithelial Root Sheath (HERS)

Most of the cellular components of Hertwig's Epithelial Root Sheath undergo apoptosis. However some epithelial cell remnants of Hertwig's Epithelial Root Sheath persist in the Periodontal Ligament. These remnants of Hertwig's Epithelial Root Sheath are known as *Epithelial Cell Rests of Malassez*.

Apparently these cell rests are functionless, but they may be source of Dental Cysts following infection of Periodontal Ligament. The number of Epithelial Cell Rests of Malassez decreases with age.



Ten Cate's Oral Histology (8<sup>th</sup> Edition, Page-91)

## Factors affecting cementogenesis

Various factors are known to affect the process of Cementogenesis. They are as follows:

- Alkaline Phosphatase
- Bone Morphogenic Protein (BMP)
- Adhesion Molecules
- Gla ( $\gamma$ -Carboxyglutamic Acid) Protein
- Transcription Factors
- Other Factors

### Alkaline phosphatase

The term Alkaline Phosphatase is non-specific and describes a group of enzyme that has capacity to cleave phosphate group from substrates at alkaline pH. They can be found in the Organic Matrix in free or vesiculated form. The presence of Alkaline Phosphate is always associated with production of mineralized tissue. It promotes the growth of Hydroxyapatite Crystals in dental hard tissues by cleaving the Pyrophosphate group.

### Bone Morphogenic Protein (BMP)

They belong to “Transforming Growth Factor  $\beta$  Superfamily” and act through Transmembrane Serine/Threonine Protein Kinase Receptors. BMPs can induce pluripotent cells into the osteoblastic lineage and facilitate formation of new bone. They also act as Epithelial-Mesenchymal signaling molecule during Tooth Development. BMP-2, BMP-4 & BMP-7 is known to promote differentiation of Preosteoblast & Putative Cementoblast Precursor cell.

### Adhesion molecules

They are the proteins with RGD (Arginyl-Glycyl-Aspartic Acid) motifs that help in cell adhesion. Cementum Adhesion Molecules (CAP) is also found in the cemental matrix. Bone Sialoprotein promotes mineral formation on root surface. Osteopontin regulates mineral growth on root surface.

### Gla ( $\gamma$ -Carboxyglutamic Acid) Protein

They are the  $\text{Ca}^{++}$  binding Amino Acids. Osteocalcin (Bone Gla Protein) is the marker for maturation of Osteoblast, Odontoblast & Cementoblast. Matrix Gla Protein (MGP) is supposed to have a role as Inhibitor of Mineralization. The intricate balance between the two is considered to regulate the extent of mineralization.

## Transcription factors

CBFA1 Gene is considered as the Master Switch for differentiation of Odontoblast. Its role in the process of Amelogenesis & Cementogenesis is still under investigation.

## Other factors

Apart from these factors, many other factors are reported to play an important role in Cementogenesis. However, more research work is required so as to establish the exact role of each factor in Cementogenesis. These factors are:

- **Dentin Matrix Protein (DMP)-1:** (Sawada *et al.*, Ultrastructural immunolocalization of dentin matrix protein 1 on Sharpey's fibers in monkey tooth cementum, Department of Ultrastructure Science, Tokyo Dental College, Japan, 2012)
- **Amelogenin:** (Kunimatsu *et al.*, Ameloblast Enhances the proliferation of Cementoblast Lineage Cells, JOP, Vol 82, Number 11, Page 1632-1638, 2011)
- **Prostaglandins (PG-E2 & PG-E2):** (Camargo *et al.*, Prostaglandin E2 & E2 Enhance Differentiation of Cementoblast Cells, JOP, Vol 76, Number 2, Page 303-309, 2005)
- **Growth factors (IGF, TGF- $\beta$ , PDGF)**
- **Metalloproteinases**

## Classification of cementum

Cementum can be classified as:

### 1. According to location

- a) Radicular Cementum
- b) Coronal Cementum

### 2. According to cells present

- a) Acellular Cementum
- b) Cellular Cementum

### 3. According to fibers present (Schroeder, 1991)

- a) Acellular Afibrillar Cementum (AAC).
- b) Acellular Extrinsic Fiber Cementum (AEFC).
- c) Cellular Matrix Stratified Cementum (CMSC).

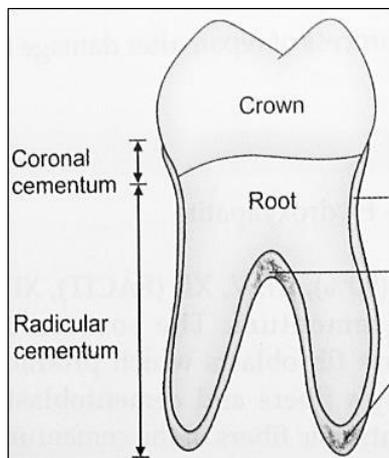
d) Cellular Intrinsic Fiber Cementum (CIFC).

e) Intermediate Cementum.

### 1. Radicular & coronal cementum

Cementum situated towards the coronal end of tooth root is known as Coronal Cementum. It is the area of cementum that is most susceptible to exposure to oral cavity.

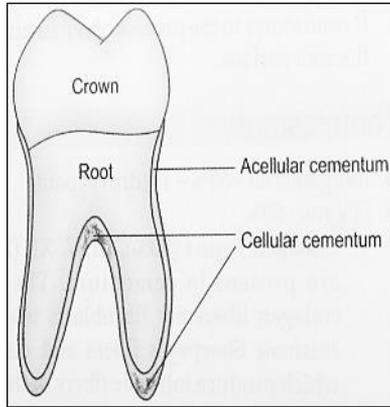
Cementum located apical to the coronal cementum is known as Radicular Cementum.



### 2. Acellular & Cellular cementum

The basis of this classification is the presence or absence of Cementoblasts within the cemental layers.

Cementum that has cementoblasts within the cemental layers is known as Cellular Cementum while the cementum that does not have cementoblast within the cemental layer is known as Acellular Cementum.



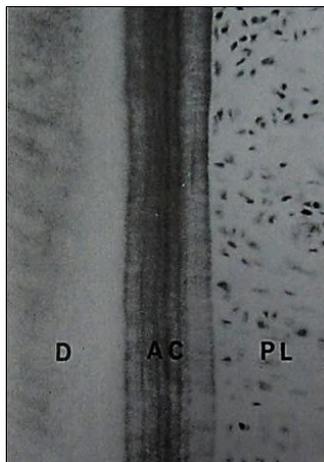
**2a) Cellular cementum**

It is located at the apical half of root and in furcation areas. It is formed after the tooth has reached occlusal plane. It contains cementocytes in individual spaces that communicate with each other through a system of anastomosing canaliculi.

**2b) Acellular cementum**

It is the 1<sup>st</sup> Cementum to be formed and covers approximately the cervical half/third of the root. It is devoid of any cells. This cementum is formed before the tooth reaches the occlusal plane. Sharpey's fiber makes up most of the structure of acellular cementum.

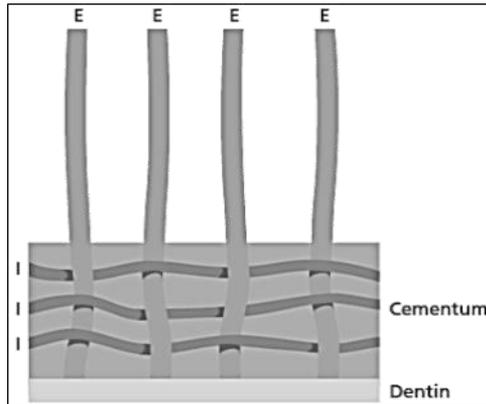
Sharpey's fibers are inserted at right angles into the root surface and penetrate deep into cementum.



**Acellular Cementum (AC) devoid of any cells (Carranza, 10<sup>th</sup> Ed, Pg-75)**

Acellular cementum also contains intrinsic collagen fibrils that are calcified and irregularly arranged or parallel to the surface.

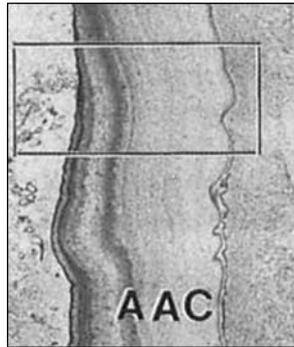
The Sharpey's fibers constitute the Extrinsic Fiber System (E) of acellular cementum and are produced by Fibroblasts in the PDL. The Intrinsic Fiber System (I) is produced by Cementoblasts (Linde 5<sup>th</sup> Ed, Pg-33).



	<b>Acellular Cementum</b>	<b>Cellular Cementum</b>
Formation	Forms before tooth reaches occlusal plane	Forms after tooth reaches occlusal plane
Cells	Does not contain any cell	Contains Cementocytes
Location	Coronal portion of root	Apical portion of root
Calcification	More Calcified	Less Calcified
Sharpey's Fibers	More	Less
Thickness	30-230 $\mu\text{m}$	1 $\mu\text{m}$ to several mm
Rate of Formation	Slower	Faster
Incremental Lines	More	Sparse
Function	Forms after Regenerative Periodontal Surgical Procedure	Contributes to length of root during growth

### 3a) Acellular Afibrillar Cementum (AAC)

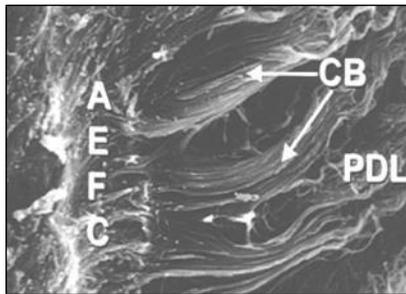
It is the only mineralized ground substance product of Cementoblasts. It is devoid of Cells & Collagen. It is deposited as isolated patches in proximity to Cemento-Enamel Junction (CEJ) and its thickness varies from 1-15  $\mu\text{m}$ . It forms the coronal Cementum and has no role in tooth attachment.



### 3b) Acellular Extrinsic Fiber Cementum (AEFC)

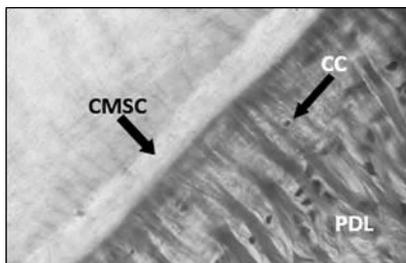
It is also known as Primary Cementum. It contains densely packed bundles of Sharpey's Fibers and density can be as high as 30,000 Fibers/mm<sup>2</sup>-*Schroeder*.

It is devoid of Cells and its thickness ranges from 30-230 μm. It is found in coronal half of root. It has a significant role in Tooth Anchorage.



### 3c) Cellular Matrix Stratified Cementum (CMSC)

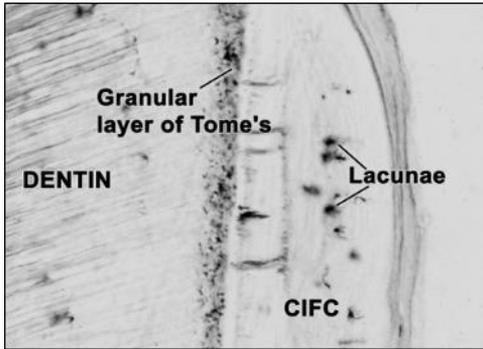
It is composed of Intrinsic & Extrinsic Fibers and is a co-product of Fibroblast & Cementoblast. It is laid down throughout the functional period of tooth. It may contain cells and its thickness ranges from 100-1000 μm. It is found in apical 1/3<sup>rd</sup> of root, apices & furcation areas.



### 3d) Cellular Intrinsic Fiber Cementum (CIFC)

It is also known as Secondary Cementum. It contains Cells & Intrinsic Fibers. No extrinsic fiber is present in Cellular Intrinsic Fiber Cementum.

It is the only cementum that has got the capacity to repair a resorptive defect. It has got no immediate role in tooth attachment.



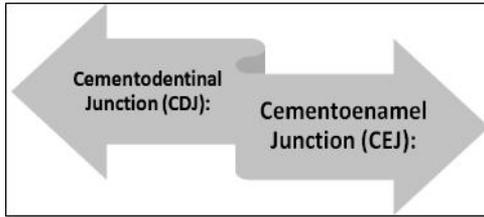
	AEFC	CIFC
Location	Cervical 1/3 <sup>rd</sup>	Apical 1/3 <sup>rd</sup> & Furcation
Time of formation	Earlier-Primary Cementum	Later-Secondary Cementum
Cementoblast	Suggested to be derived from HERS	Suggested to be derived from Ectomesenchymal Cells of Dental Papilla
Collagen Fibers	Extrinsic-Fibroblast	Intrinsic-Cementoblast
Rate of Formation	Slow	Fast
Cementocytes	Absent	Present
Cementoid	Absent	Present
Main Function	Anchorage	Adaption & Repair

### 3e) Intermediate cementum

It is an ill-defined zone near the Cementodentinal Junction. It appears to contain the cellular remnants of Hertwig's sheath embedded in calcified ground substance. It is frequently observed between AEFC & Dentin in rodent Molars. It is absent in Humans. It is also called as *Layer of Hopewell & Smith*.

### Cemental junctions

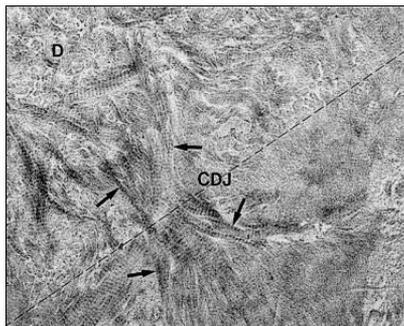
- 1) Cementodentinal Junction.
- 2) Cementoenamel Junction.



### Cementodentinal junction

The terminal apical area of the cementum where it joins the internal root canal dentin is known as CDJ. Its width (2-3µm) appears to remain stable.

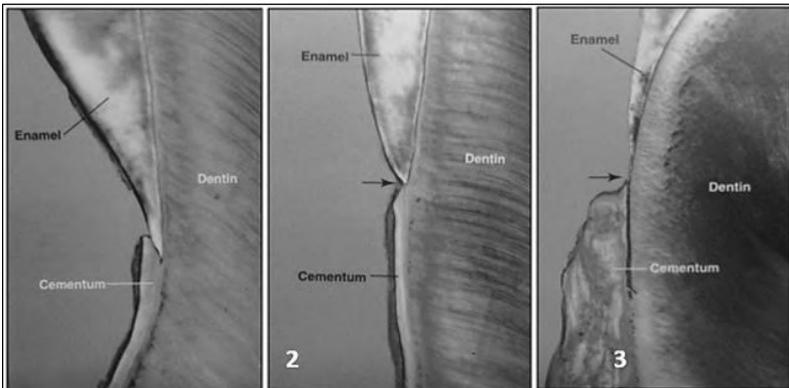
It is characterized by interdigitation of collagen fibrils from Dentin (D) & Acellular Extrinsic Fiber Cementum (AEFC).



### Cemento enamel junction

Three types of relationship involving cementum may exist at CEJ:

- 1) Cementum Overlaps the Enamel: 60-65%.
- 2) Edge to Edge Butt joint: 30%.
- 3) Cementum & enamel fail to meet: 5-10%.



## Age changes in cementum

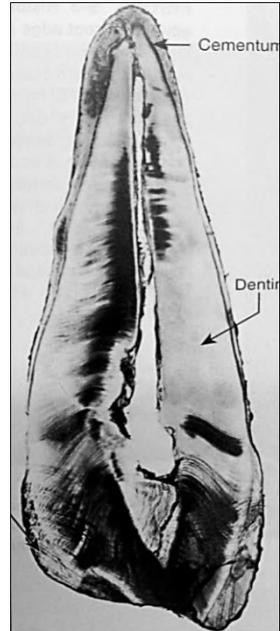
### 1. Changes in physiological activity of cementoblast

With continuous cementum deposition, the cementocytes in deeper layer eventually die and the lacunae appear empty. Whether the eventual cell death is due to starvation or is due to ageing is, however, not known.

### 2. Changes in thickness of cementum

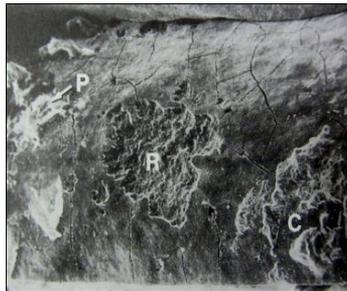
Cementum formation on Human teeth continues lifelong. More cementum is deposited apically than cervically.

The thickness of cementum varies from 16-60  $\mu\text{m}$  near cervix to 150 - 200  $\mu\text{m}$  near the apex/furcation area. The amount of total cementum triples from the age of 11 years to 70 years. The average value of thickness of cementum for a 20 year old is approximately 95  $\mu\text{m}$  and that for a 60 year is approximately 215  $\mu\text{m}$ .



### 3. Changes due to physiologic tooth movement

Cemental deposition is thicker on the distal root surface due to net mesial drifting of teeth.



**Scanning Electron Micrograph of root exposed by periodontal disease showing large Resorption Bay (R), remnants of PDL (P) & Calculus (C) (Carranza, 10<sup>th</sup> Ed, Pg-78)**

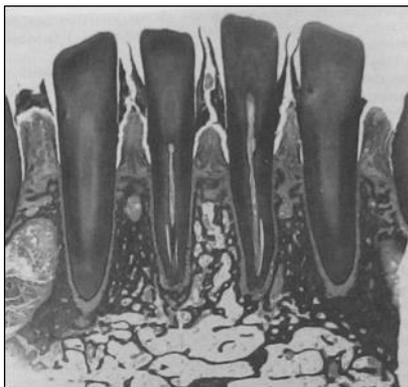
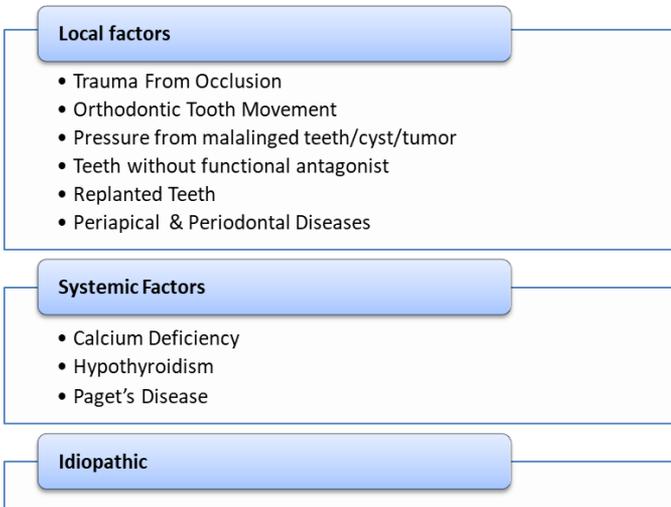
### Cemental resorption & repair

Cementum Resorption occurs microscopically as *“Bay Like Concavity”* in the root surface. Several sites may coalesce to form a large area of

destruction. The process may extend to underlying dentin and pulp however the patient is usually asymptomatic.

It may alternate with periods of Repair and Deposition of new cementum. On microscopic examination, a dark & irregular line may be seen that demarcates newly formed cementum from root. This line is referred to as *Reversal Line*.

Resorptive changes in Cementum are seen in erupted as well as unerupted teeth. The common etiological factors are:



**Low Power Histological Section of Mandibular Anterior teeth subjected to excessive Orthodontic Forces (Carranza, 10<sup>th</sup> Ed, Pg-78)**



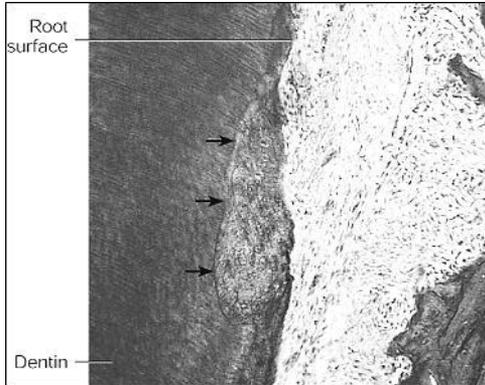
**High Power Micrograph of left central incisor shortened by resorption of Cementum and Dentin (Carranza, 10<sup>th</sup> Ed, Pg-78)**

Cemental repair requires presence of viable connective tissue, i.e., Repair will not take place if Epithelium proliferates into an area of resorption. The types of Cemental Repair are:

- Anatomic repair.
- Functional repair.

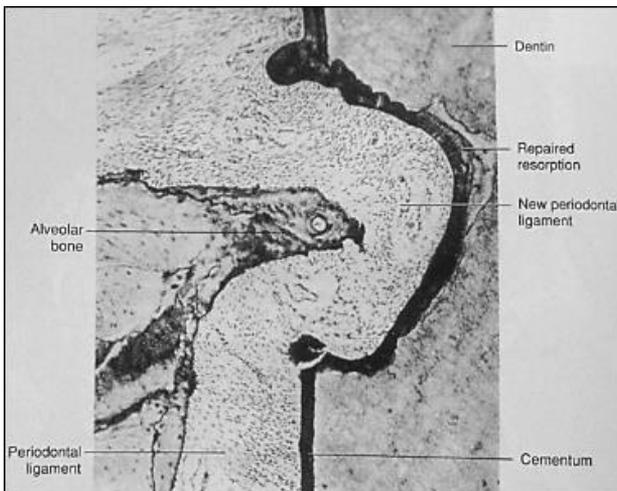
### Anatomic repair

In this type of cemental repair, the root outline is restored by cemental deposition. This type of cemental repair takes place in superficial resorption.



### Functional repair

This type of cemental repair takes place in cases of deep resorption and the root outline is not restored. However, the alveolar bone grows and follows the outline of recess to maintain the periodontal space.

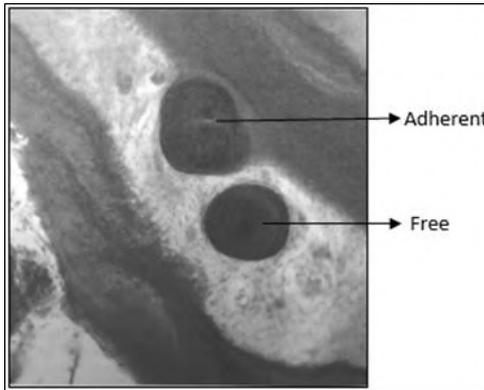


## Cementicles

Cementicles are the calcified round/ovoid masses found within the PDL. They may lie freely or may fuse with the cementum. Usually seen in advanced age or due to trauma. Cementicles develop around a central nidus, which may be:

A spicule of bone/cementum.

Degenerated epithelial rests.



## Functions of cementum

### Anchorage

- Cementum furnishes a medium for attachment of collagen fibers that bind the tooth to the alveolar bone.

### Adaption

- Cementum makes functional adaption of teeth by continuous deposition.

### Repair

- Cementum is the major reparative tissue for root surface.

## Clinical considerations

We routinely come across many clinical cases that involve cementum in the disease process. Therefore, it is imperative to know and understand these clinical considerations.

They are:

- Root Planing.
- Root Biomodification.

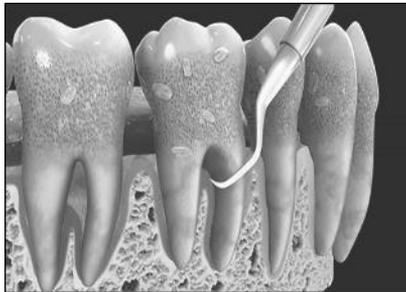
- Cemental Aplasia & Hyperplasia (Hypercementosis).
- Ankylosis.
- Exposure of Cementum to Oral Environment.
- Radiographic features of some diseases associated with cementum.

### Root Planing

Calculus is the mineralized dental plaque that forms over the natural tooth and prosthesis.

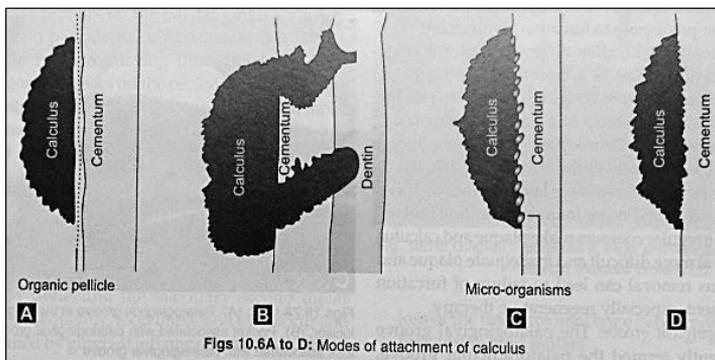
Root Planing is the process by which the residual embedded calculus and the portions of diseased cementum are removed from the tooth to produce a smooth hard & clean surface (*Carranza's Clinical Periodontology, 10<sup>th</sup> Ed, Page-774*)

Calculus embedded deeply in cementum may appear morphologically similar to cementum and thus has been termed *Calulocementum* (*Carranza's Clinical Periodontology, 10<sup>th</sup> Ed, Page-173*)



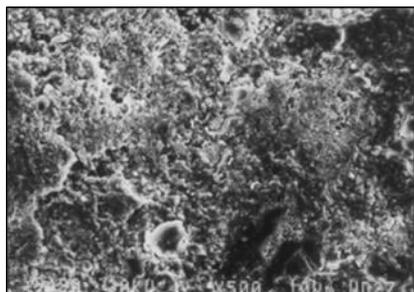
Helmut A. Zander (1952) described four types of Calculus attachment

- A. Attachment by means of Organic Pellicle.
- B. Mechanical locking into surface irregularities.
- C. Penetration of calculus bacteria into cementum.
- D. Close adaption of calculus undersurface depressions to gently sloping mounds of unaltered cementum.

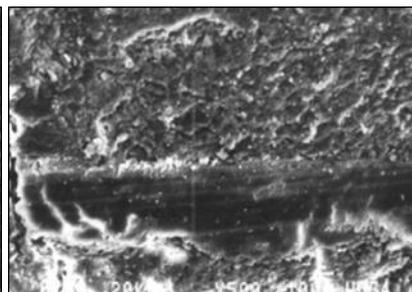


The various methods used for root planing are:

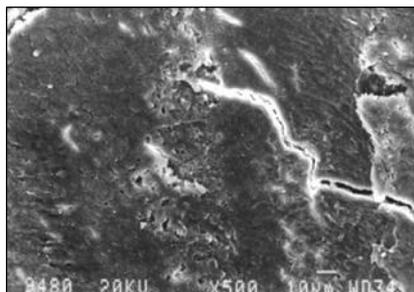
- Hand Root Planing
- Ultrasonic Root Planning
- Rotary Root Planing
- Chemical Root Planing
- LASERS



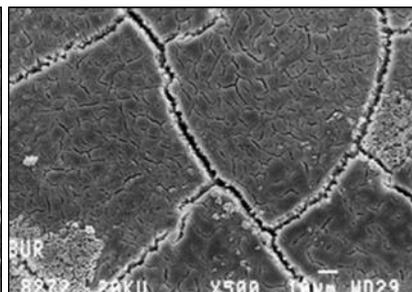
**Scanning Electron Microscope view of a Diseased Cementum**



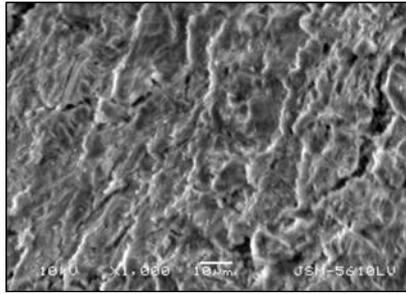
**Scanning Electron Microscope view of root surface planed with Gracey curette**



**Scanning Electron Microscope view of root surface planed with Ultrasonic Instrument**



**Scanning Electron Microscope view of root surface planed with Rotary Burs**



**Scanning Electron Microscope view of root surface planed with Chemical Agents**

Though, root planing with rotary burs gives the best result, it is very time consuming. The problem with chemical root planing is that one can't control the seepage of chemical into periapical and lateral tissues. Root planing with lasers is still under investigation. So, this suggests that ultrasonic root planing is the most convenient and widely accepted method of root planing.

Dahiya P, Kamal R, Ultra-Morphology of Root Surface subsequent to periodontal instrumentation: A SEM Study, JISP, Vol 16, Issue 1, 2012, Page 96-100.

Verma SJ, Gohil MH, SEM Study to analyze the morphological characteristics of root surfaces after application of Carisolv gel in association with scaling and root planing: In vitro Study, JISP, Vol 16, Issue 3, 2012, Page 329-332.

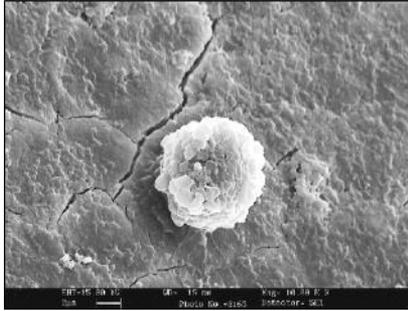
### **Root biomodification**

Changes in the tooth surface wall of Periodontal Pockets interfere with new attachment. Therefore, it is necessary detoxify, decontaminate and demineralize the root surface thereby removing the smear layer and exposing the collagenous matrix of dentin and cementum. Root Biomodification is a procedure by which we make the contaminated root surfaces biologically acceptable. Various agents have been used successfully:

- A) Citric Acid - freshly prepared, 61 g/100 ml pH 1, application time of 2-3 minutes
- B) Tetracycline - 125 mg/ml, collagenase inhibition activity as well
- C) EDTA (Ethylene Diamine Tetra Acetic Acid) - 18% EDTA
- D) Fibronectin - Tissucol
- E) Laminin

F) Growth Factors - PDGF, IGF

G) LASERS - Er: YAG, Nd: YAG, CO<sub>2</sub>



**SEM View of Round Fibroblast seen on root surface post SRP**



**SEM View of Flat (Healthy) and firmly attached Fibroblast seen on root surface post SRP & CO<sub>2</sub> LASER Therapy**

Round fibroblast appears on the surface of scaled specimen (*in vitro* after 3 days). However, lased and scaled specimen shows fibroblast that is flat and considered healthy and firmly attached due to well-developed lamellipodia.

(Crespi R. *et al.*, Effects of CO<sub>2</sub> Laser Treatment on Fibroblast Attachment to Root surfaces-A SEM Analysis, JOP, Vol 73, Number 11, 2002, Page 1308-1312).

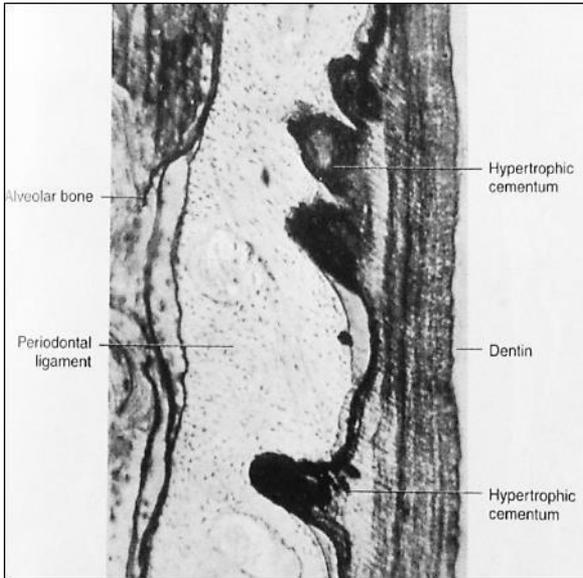
### **Cemental aplasia & hyperplasia**

Abnormalities in thickness of Cementum may range from:

- Absence of Cementum: Cemental Aplasia (Hypophosphatasia).
- Paucity of Cementum: Cemental Hypoplasia (Hypopituitarism).
- Excessive Deposition of Cementum: Cemental Hyperplasia or Hypercementosis.

Hypercementosis is usually an age-related phenomenon that may be Localized/Generalized. Excessive thickening may occur in broad spectrum of neoplastic & non-neoplastic conditions (Benign Cementoblastoma, Cementifying Fibroma, Florid-Cemento Osseous Dysplasia, etc.)

It may be Spike Like resulting from excessive Tension from Orthodontic Appliance or may be Generalized as follows:



**a) Affecting single tooth**

- i) Teeth without antagonists.
- ii) Teeth with low grade Periapical Infection.

**b) Affecting whole dentition**

- i) Paget's Disease
- ii) Acromegaly
- iii) Arthritis
- iv) Rheumatic Fever
- v) Thyroid Goitre



## Ankylosis

Fusion of Cementum and Alveolar bone with obliteration of Periodontal Ligament is termed as Ankylosis. It occurs in teeth with cemental resorption where the defect is filled up by bone tissue-abnormal repair. It is more frequent in Primary Dentition

Features of Ankylosed Tooth:

- Loss of Physiologic Mobility.
- Loss of Proprioception.
- Metallic Percussion.
- Infraocclusion.
- PDL space is missing radiographically.

## Exposure of cementum to oral cavity

Cementum becomes exposed to the oral environment as a result of:

- Gingival recession
- Loss of Attachment



Sufficient permeability of cementum allows penetration by organic substances, inorganic ions and bacteria (Periodontal Disease). It results into either of the two:

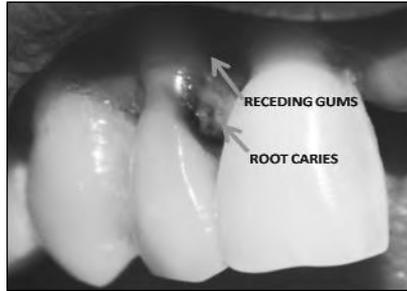
- Areas of increased mineralization.
- Areas of decreased mineralization.

## Areas of increased mineralization:

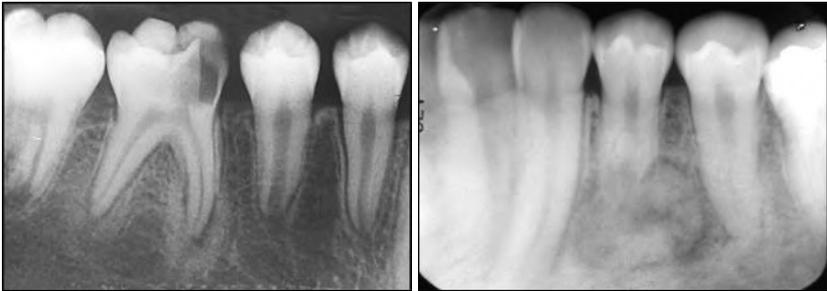
It arises due to exchange of minerals from saliva. High concentrations of  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ,  $\text{K}^+$  &  $\text{F}^-$  are deposited in the exposed cementum thereby increasing the resistance of tooth to decay.

## Areas of decreased mineralization

It arises due to proteolysis of Sharpey's Fibers resulting in cavitations causing caries. Microorganisms responsible for root caries in exposed cementum are *Actinomyces viscosus*, *Actinomyces naeslundii*, *S. mutans*, *S. Salivarius*, *S. Sanguis* & *Bacillus cereus*. This type of caries tends to progress around the teeth rather than into the teeth.



## Radiographic appearance of some diseases involving cementum



**Condensing Osteitis**

**Children & Young Adults**

**Intact Lamina Dura & widened PDL Radiopaque mass surrounded by a space. Radiopaque mass of sclerotic radiolucent line bone surrounding the apex**

**Cementoblastoma < 25 yrs**

**Mandible**

## Conclusion

The understanding of human physiology has changed considerably with the advent of newer techniques, from macroscopic level to molecular level.

However, the knowledge of Cementum physiology still lags behind than what is known about other dental & periodontal tissues.

Recent studies have contributed a lot to the understanding of Cemental physiology, thereby leading to newer concepts in treatment modalities, still more work is required so as to attain the true goal of "PRIODONTAL THERAPY".

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**Chapter - 5**  
**Acute Gingival Infections**

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# Chapter - 5

## Acute Gingival Infections

Dr. Shivam Yadav

### Abstract

This present chapter provides updates on acute conditions affecting the gingival tissues and their managements. These infections are abrupt in onset and cause illness that is short in duration and is rapidly progressing. These infections mainly include conditions like Necrotising ulcerative gingivitis, Pericoronitis, Primary herpetic gingivostomatitis, abscesses in the Periodontium, necrotizing periodontal diseases and other acute conditions that cause gingival lesions with acute presentation, such as infectious processes not associated with oral bacterial biofilms, mucocutaneous disorders and traumatic and allergic lesions.

The review systematically elaborates the clinical features of these acute gingival conditions, etiology, diagnosis, differential diagnosis, associated complications and their best possible management.

**Keywords:** Necrotising ulcerative gingivitis, pericoronitis, primary herpetic gingivostomatitis, periodontal abscess, gingival abscess

### Introduction

Acute means of abrupt onset. It refers to an illness that is of short duration and is rapidly progressive.

### Necrotizing ulcerative gingivitis

Acute necrotizing ulcerative gingivitis, (ANUG) now classified as Necrotizing Periodontal disease according to the 1999 American Academy of Periodontics classification system.

NUG is a distinct and specific disease characterized by-

### Rapidly progressive ulceration

- Typically starting at the tip of interdental papilla.
- Spreading along the gingival margins.

- Going on to acute destruction of periodontal tissue.

This disease entity has been described so far back as the days of Hippocrates and is known by many synonyms such as-

- Trench Mouth.
- Vincent's Disease.
- Vincent's Gingivostomatitis.

### **Historical Aspect**

- Xenophon (4th century B.C).
- The greek soldiers were affected with sore mouth and foul-smelling breath.
- In 1778, Hunter described the clinical features of the disease and differentiated it from scurvy and chronic periodontitis.
- Vincent (1896) and Plaut (1894)-origin of spirochetal and fusiform bacilli.
- In 1904, Vincent described these organisms in ulceronecrotic gingivitis.

### **Clinical features**

- An acute disease.
- Often undergoes a diminution in severity without treatment leading to subacute stage.
- It is milder and more persistent type.
- Patient may have history of repeated remissions and exacerbations-recurrent type.
- May be limited to single tooth, group of teeth or widespread throughout mouth.

### **Predisposing factor**

#### **1. Local factors**

- A) Contributing to Accumulation of Bacteria
  - 1) Poor oral hygiene
  - 2) Overhanging margins from restorations
  - 3) Food impaction
  - 4) Malpositioned teeth

- 5) Calculus
- B) Contributing to Local Ischemia
  - Cigarette smoking

## 2. Systemic predisposing factors

- Systemic diseases
- Nutritional deficiencies
- Emotional stress
- Hormonal imbalance

### Etiology

#### The Role of Bacteria

- Caused by fusiform bacillus and spirochetes (Plaut, 1894 & Vincent, 1896).
- Spirochetes invade the underlying living tissue (Cahn, 1929, Listgarten *et al.*, 1967).
- Fusospirochetal complex (Rosebury *et al.*, 1950).
- **Dominant bacteria:** Prevotella intermedia, Fusobacterium, Treponema, (Loesche *et al.*, 1982).
- *Treponema pallidum* related spirochetes have been reported to be associated with acute necrotizing ulcerative gingivitis (Riviere *et al.*, 1991).

#### The role of host response

- Impaired host response
- Associated with physical & emotional stress
- All predisposing factors associated with immunosuppression.
- Depression in host defense mechanisms, PMN chemotaxis and phagocytosis (Cogen *et al.*, 1983).
- High incidence of ANUG in HIV positive patients.

#### Psychosomatic factors

- **Cohen-Cole *et al.*, 1983:** Activation of hypothalamic-pituitary-adrenal axis in psychiatric disturbances and stress.
- Elevation of serum and urine cortisol levels.
- Depression of lymphocyte and PMN function.

## Intraoral Signs and Symptoms

- Punched-out crater like depressions at the crest of interdental papillae extending to marginal gingiva.
- Craters covered by gray, pseudomembranous slough which is demarcated from rest of the oral mucosa by linear erythema.



- Pseudomembrane surface may be denuded exposing gingival margin which is red, shiny and hemorrhagic.
- Lesions destroy gingiva and underlying periodontal tissues.
- Spontaneous gingival hemorrhage.
- Fetid odour.



- Increased salivation.
- Pain-radiating or gnawing type.
- Lesion is sensitive to touch.
- Metallic foul taste.
- Excessive amount of 'pasty' saliva.



### Extra oral signs and symptoms

- Local lymphadenopathy and slight elevation in temperature in mild and moderate
- High fever, increased pulse rate, leucocytosis, loss of appetite and general lassitude.
- Insomnia, constipation, gastro-intestinal disorders, headache and mental depression.

### Clinical course

- **Pindborg (1966):** Described three stages in the progress of NUG.
- Erosion of the tip of interdental papilla.
- Lesion extending to marginal gingiva and causing further erosion of whole of the papilla and finally complete loss of papilla.
- The attached gingiva also being affected.

### Exposure of bone

NUG may lead to NUP with a progressive destruction of the periodontium and gingival recession (Horning and Cohen *et al.* in 1995).

- **Stage 1:** Necrosis of tip of interdental papilla (93%).



- **Stage 2:** Necrosis of entire papilla (19%).



- **Stage 3:** Necrosis extending to gingival margin (21%).
- **Stage 4:** Necrosis extending to attached gingiva (1%).
- **Stage 5:** Necrosis extending to buccal or labial mucosa (6%).
- **Stage 6:** Necrosis exposing alveolar bone (1%).
- **Stage 7:** Necrosis perforating skin of cheek (0%).

**Severe sequelae of necrotizing gingivitis in children with severe malnutrition**



**Gangrenous Gingivitis**



### **Noma with Advanced Destruction of Facial Tissues**

#### **Histopathology**

- It is acute necrotizing inflammation of gingival margin.
- Involves stratified squamous epithelium and underlying connective tissue.
- Surface epithelium is destroyed and replaced by fibrin, epithelial cells, PMNs.
- Epithelium is edematous.
- Underlying CT is hyperaemic with numerous engorged capillaries & dense.
- Infiltration of PMNs.
- Plasma cells in periphery of Infiltrate.



#### **Lisgarten 1965**

Provided electron microscopic data confirming the invasion of non-necrotic gingiva by large and intermediate spirochetes.

He further noted that the invasion of spirochetes in the ulcerated lesion could be broadly grouped into four zones of increasing depth from the tissue surface.

### **Zone 1: Bacterial Zone**

- The most superficial, consists of varied bacteria, including few spirochetes of small, medium and large types.

### **Zone 2: Neutrophilic Rich Zone**

- Contains numerous leucocytes, mainly neutrophils with bacteria, including many spirochetes of various types between the leucocytes.

### **Zone 3: Necrotic Zone**

- Consists of disintegrated tissue cells, fibrillar material, remnants of collagen fibers and numerous spirochetes of the medium and large types with few other organisms.

### **Zone 4: Zone of Spirochetal Infiltration**

- Consists of well-preserved tissue infiltrated with medium and large spirochetes without other organisms.

### **Diagnosis of NUG**

- 1905, Weaver and Tunncliff: smears diagnostic if they showed "the characteristic fusiform bacilli".
- Rosenthal 1929 stated that microscopic examination was essential for a positive diagnosis.
- 1945, the Research Commission of the ADA: diagnosis confirmed by clinical findings.
- Barnes *et al.* diagnosis of ANUG can be confidently based on clinical findings alone.

### **Diagnostic essentials**

1. Lesions are painful
2. Lesions are gingival ulcers, punched-out crater-like, of interdental papilla and may involve marginal gingiva
3. Gingival ulcers bleed spontaneously or readily

- Barnes *et al.*, 1973.
- Rowland, 1999.

**Table 2. Non-essential clinical features of NUG, the absence of which does not preclude the diagnosis of NUG**

1. "Pseudomembrane" of sloughed necrotic debris and bacteria covering the ulcerated area
2. <i>Foetor ex ore</i> ( <i>foetor oris</i> , fetid breath)
3. Fever, malaise
4. Lymphadenopathy – submandibular (and cervical)

- Differential diagnosis
- Herpetic gingivostomatitis
- Desquamative gingivitis
- Streptococcal gingivostomatitis
- Aphthous stomatitis
- Diphtheritic lesions
- Syphilitic lesions
- Tuberculous gingival lesion
- Candidiasis
- Agranulocytosis

### **Epidemiology and Prevalence**

- Considered contagious (Schluger, 1949).
- Occurs at all ages (Daley, 1928).
- Highest incidence between 20-30 years (Stammers, 1944, Dean, 1945).
- Common in children from low socioeconomic group and in underdeveloped countries. (Jimenez, 1975).

### **Treatment**

#### **First visit**

- 1) Complete evaluation of the patient.
  - 2) Examination of patient.
  - 3) Oral hygiene is evaluated.
- Treatment during this initial visit is confined to the acutely involved areas which are isolated with cotton rolls and dried.

- A topical anesthetic is applied and after 2 or 3 minutes the areas are gently swabbed with a moistened cotton pellet to remove the pseudo membrane.
- Bleeding may be profuse.
- Cleansed with warm water, the superficial calculus is removed.
- Sub gingival scaling and curettage are contraindicated.
- Patient with moderate or severe NUG and local lymphadenopathy or other systemic signs or symptoms are placed on the antibiotic regimen of amoxicillin, 500 mg orally every 6 hours for 10 days.
- Tooth extractions and periodontal surgery should be postponed.
- Patient instructed to report back in 1-2 days.

#### Patient Instructions

- Avoid tobacco, alcohol and condiments.
- Rinse with a glassful of equal mixture of 3% hydrogen peroxide and warm water every 2 hours or twice daily with 12% chlorhexidine solution.
- Get adequate rest.
- Confine tooth brushing to the removal of surface debris with a dentifrice and ultra-soft toothbrush.
- NSAID's can be taken for pain relief.

#### Second visit

- Patient evaluation.
- Scaling performed.

#### Third visit: 5 days after 2nd visit.

- Patient should be symptom free.
- Plaque control procedures.
- Discontinuation of hydrogen peroxide rinses.
- Re-evaluation after 1 month.

#### Gingival changes with healing

- Removal of surface pseudo membrane exposes the underlying red, haemorrhagic, crater like depressions in gingiva, indicating inflammation caused by necrosis and microbial infiltration of tissues that has lost the normal barrier functions of epithelium.

- Bulk and redness of the crater margins are reduced, indicating a reduction in inflammation and re epithelization.
- Early signs of restoration of normal gingival contour and colour, indicating reestablishment of the normal barrier functions of the epithelium including keratinization and further reduction of inflammation.
- Normal gingival colour consistency, surface texture and contour may be restored.

### **Additional treatment consideration**

- Contouring of gingiva.
- Systemic antibiotics.
- Supportive systemic treatment.
- Nutritional supplements.

### **Persistent or recurrent cases**

- Reassessment of differential diagnosis.
- Underlying systemic disease-causing immunosuppression.
- Inadequate local therapy.
- Inadequate compliance.

### **Pericoronitis**

- Inflammation of the gingiva in relation to the crown of an incompletely erupted tooth.



- Occurs most common in mandibular third molar.

### **Clinical features**

#### **Symptoms**

- **Pain:** Pain may be mild but is usually quite intense and may radiate to external neck, throat, ear or oral floor.

- Trismus.
- Bad taste in mouth caused by pus oozing from beneath the flap.
- Swelling in the neck or in area of effected tooth.
- Fever.

### **Signs**

- Partially erupted tooth.
- Markedly red, swollen, suppurating lesion around a partially erupted tooth.
- Pus oozing from under an overlaying flap.
- Swelling of cheek.
- Cervical lymphadenopathy.
- Elevated temperature, leucocytosis, malaise, tonsillitis or upper respiratory infection.

### **Complications**

Pericoronal Abscess.

Lymphadenopathy.

Peritonsillar abscess formation, Cellulitis, Ludwig's Angina (Infrequent Sequelae).

### **Treatment**

The treatment depends on-

- The severity of the inflammation.
- Systemic complications.
- Advisability of retaining the involved tooth.

The treatment of acute Pericoronitis consists of

### **Non-surgical therapy**

- 1) Gently flushing the area with warm water and H<sub>2</sub>O<sub>2</sub> to remove debris and exudates.
- 2) Swabbing with antiseptic after elevating the flap gently from the tooth with a scaler.
- 3) Underlying debris is removed and the area is flushed with warm water.

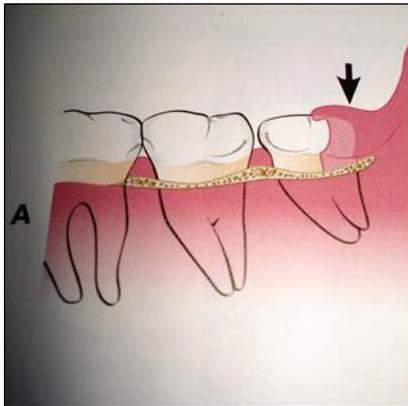
- 4) Occlusion is evaluated to determine if any opposing tooth is occluding with the pericoronal flap.
- 5) Removal of soft tissue or occlusal adjustment may be necessary.
- 6) Antibiotics can be prescribed in severe cases.

### **Surgical therapy**

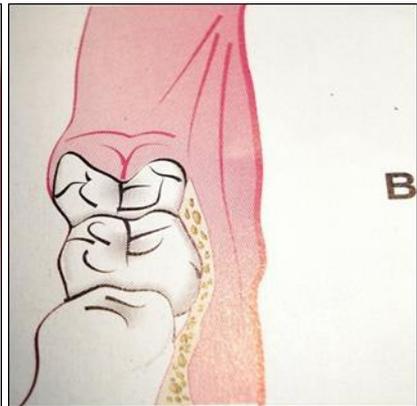
- After acute symptoms have subsided a determination is made as whether the tooth is to be retained or extracted.
- Decision to save the tooth or extract it depends upon various factors like its position, opposing tooth, chances of eruption to proper occlusion and periodontal status.

### **Operculectomy**

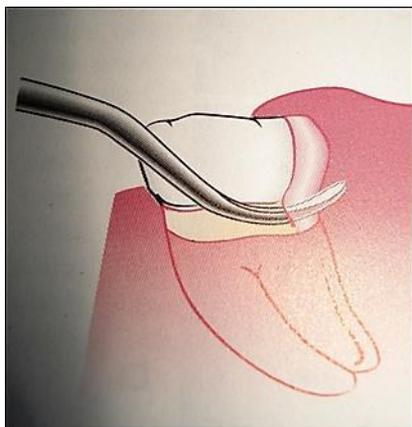
- LA is given for mandibular molar.
- The pericoronal flap is removed using periodontal knives or electrosurgery.
- Incision is given anterior to anterior border of ramus and brought downward and forward to the distal surface of crown as possible to the level of CEJ, which will detach a wedge-shaped tissue.
- It is necessary to remove the tissue distal to the tooth, as well as the flap on the occlusal surface.
- Incising only the occlusal portion of the flap leaves a deep distal pocket, which invites recurrence of acute pericoronal involvement.



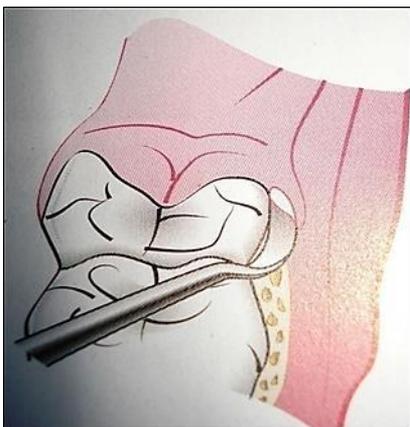
**Inflamed Pericoronal Flap in Relation to Mandibular Third Molar**



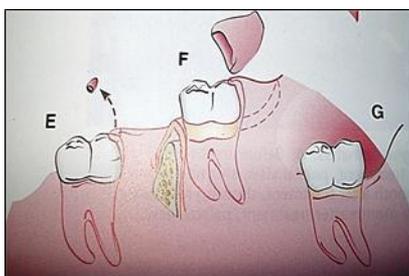
**Anterior View of Third Molar and Flap**



**Lateral View of Scaler in Position to Gently Remove Debris under Flap**



**Anterior View of Scaler in Position**



**E:** Incorrect Removal of Tip of Flap, Permitting Deep Pocket to Remain Distal to Molar.

**F:** Removal of Section of Gingiva Distal to Third Molar.

**G:** Appearance of Healed Area.

### **Primary herpetic gingivostomatitis**

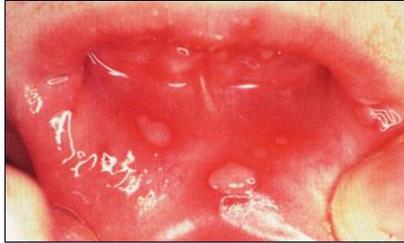
- Primary herpetic gingivostomatitis is an infection of the oral cavity caused by herpes simplex virus type 1 (HSV-1).
- It occurs most often in infants and children younger than 6 years of age but it is also seen in adolescents and adults.
- It occurs with equal frequency in males and female patients.
- In the primary infection, the virus ascends through sensory and autonomic nerves.
- Persists as latent HSV in the ganglia.

## Secondary manifestations

- It results from various stimuli such as sunlight trauma, fever, stress:

### Includes

- Herpes Labialis.
- Herpes Stomatitis.
- Herpes Genitalis.
- Ocular Herpes.
- Herpetic Encephalitis.



### Clinical features

#### Oral signs

- Diffuse, erythematous, shiny involvement of the gingiva and adjacent oral mucosa with varying degree of edema and gingival bleeding.
- Presence of discrete spherical gray vesicles appear on the gingiva, labial and buccal mucosa, soft palate, pharynx, sublingual mucosa and tongue.
- After 24 hours the vesicles rupture and form painful small ulcers with a red, elevated, depressed, yellowish or grayish white.
- The course of disease is limited to 7-10 days.



- Primary herpetic gingivostomatitis in 12 yr old boy with diffuse erythematous involvement of the gingiva and spherical gray vesicle in the lip.

### Oral symptoms

- Accompanied by generalised “soreness” of the oral cavity which interferes with eating and drinking.
- The ruptured vesicles are the focal sites of pain and are particularly sensitive to touch, thermal changes.



### Differential diagnosis

- Erythema multiforme.
- Steven- Johnson syndrome.
- Bullous lichen planus.
- Desquamative gingivitis.
- Recurrent aphthous Stomatitis.



### Treatment

- Treatment consists of early diagnosis and immediate initiation of antiviral therapy.
- Antiviral therapy with 15mg/kg of an acyclovir suspension given five times daily for 7 days has been found helpful.

- Removal of plaque and food debris.
- An NSAID'S can be given systemically to reduce fever and pain.
- Patient may use either nutritional supplements.
- Periodontal therapy should be avoided.
- The patient should be informed that disease is contagious.

	NUG	AHG
Site of ulcers	Interdental papilla Marginal gingival	Gingiva, no predilection for interdental papilla Entire oral mucosa
Character of ulcers	Punched-out, crater-like Covered by yellow/white/gray slough Bleed readily or spontaneously Painful on stimulation	Multiple vesicles that coalesce and form shallow, fibrin-covered, regular-shaped ulcers No marked tendency to bleed Not specially tender
Fever	Doubtful or slight only	38 °C (or more)
Symptoms	Painful gums, 'dead-feeling teeth'	Sore mouth
Duration of ulcers and discomfort	Short-lived (1-3 days), with appropriate therapy	More than 1 week, even with therapy

### Abscesses of periodontium

An Abscess is a localized collection of pus in a cavity formed by the disintegration of tissues.

Dentoalveolar abscesses consist of three main types: (Van Winkelhoff *et al.*, 1985).



**Endodontic abscess**



**Periodontal Abscess**



**Pericoronal Abscess**

## **Basis of classification of abscess**

- 1) Depending on Location.
- 2) Depending on Course.
- 3) Depending on Number.

### **Depending on location**

(Gillette & Van House 1980/Meng,1990)

- 1) **Gingival abscess:** Localized purulent infection that involves the marginal gingiva and interdental papilla.
- 2) **Periodontal abscess:** Localized purulent infection within the tissues adjacent to periodontal pocket that may lead to destruction of pdl and alveolar bone.
- 3) **Pericoronal abscess:** Localized purulent infection within the tissues surrounding partially erupted teeth.

### **Depending on course of lesion (Carranza 1990)**

#### **1. Acute abscess**

- Short period of time and lasts for few days or a week.
- Sudden onset of pain on biting and a deep throbbing pain.
- Influencing factors include increased number of bacteria present combined with lowered tissue resistance and lack of spontaneous drainage.
- Red, edematous, smooth, ovoid swelling of the gingival tissues.
- Exudate may be expressed with gentle pressure.
- Fever and regional lymphadenopathy.

#### **2. Chronic abscess**

- Last for long time and often develops slowly.
- Spontaneous bleeding may accompany discomfort.
- Pus may be present as also may be discharges from the gingival crevice or from a sinus in the mucosa overlying the affected root.

#### **3. Depending on number (Topoll *et al.* 1990)**

##### **Single abscess**

- Related to local factors which contribute due to the closure of the drainage of a periodontal pocket.

## Multiple abscess

- Are associated with increased blood sugar and with an altered immune response in diabetic patients.
- Assessment of the diabetic status through the testing of random blood glucose, fasting blood glucose level is mandatory.

## Periodontal abscess

- Localized purulent infections within the tissue which is adjacent to the periodontal pocket that may lead to the destruction of the periodontal ligament and the alveolar bone.
- In this localized accumulation of pus in the gingival wall of the periodontal pockets usually occurring on the lateral aspect of the tooth.

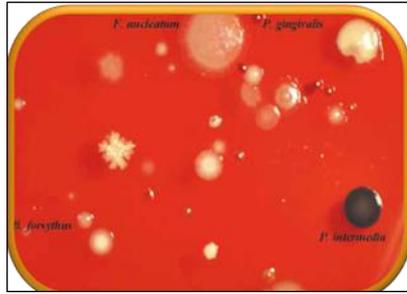


## Periodontal abscess

### Microbiology

Non-motile, gram negative, anaerobic rod-shaped bacteria are present having proteolytic activity

- Porphyromonas gingivalis-55-100% (Lewis *et al.*).
- Prevotella intermedia-25-100% (Newman and Sims).
- Fusobacterium nucleatum-44-65% (Hafstorm *et al.*).
- Actinobacillus actinomycetemcomitans.
- Campylobacter rectus.



### **Etiology of periodontal abscess in periodontitis**

- 1) Changes in the composition of the microflora.
- 2) Closure of the margins of the periodontal pocket.
- 3) Tortuous periodontal pocket associated with furcation defects.
- 4) Inadequate scaling which allow calculus to remain in the deepest pocket area.
- 5) Treatment of systemic antibiotics in the absence of subgingival debridement.

### **Etiology of periodontal abscess in absence of periodontitis**

- Impaction of foreign bodies.
- Perforation of tooth wall by endodontic instrument.
- Infection of lateral cyst.
- Local factors affecting the morphology of root, cemental tears, external root resorption and cracked tooth syndrome-Haney *et al.* 1992, Ishikawa *et al.* 1996.

### **Pathogenesis**

- Infiltration of bacteria into the periodontium.
- Initiate the inflammatory process.
- Activates the inflammatory response.
- Tissue destruction is caused by the inflammatory cells and the extracellular enzymes.
- An inflammatory infiltrate is formed followed by the destruction of the connective tissue and encapsulation of the bacterial mass and thus leading to pus formation.

**Clinical features**

<b>Acute</b>	<b>Chronic</b>
Mild-severe discomfort	No or dull pain
Localized red, ovoid swelling	Localized inflammatory lesion
Periodontal pocket	Fistulous tract associated with deep pockets
Mobility	
Tooth elevation in socket	Slight tooth elevation
Tenderness to percussion	
Exudation	Intermittent exudation
Elevated temperature	Rare
Regional lymphadenopathy	Minority of cases

**Differential diagnosis**

- Gingival abscess.
- Pericoronal abscess.
- Periapical abscess.
- Lateral periapical cyst.
- Vertical root fracture.
- Endo-periodontal lesion.
- Cracked tooth syndrome.

**Difference**

Periodontal Abscess	Periapical Abscess
1) Periodontal Pocket	1) No Periodontal Pocket
2) Angular Bone Loss with Furcation Involvement	2) No Bone Loss
3) Vital Pulp	3) Non-Vital Pulp
4) Dull and Localized Pain	4) Severe Pain
5) Swelling May or May Not Be Present	5) Swelling Present
6) Sensitivity May or May Not Be Present	6) Sensitivity to Percussion

**Treatment**

**1) Local measures**

- Drainage
- Maintain Drainage
- Eliminate Cause

## 2) Systemic measures in conjugation with local measures

- Immediate Management
- Initial Management
- Definitive Therapy

### Initial therapy

The treatment options for periodontal abscess under initial therapy-

- 1) Drainage through pocket retraction or incision.
- 2) Scaling and root planning.
- 3) Periodontal surgery.
- 4) Systemic antibiotics.
- 5) Tooth removal.

### Drainage through the periodontal pocket

- Topical/local anaesthesia
- The pocket wall is gently retracted with a probe/curette in an attempt to create an initial drainage through the pocket entrance
- Gentle digital pressure is applied
- Irrigation is used to clear the pocket
- Small lesion-scaling and curettage may be undertaken
- Large lesion-scaling, curettage and surgery is delayed until the major clinical signs have been resolved after antibiotic therapy.
- Adjunctive systemic antibiotics are given

### Drainage through an external incision

- If the LESION is sufficiently large, pin-pointed and fluctuating than external incision is made to drain the abscess.

### Periodontal surgery

- Surgical therapy either gingivectomy or flap procedures has been advocated in the cases of abscess which are associated with deep vertical defects
- Surgical flaps have also been proposed in cases in which the calculus is left subgingivally after the treatment
- Eliminate the calculus and to obtain the drainage.

## **Definitive treatment**

- The treatment following reassessment after the initial therapy is to restore the function and aesthetics and to enable the patient to maintain the health of the periodontium.

## **Conclusion**

A thorough understanding and the interpretation of clinical findings is the basis for establishing the correct diagnosis of acute gingival infections. Early diagnosis is important in dispensing treatment at the correct time.

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**Chapter - 6**  
**Artificial Intelligence and Its Contemporary  
Applications in Dentistry: The Current Concepts  
and A Dip in the Future**

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# Chapter - 6

## Artificial Intelligence and Its Contemporary Applications in Dentistry: The Current Concepts and A Dip in the Future

Dr. Neelam Das

### Abstract

**Background:** Artificial intelligence is a relatively newer technology in the field of medical world. This science uses the machine-learning algorithm and computer software to aid in the diagnostics in medical and dental fields. It is a huge talking point in the field of technology which is spreading its wings in all possible sectors at a great speed. This field covers solutions from coaching solutions to diagnostics in medical field covering under the umbrella of all what can be achieved by machine and deep learning.

**Content:** In dentistry, artificial intelligence is creating a revolution in all sections from collection of data, creating algorithms for orthodontic procedures, diagnostic records in the aspect of radiographic data, three dimensional scans and cone beam computed tomography, CAD-CAM systems for restorative and prosthetic purposes. Similarly, continuous research is being done in the field of periodontics in terms of measuring bone loss, amount of plaque present and much more.

**Conclusion:** The field of artificial intelligence is relatively young but has still come a long way in the fields of medicine and dentistry. Hence, there is a need for the dentists to be aware about its potential implications for a lucrative clinical practice in the future. This chapter reviews on how this technology is tremendously utilized for easy and early diagnosis, proper treatment with satisfying outcome.

**Keywords:** Artificial intelligence, machine learning, artificial neural networks, deep learning, periodontics, dentistry

### Introduction

The human brain is a highly complex structure composed of networks of interlinked neurons which transmit signals throughout the body. Its complexity has made it to be one of the most intriguing structures of human body for researchers since time immemorial.

Technology has undergone a great change in the last decade. Existing in an era of COVID-19 pandemic has forced the mankind to develop a lifestyle which is faster, non-explosive and controlled at the fingertips. In medical practice precautionary measures and risk of infection has demanded the introduction of a non-invasive and minimally expositive procedures for patients. In such scenarios Artificial Intelligence (AI) has emerged as a life-saving wizardly tool.

With an enormous increase in the documented patient data, intelligent software for its computation has become a necessity <sup>[1]</sup>. Computer-based diagnosis is gaining momentum due to its ability to detect and diagnose lesions which may go unnoticed to the human eye <sup>[2]</sup>. The conventional approaches have provided much information, but are subject to limitations <sup>[3]</sup>. The deed of the constant search has given rise to artificial intelligence (AI), which is a highly evolved system capable of mimicking functioning of the human brain. This chapter will give an insight into the current concepts and uses of artificial intelligence in various fields of dentistry.

## **History**

There are different contributors in the research history, conceptualization and evolution of artificial intelligence. History dates back to the Aristotle era when he for the first time presented the concept of artificial intelligence. Though he only proposed a view on the outset of machinery that can substitute human thought processes, his endeavor to acknowledge human thinking as a form of logical system focused on analytic reasoning has been a foundation that computers can fully substitute man's method of thinking <sup>[4]</sup>.

Later in the 1950s, McCarthy acquainted us with his work on logistic AI through a paper in which he listed non-monotonic logic, practical reasoning and ability, the belief and knowledge and conceptualizing the context, altogether lay down the analytical facts that can be further reinforced by researchers to solve bigger problems. Newell and Simon in 1955 designed "The Logic Theorist" which is considered to be the first artificial intelligence AI program which marks the development of modern artificial intelligence.

In 1956, the field of artificial intelligence gained academic recognition and John McCarthy was honored as the father of artificial intelligence <sup>[5]</sup>.

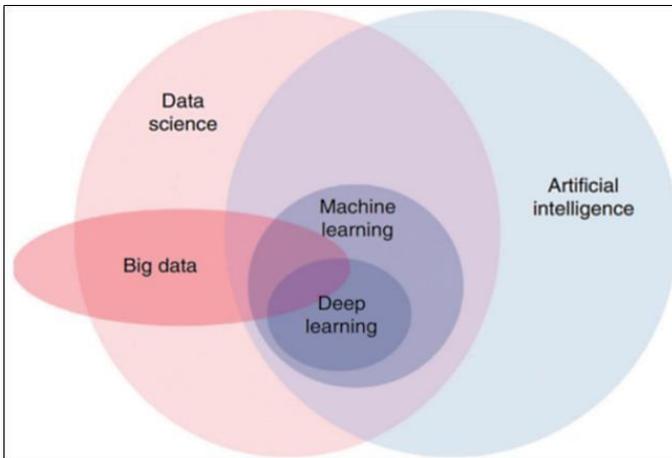
In 1978, an applied mathematician, named Richard Bellman, described artificial intelligence as the mechanics associated with human activity related to thought process, consisting of basic cognitive process, decision making ability and problem-solving. <sup>[6]</sup> It is a field of both engineering and science,

associated with the perceptive of intelligent behavior and creating artifacts that replicate such behavior [7]. “It’s basically an area of computer science that focuses on the foundation of machines that work and respond like humans” [8].

### Definition of artificial intelligence

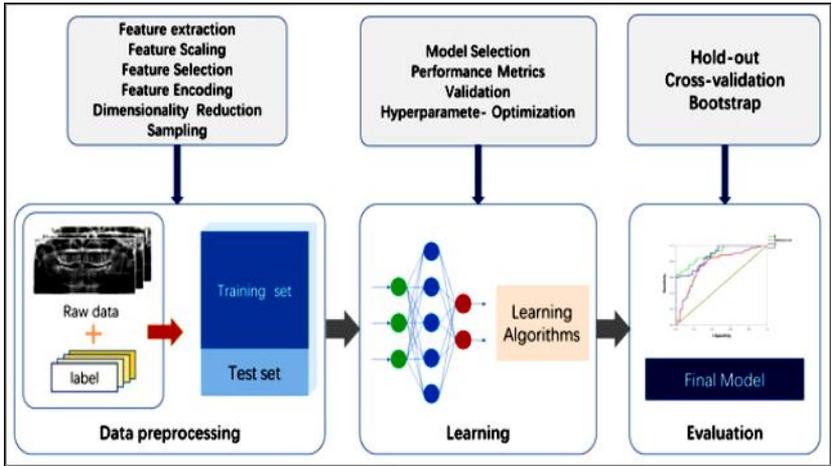
Alan Turing, a young British polymath devised the Turing test to suggest that machines can use available information and reason to solve problems like humans. The term artificial intelligence was coined by John McCarthy in 1956 and it is defined as ‘a field of science and engineering concerned with the computational understanding of what is commonly called intelligent behaviour and with the creation of artefact’s that exhibit such behaviour’ [9].

**Essential terminologies to understand the paradigm of artificial intelligence are indicated in (figure 1)**



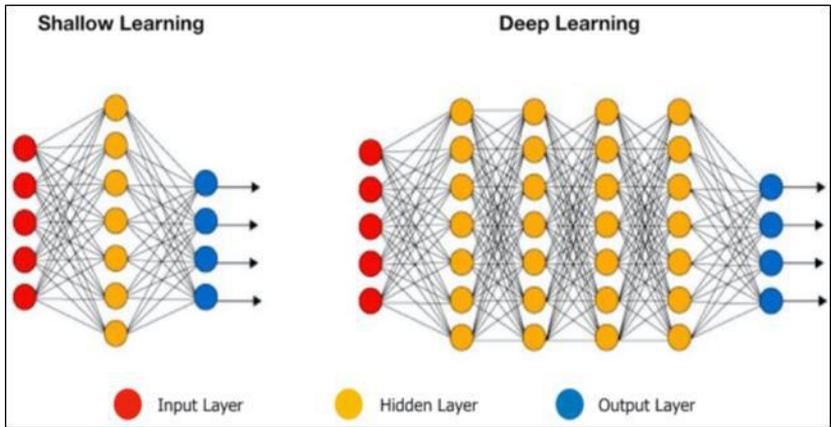
**Fig 1:** Key elements of artificial intelligent systems

- 1) *Artificial intelligence* is a machine's ability to express its own intelligence by solving problems based on data.
- 2) *Machine learning* uses algorithms to anticipate outcomes from a set of data. The goal is to make it easier for machines without human intervention to learn from data and solve problems (Figure 2).



**Fig 2:** Machine learning technique to get final model using image processing

- 3) *Neural networks* compute signals using artificial neurons which operates similar to human brain.



**Fig 3:** Neural network designs

- 4) *Deep learning* with multiple computational layers builds a neural network that automatically recognises patterns in order to improve feature detection <sup>[10]</sup>.
- 5) *Data science* is the process of analyzing data and extracting useful information from it <sup>[11]</sup>.
- 6) *Big data* provides users with accurate information by assessing a vast set of data that has been continually growing for years at the right time <sup>[12]</sup>.

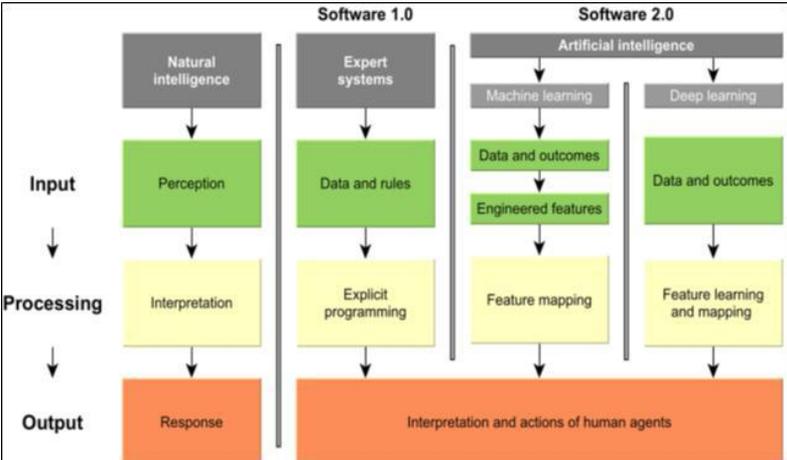
Today, AI is defined as a field of science and engineering concerned with the computational understanding of what is commonly called intelligent behaviour and with the creation of artifacts that exhibit such behavior. Colloquially, the term “AI” is used when a machine mimics, cognitive functions that human associates with other human minds, such as “learning and problem solving” [13].

In general, AI consists of the knowledge base, research methods, problem solving systems, reasoning systems, planning systems, learning systems (from previous examples/instances and from the knowledge base), genetic programming and decision-making or conclusion-drawing systems. AI methodologies have found applications in various disciplines ranging from telecommunication, aerospace, robotics, medical diagnosis, exchange market, law, science, or entertainment to name a few.

This highly advanced technology with its great capabilities and capacities in recognition of meaningful data patterns has also revolutionized the field of dentistry in the last decade. Clinical decision support system (CDSS), a component of AI is being applied in dentistry which includes artificial neural networks (ANN), genetic algorithms (GA) and fuzzy logic.

**Working principle**

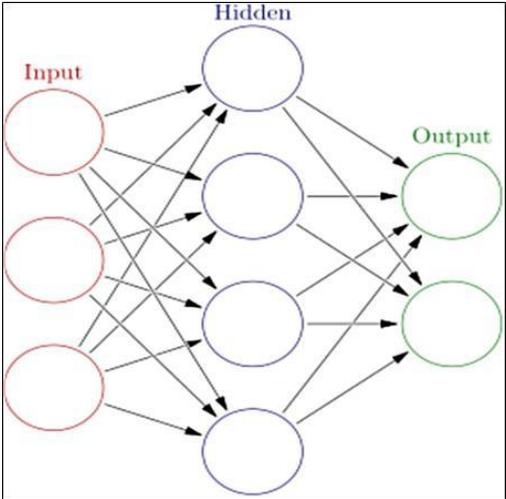
A machine learning prediction technique is an algorithm that estimates an unknown dependency between a set of given input variables and its output variable. When such dependency is observed, it can predict the future output by identifying the target function that best describes the behavior governing the input-output patterns [14].



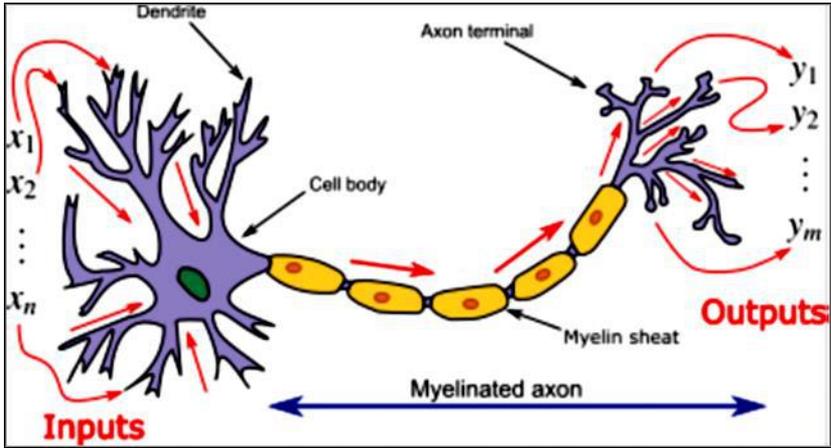
**Fig 4:** Natural and computer intelligence

In 1957, Frank Rosenblatt invented the perception algorithm which was designed for recognition of the images. It had the “neurons” which is randomly connected with an array of 400 photocells. The signals are sent by the neurons only when the aggregate signals crosses the threshold of the specific neuron. Usually, the neurons are settled or aggregated in the form of layers (Figure 5). Each layer will perform differently or gives different signals depending on their inputs. We can get different transformations from each layer. Signals travel from the input layer (the first layer), to the output layer (the last layer), mostly after passing the layers several times (Figure 6). Potentiometers are used to encode the weights and electronic motors will perform weight updates during learning.<sup>[15]</sup> Back propagation learning was proposed by Paul Webros in 1974. It is a method used in AI to calculate a gradient that is needed in the calculation of the weights to be used in the networks. This is used by health professionals to diagnose the disease early and to communicate with fellow professionals worldwide; thus, more effective treatment is possible to provide for the patient.

Now, there are two sub-concepts which will divide the whole range of meanings which are presently derived by the term “AI.” The coexistence of the concepts of strong and weak AI can be seen as a result of the recognition of the limits of mathematical and engineering concepts that dominated definitions of AI in the first place.



**Fig 5:** An artificial neural network is an interconnected group of nodes, inspired by a simplification of neurons in a brain. Here, each circular node represents an artificial neuron and an arrow represents a connection from the output of one artificial neuron to the input of another



**Fig 6:** Neuron and myelinated axon, with signal flow from inputs at dendrites to outputs at axon terminals

**Weak artificial intelligence-definition and its concept**

The concept of weak AI intends to improve the cognitive behavior and judgmental capacity of computer system to make them inherent in those computing systems, denying the unreasonable reduction and in attempt to reproduce the human intelligence, which is predicted and planned by strong intelligence [16]. The meaning of weak AI is, the system in which human beings can gain advantage of few medical and logical mechanisms in which the intellectual activities to execute efficiently by intelligence neural networks like human can perform.

**Strong artificial intelligence-definition and its concept**

Strong AI means a system that works in the same way as human intelligence through unnatural, software construction and artificial hardware. It is a theoretical form of machine intelligence [17]. The key feature of strong AI involves reasoning ability, puzzle-solving, judgment making, planning, learning and communicating, i.e., the capacity of machines to perform human tasks and replicate or reproduce human behavior efficiently.

**Clinical Decision Support System (CDSS)**

A Clinical decision support system (CDSS) is a network between an extensive dynamic (medical) knowledge database and an inferencing output mechanism that are a set of algorithms derived from evidence-based medical practice implemented through medical logic modules. These systems include artificial neuronal networks (ANN), genetic algorithm, fuzzy logic, evolutionary computation and hybrid intelligent systems. Currently, the

interactive interphase with voice controls are designed to assist the health care professional to work more efficiently with time saving and cost effective clinical dental practice [18].

### Artificial Neuronal Networks (ANN)

Artificial neural networks consist of a highly interconnected network of computer processors which process data by their automated dynamic-state response to external inputs. The ANN can recognize pattern, manage data and learn just like the human brain. Neural network expert systems may be trained with clinical data and these can be used in clinical situations of diagnostic dilemmas to improve clinical strategies of health care systems. [8] Various fields of medicine such as diagnostic systems, biomedical analysis, image analysis and drug development have utilized this complex and highly advanced element of AI.

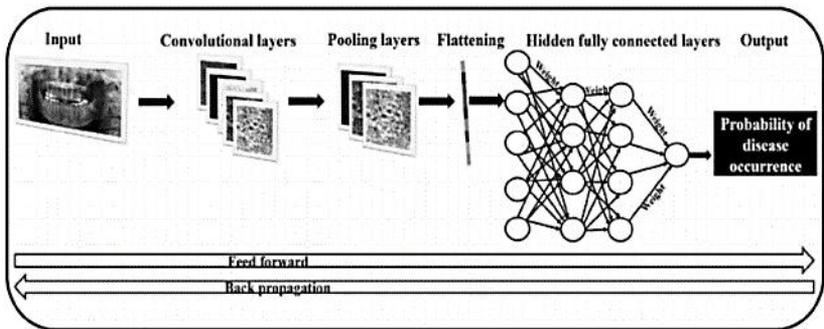


Fig 7: Artificial neural networks

### Genetic algorithm

Another system that is used to predict genetic disorders and susceptibility to the same is genetic algorithm (GA) which is a search heuristic, that mimics the process of natural evolution [19]. With the advent of voice recognition the hurdle of feeding huge amount of structured information into the system has been overcome. Along with this, an interactive interphase is incorporated which helps the health care professional to comprehend this vast amount of information more easily.

### Fuzzy logic

It is the science of reasoning, thinking and inference that recognizes that everything is a matter of shades of grey rather than conventional black and white. Fuzzy logic can be used for uncertain reasoning in the systems in which there are no certain or precise statements [20]. This type of methodology is useful in medical and dental field particularly for radio-diagnosis.

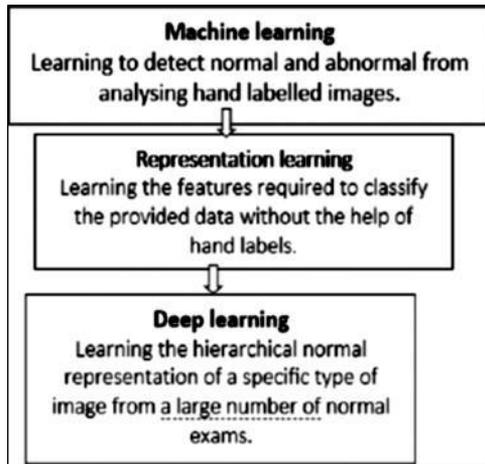
## **Augmented Reality and Virtual Reality**

Augmented reality is defined as “a technology that superimposes a computer-generated image on a user’s view of the real world, thus providing a composite view”. The invention of augmented reality has simplified the process of delivering aesthetic prosthesis and meeting the patient’s expectations <sup>[21]</sup>. With the help of AI systems and augmented reality, the patient can try on a virtual prosthesis, that can be altered till the patient is satisfied and, the final prosthesis is made exactly according to these specifications. Virtual reality on the other hand is a computer-generated simulation of a three-dimensional image or environment that can be interacted with, in a seemingly real or physical way by a person using special electronic equipment. The AI systems along with virtual reality has been used not only to reduce dental anxiety but is also regarded as a powerful tool for non-pharmacological control of pain. Additionally, virtual reality is a promising tool in training dental students. Le Blanc et.al in their preliminary study in using virtual reality to train dental students between 6 to 10 hours a day showed significant improvement in their performance <sup>[22]</sup>.

## **Artificial intelligence in different fields of dentistry**

### **Artificial intelligence in patient management**

Virtual dental assistants which are based on AI can perform various functions and tasks with greater accuracy in the dental clinic, minimal errors and less workforce compared to humans <sup>[23]</sup>. In the departments such as oral medicine and radiology, oral pathology, it can be used to arrange appointments, managing insurance and article works as well as helping in diagnosis or planning treatment. It is very helpful in notifying the dentist regarding patients’ complete medical and dental history as well as other oral hygiene habits, food and diet habits and habits such as alcoholism and smoking. In dental emergencies, the patient has an option of emergency tele-assistance, especially when the practitioner is unavailable. Thus, a comprehensive virtual data of the patients can be generated which will help in providing ideal treatment for the patient in long run <sup>[24]</sup>.



**Fig 8:** Hierarchy of artificial intelligence

### **Artificial intelligence in diagnosis and treatment**

For a successful clinical practice, correct diagnosis is a strong foundation. In this concern, efficiently trained neural networks can be a precious present to diagnosticians, particularly in the diseases and conditions with multifactorial cause or etiology. To say, recurrent aphthous ulceration is one of the conditions without a specific etiology or with multiple etiology, where the clinical diagnosis is given based only on the recurrence of the lesion and excluding the other factors <sup>[25]</sup>. In this regard, AI can be considered as one of the useful and ideal modalities in diagnosing and treatment planning or treating of oral mucosal lesions and can be utilized in examining and grouping doubtful or unsure altered mucosa which is considered to show premalignant and malignant changes. Even minimal to minute changes at the level of single pixel which might go undetectable by the human eye can be detected. AI can precisely prognosticate the predisposition of genes in oral cancer for a large population.

### **Artificial intelligence in oral and maxillofacial surgery**

The huge application of AI in this field is the development of robotic surgery where the stimulation of human body motion and human intelligence is shown by AI. Successful clinical application in image-guided surgery in the cranial area includes oral implant surgery, removal of tumor and foreign bodies, biopsy and temporomandibular joint surgery.

Few comparative studies in the literature of using AI in oral implant surgery indicate significantly more accuracy compared to manual freehand

procedures even if performed by experienced surgeons. In addition, no significant difference between experienced surgeon and

trainees were identified. In spite of that shorter operation time, safer manipulation around delicate structures and higher intraoperative accuracy has been recognized with the help of AI. Image guidance allows thorough surgical resection which may decrease the requirement of revision procedures <sup>[26]</sup>.

### **Artificial intelligence in prosthetic dentistry**

In order to render ideal flawless esthetic prosthesis for the patient various factors such as facial measurements, anthropological calculations, ethnicity and patient preferences has been integrated by a design assistant which uses AI (RaPid) for use in prosthodontics. RaPiD integrates computer-aided design (CAD), knowledge-based systems and databases, recruit a logic-based information as a unifying medium. AI in the form of CAD/computer-aided manufacturing (CAM) application which is used in dentistry, in which the dental restorations are processed and finish restorations through fine grinding process of ready ceramic blocks. It is used in inlay manufacturing, onlay manufacturing, as well as crowns and bridges. CAD/CAM technique essentially helps to create two-dimensional and three-dimensional models and numerically controlled mechanics aids in their materialization process. It has replaced the time-consuming procedures like laboratory procedures of routine casting and reducing the human mistakes in final prosthesis <sup>[27]</sup>.

### **Pediatric dentistry**

Looking at the current literature, it is pointed out that the branch in which AI finds perhaps the least use in pediatric dentistry. Baliga in 2019, reported that early orthodontic movements can be performed with appliances customized by AI and pain control can be provided by using injection-free pedodontic practice with AI-based devices in pediatric dentistry <sup>[28]</sup>.

### **Artificial intelligence in orthodontics**

Diagnosis and treatment planning can be done in orthodontics by the analysis of radiographs and photographs by intraoral scanners and cameras which works on the principles of AI. This eliminates the requirement for making patient impressions as well as several laboratory steps that are usually followed. From this, the results are usually much more accurate compared to human perception. The tooth movement and final treatment outcome can be predicted by using algorithms and statistical analysis <sup>[29]</sup>.

## **Applications in the specialty of periodontics**

Deep learning analysis using radiographs can assist in diagnosing and treatment planning of periodontal diseases by enabling the early detection of periodontal changes <sup>[30]</sup>, bone loss and changes in bone density. Detection of peri-implantitis can also help in early intervention in implantology <sup>[31]</sup>.

## **Dental implant**

Navigational implant placements have shown great success by decreasing the incidence of maxillary sinus perforations and other chronic complications of sinus cavity and prevalence of infections. Dynamic navigation device was used with planning data and Cone Beam Computed Tomographic (CBCT) image for surgical implant insertions <sup>[32]</sup>.

## **Temporomandibular disorders**

Baş *et al.* in 2012 measured the diagnostic determination ability of the neural networks (NN) on 58 patients after training the NN model with the clinical symptoms and diagnoses of 161 patients. They measured the sensitivity and specificity of ANN in determining TMD subgroups by comparing it with clinical diagnosis, which is considered the gold standard <sup>[33]</sup>.

## **In general dentistry**

Due to various upcoming advancements in the field of dentistry with the use of artificial intelligence, such as improvement in the dental equipment and chairs from conventional hydraulic to an electrically operated chairs. The upcoming recent advances includes voice controlled dental chair which requires no or minimal efforts of dentists. It's not of a much time to see in this evolving era, where dental chairs would be able to record patients vitals and would be able to assess anxiety levels of the patient as he/she sits on the chair <sup>[34]</sup>.

## **Artificial intelligence in dental education system**

Recently artificial intelligence has been incorporated into tutoring intelligent education system and training in dentistry. These technologies have the ability to create virtual reality that enables simulation of the practical procedures in three dimensions that enable simulation and allow assess to clinical and surgical techniques <sup>[35]</sup>. The practice sessions can be done several times till the skill set is expertise by students over the subject prior to actual handling of real clinical cases reducing the risk of iatrogenic damage. This method of training proves to be more efficient, inexpensive and reliable.

## Nano dentistry

Nanodentistry comprises of nanomaterials, biotechnology and dental nanorobotics for maintaining comprehensive oral health. This allows treatment possibilities in the fields of restorative dentistry, orthodontics, periodontics and oral medicine. The introduction of nanorobotics or nanobots in this field has made managing complicated cases at the microscopic level more precise and easier. Due to their size nanobots work at atomic, cellular and molecular level. In endodontic and conservative dentistry this can be used for cavity preparation, restoration etc. In the field of orthodontics it can help in single sitting alignments and in periodontics it can offer alternative techniques to induce controlled oral analgesia and manipulate tissues to aid in managing restorative and periodontal treatment. [36] Oral hygiene can be maintained by destruction of pathogenic bacteria and plaque removal using dentifrobots. This can also change the way of drug delivery systems by nanoencapsulation and also provide new ways of bone grafting. Furthermore, in the near future it can ensure us improved dental material with the help of nanosolutions. This involves the recent invention in dentistry like lab on a chip which might be in demand in future.

### Applications of artificial intelligence

Adapting of AI in maxillofacial radiology, its clinical applications can be divided into three types (Figure 9).

- 1) Clinical workflow.
- 2) Types of applications.
- 3) Classes of use cases.

<b>Clinical workflow</b>	<b>Types of applications</b>	<b>Classes of use cases</b>
<b>Triage scenario</b>	<b>Detection</b>	<b>For workflow optimization and quality assurance</b>
<b>Replacement scenario</b>	<b>Segmentation</b>	<b>Separate normal from not normal</b>
<b>Add on scenario</b>	<b>Classification</b>	<b>Grading and classification of images</b>
		<b>Computer aided detection</b>
		<b>Radiomics</b>
		<b>Natural language processing, computer-assisted reporting, and knowledge management</b>

**Fig 9:** Table representing clinical applications of artificial intelligence

## **Advantages of artificial intelligence**

- 1) Tireless performance of the tasks which saves time.
- 2) Logical and feasible decisions without any involvement of human emotions which results in an accurate diagnosis.
- 3) Standardization of procedures.

## **Disadvantages of artificial intelligence**

- 1) The complexity of the mechanism.
- 2) The cost involved in the setup.
- 3) Enormous data is required for training and precision and therefore it is difficult to achieve accuracy in rare conditions or diseases.

## **Limitations**

- 1) Requires a very huge and sound powerful database of knowledge, if not may result in irrelevant answers when given with images outside of their set of knowledge. For example, when image techniques are not appropriate or if there are any artifacts may result in the faulty.
- 2) Interpretation of image.
- 3) May not adapt with new imaging software or new machine immediately.
- 4) Not all the algorithms used are apt for clinical application. More trials to recommend apt analytic programs for different scenarios.

## **Research challenges and Future directions**

Artificial Intelligence is the new renaissance of dentistry. It involves itself in every aspect evolving the manual dental chairs to an electrical one with voice recognition centers to facilitate command operations by the dentist. In future AI will be adorned by all dental practitioners. With the wise use of machine learning the patient records and diagnostic data can be saved virtually. This will not only help patients in maintaining health track records but also help practitioners share the data with their colleagues for consultation and case discussion in a hassle-free way.

In future, the cutting-edge technologies will serve as a great assistant to the dentist by preserving their valuable time, giving them streamlined workflow and increasing their precision. AI has less bias and better judging probability, making it a great assistant to the dentist in analysis of the diseases, diagnosing them and providing an optimal treatment plan based on

collected evidence. However, a clinician still retains the responsibility of making the final decision.

The use of dental insurance for AI could be beneficial in future. Uploading radiographs and CT scans will give insurance companies more transparency and faster claim of insurance by the patient thus increasing patient benefits and reducing practitioner's loss<sup>[37]</sup>.

Newer innovations would help clinicians master treatment plans. Nanotechnologies are expected to bring more wonders in the field of dentistry using robots and nanobots to provide an extra hand to dentists instead of replacing them. The catalytic antimicrobial robots (CARS) will enhance the oral hygiene maintenance. The trend of 3D printers are revolutionaries in the field of prosthetics and surgery by providing desired biocompatible parts in a very less period of time and making the procedure cost effective as well.

## **Discussion**

While artificial intelligence's value as a provider of second opinions and enforcer of consistency is evident, other applications-merging practice and patient data with diagnostic and treatment outcome data-will gradually establish new standards of care and operating efficiencies. Once AI is firmly established as a tool in care and practice management, new forms of data linkage-not only dental, but genetic, geographic, demographic and medical-will allow AI to deliver truly revolutionary and potentially life-saving value by forging new links between systemic health and dental health.

Ozden *et al.* used an identification unit for classifying periodontal diseases using support vector machine (SVM), decision tree (DT) and artificial neural networks (ANNs). The performances of SVM and DT were found 98% with total computational time of 19.91 and 7.00 s, respectively<sup>[38]</sup>.

Krois *et al.*<sup>[39]</sup> used CNNs to detect periodontal bone loss on panoramic dental radiographs. This system can still help in reducing the dentist's diagnostic efforts.

The progressive technology should not harm the morale of the humankind or the machinery itself. It has various drawbacks such as collection of previous data, interpretability i.e. bridging the gap between the medical terms and mathematical algorithms, the need for complex and strong computing power and ethical considerations in which the doctor will be liable and responsible for the patient and the use of his information.

AI solutions still are a faraway reach in routine dental practice, mainly because of:

- a) Limited data availability, accessibility, structure and comprehensiveness.
- b) Lacking methodological rigor and standards in their development.
- c) Practical questions around the value and usefulness of these solutions, but also ethics and responsibility.

## **Conclusion**

Artificial intelligence in the upcoming times will link dentistry, systemic medicine and electronic record keeping into a continuum that will bring a new level of consistency, clarity and convenience to patients, not to mention better outcomes, which is what we're all trying to achieve. The dentist in obvious terms will not be replaced but will be aided to another level for smooth treatment plans in the long run. The near future will hold a lot of challenges, but will be worth for the to overcome in order to reduce the inaccuracies and thus surge the proficiency of dental practices for various conditions. With the speed of which artificial intelligence is booming in the sector of dentistry, the need of the hour is to have more systematic reviews and meta-analysis to enhance the knowledge and reach of applications.

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**Chapter - 7**  
**Nanotechnology in Dentistry: From Basics to Applied**

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# Chapter - 7

## Nanotechnology in Dentistry: From Basics to Applied

Dr. Mansimranjit Kaur Uppal, Dr. Sahil Thakar, Prof. Dr. Manish Sharma and  
Dr. Shailesh Jain

### Abstract

Nanotechnology depicts the use of structures and devices that work at the atomic or cellular level. The dimension of one such particle is approximately between 1 and 100 nanometres.

Various equipments containing nanomaterials have been designed to meticulously carry out the tasks which are difficult to perform manually. Nanotechnology in dentistry has encompassed all the branches and has proven to be very useful. Nano-enabled materials thus provide an alternative and superior approach to assess the onset or progression of disease, to identify targets for treatment interventions as well as the ability to design more biocompatible, microbe resistant dental materials and implants. Nanodentistry is the face of the future and makes possible a large number of innovative products that may be incorporated in the field.

**Keywords:** Nanodentistry, nanoparticles, bottom up, top down, nanorobots

### Introduction

The term “nanotechnology” has been derived from the Greek word “nano” [1]. The difference between the conventional methods in dentistry and nanotechnology is the latter being more accurate, targeting the diseases at cellular as well as molecular level [2]. Various equipments containing nanomaterials have been designed to meticulously carry out the tasks which are difficult to perform manually [3].

As properties of dental materials often significantly alter following the micro-to-nano shift in the scale at which their critical boundaries were found, a new field was born to explain the rather strange phenomenon, named nanoscience; the application of its discoveries in dentistry being known as “*nanodentistry*” [4].

Nano-enabled materials thus provide an alternative and superior approach to assess the onset or progression of disease, to identify targets for treatment

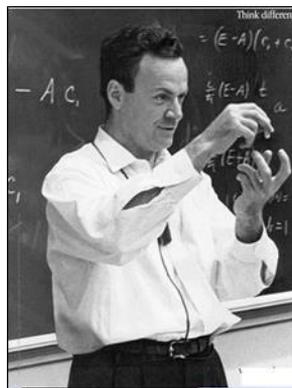
interventions as well as the ability to design more biocompatible, microbe resistant dental materials and implants [5]. This science will make possible the maintenance of comprehensive oral health by employing nanomaterials, biotechnology and dental nanorobots [5].

In this manner, many traditional and routinely used approaches, reparative and exploratory alike, which have been used in practice will be substituted with finer, more precise and sensitive methodologies. This chapter showcases a few applications that fall into the scope of contemporary nanodentistry based techniques as a way of improving and transforming nano materials into solid bases for novel methods to be applied in future applications in dentistry.

## History

A certain doubt has always accompanied nanotechnology. Many people believe that this is a new form of scientific evolution that did not develop until the late 1980s or early 1990s. The first evidence of nanomaterials dates back to sixth century BC where potteries containing carbon nanotubes were discovered in Keeladi (Keezhadi), Tamil Nadu, India [6].

One of the pioneers in nanotechnology, Prof. Richard Feynman, a Nobel prize winning physicist described a process by which the ability to manipulate individual atoms and molecules might be developed, using one set of precise tools to build and operate another proportionally smaller set, so on down to the needed scale [7]. Feynman described such atomic scale fabrication as a bottom-up approach, as opposed to the top-down approach that we are accustomed to [8]. He is considered the father of nanotechnology.



**Prof. Richard Feynman**

## Techniques applied in nanodentistry <sup>[9]</sup>

### i) Bottom-up approach

### ii) Top-down approach

The two most important techniques used in nanotechnology which are further used in dentistry are-

- a) Bottom-up Technique (self-assembly).
- b) Top-Down Technique.

**Bottom-up approach:** By using this technique, nanostructures are created by assembling small atoms or molecules <sup>[9]</sup>.

The dental procedures employed using the bottom-up approach are:-

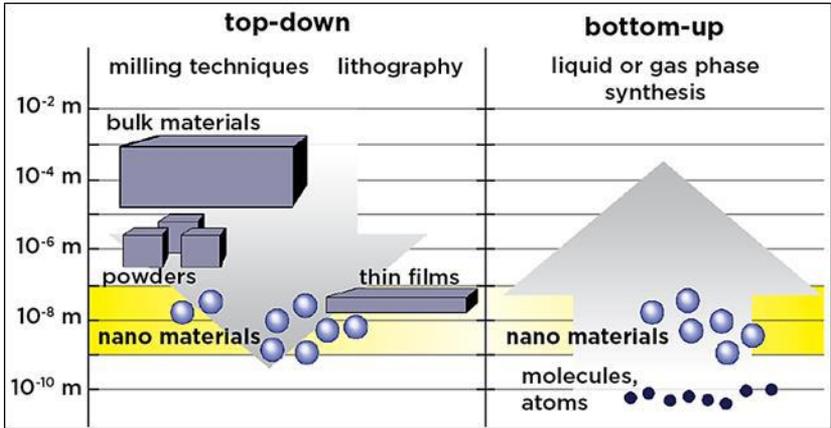
- Local anaesthesia.
- Treatment of tooth hypersensitivity.
- Nanorobotic dentifrices.
- Dental durability and cosmetics.
- Orthodontic treatment.
- Photosensitizers and carriers.
- Diagnosis and treatment of oral cancer.

### Top-down approach

This technique seeks to create smaller devices by using larger ones to direct their assembly <sup>[10]</sup>.

The dental procedures employed using the top-down approach are:-

- Nanocomposites.
- Nano Impression Materials.
- Nano encapsulation.
- Laser plasma application.
- Nano-Composite Denture Teeth.
- Nano Light-Curing Glass Ionomer Restorative material.
- Prosthetic Implants.
- Nanoneedles.
- Nano tweezers.
- Salivary diagnostics.



### Nano-theranostics

The applications of nanotechnology can be categorized into two further subtypes:

- 1) Diagnostic
- 2) Therapeutic

These are collectively called Nano-theranostics.

### Nanodiagnosics

Oral cancer is one of the most common malignancies in India <sup>[11]</sup>. It is imperative to diagnose oral potentially malignant disorders and oral cancer at an early stage for a favourable prognosis. This is where the applications of nanotechnology have been postulated <sup>[12]</sup>.

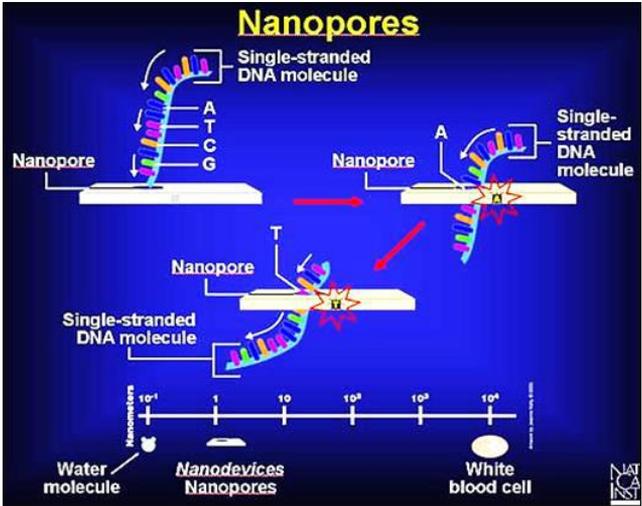
The various nanostructures used for the diagnosis of oral cancer are <sup>[13]</sup>:

- Nanopores.
- Nanotubes.
- Quantum dots.
- Nanoshells.
- Dendrimer.
- Nanobelts.
- Nanocapsules

### Nanopores

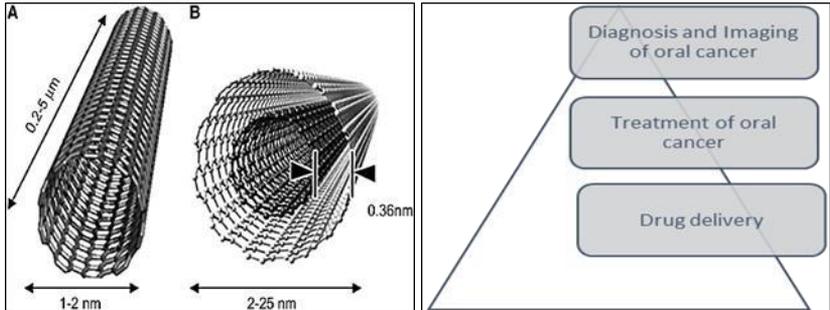
Nanopores are miniscule channels that allow DNA to pass through them, one strand at a time shall make DNA sequencing and separation more

systematic. It is possible for researchers to detect properties of a strand or a base on the DNA sequence. It can be applied to monitor errors in the coded information in diseases such as cancer [14].



**Nanotubes**

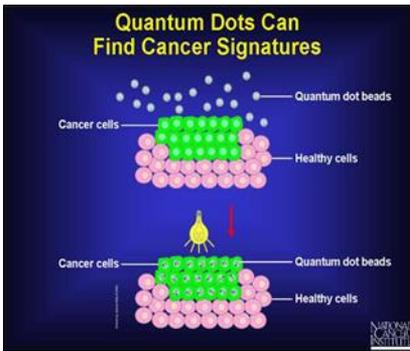
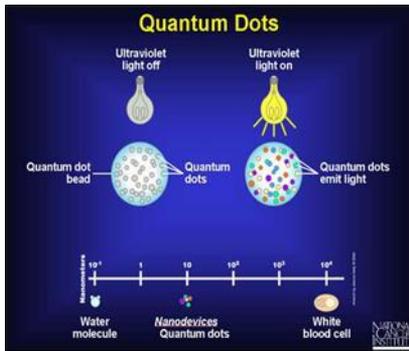
These are carbon rods about half the diameter of a molecule of DNA that not only can detect the presence of altered genes, but may help researchers pinpoint the exact location of those changes. It helps to determine altered DNA in oral cancer [14, 15].



**Nanotubes**

**Quantum dots**

Quantum dots are miniscule molecules making up tiny crystals that glow when stimulated by UV light and are used to detect cancer. When the quantum dots are stimulated with light, they emit their unique bar codes or labels, making the critical, cancer associated DNA sequences visible [14, 15].



## Quantum Dots

Quantum dots are similar to another technology called PEBBLES-Probes Encapsulated by Biologically Localized Embedding [16].

## Nanoshells

Nanoshells are miniscule beads that are coated with gold. Scientists envision nanoshells seek out their cancerous targets, then applying near infrared light [15]. In laboratory cultures, the heat generated by the light-absorbing nanoshells has successfully killed tumor cells while leaving neighbouring cells intact [15, 16].

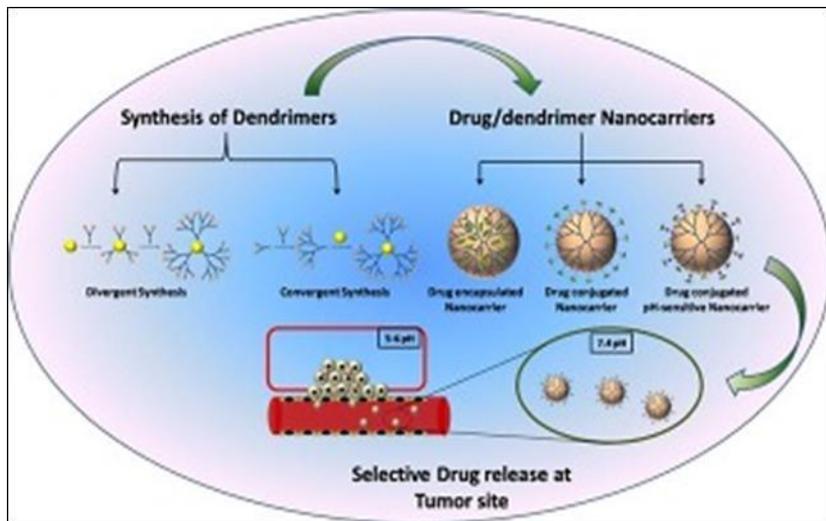


## Nanoshells-Mechanism of Action

## Dendrimers

Dendrimers are man-made molecules about the size of an average protein, and have a branching shape. This shape gives them a vast amount of surface

area to which scientists can attach therapeutic agents or other biologically active molecules. The peripheral layer can be made to form a dense field of molecular groups that serve as hooks for attaching other useful molecules, such as DNA [17].

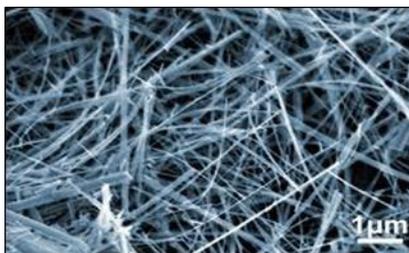


**Dendrimers**

## Nanobelts

Nanobelts have advantages over nanotubes in terms of price, flexibility and practicality.

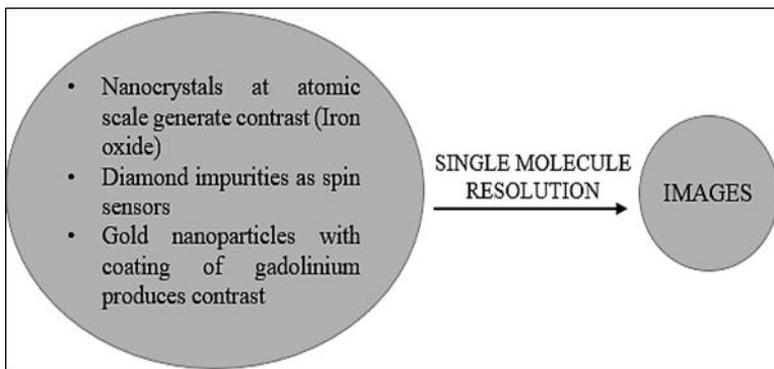
To mainly differentiate between nanotubes and nanobelts, the length of nanotubes are a few millionths of a meter long, while the nanobelts are millimeters long. Also, while nanotubes are made of pure carbon, belts have been made from five oxides [16, 17].



**Nanobelts**

Other nanotechnology-based adjuncts for the detection of oral cancer are Nano Electromechanical Systems (NEMS) [18], Oral Fluid Nanosensor Test (OFNAset) [19] and optical nanobiosensors [20].

In imaging, nano-MRI has been recently introduced. It engages nanocarriers and nanocrystals at the atomic scale to obtain single molecule resolution and obtain images of body structures such as organs <sup>[21]</sup>. Various other modalities that employ nanotechnology for imaging of oral cancer such as Optical Coherence Tomography (OCT), Raman spectroscopy, photoacoustic imaging, quantum dot imaging have also been postulated <sup>[22]</sup>.



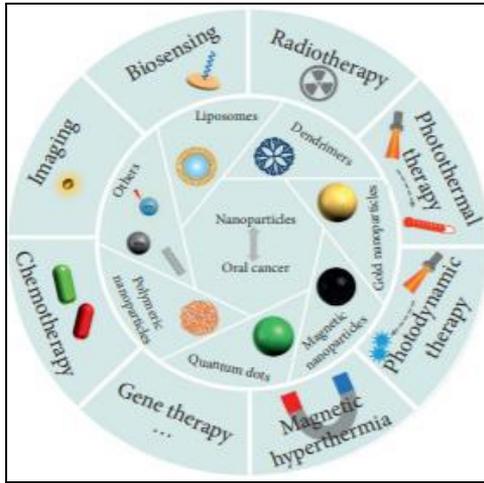
## Nanotherapeutics

The introduction of nanotechnology-based treatments recently has been a great asset to the field of oral oncology. Various modalities used for nanotherapeutics are:

- Stem cell therapy
- Drug delivery
- Ultrasound nano-theranostics
- Gene therapy
- Photodynamic therapy <sup>[23]</sup>

## Gold nanoparticles in diagnosis and treatment of head and neck cancer

Gold nanoparticles have gained a wide acclaim in medicine and dentistry due to their biocompatibility, easy synthesis and high tissue permeability. Gold nanoparticles gain entry into the cell via endocytosis and by targeting receptors. The rationale behind their entry is the increased intra-cellular spaces between the tumor cells <sup>[24]</sup>. In head and neck region, a trial for differentiating the benign and malignant salivary gland tumors using gold nanoparticles has been recently completed in the US <sup>[25]</sup>. For diagnosis and prognosis of salivary gland tumours, gold nanoparticles have been employed as biomarkers for cancer stem cells <sup>[26]</sup>. Gold nanoparticles have proven efficacious as drug delivery systems in conjugation with Cetuximab for increasing the radiosensitivity during radiotherapy for salivary gland carcinomas <sup>[27]</sup>.



## Applications of nanotechnology in oral cancer

### Advantages of nanomaterials <sup>[23]</sup>

- Biocompatibility.
- Reduced drug resistance.
- Specificity for target cells.
- Non-invasive.
- Reduction in tumor recurrence and prevention of metastasis.

### Disadvantages of nanomaterials

Various hazards have been associated with ferric nanoparticles such as lung toxicity <sup>[23, 28]</sup>. Some of the nanoparticles can cross the blood brain barrier (BBB) and even cause free radical damage to DNA <sup>[23]</sup>.

### Challenges faced by nano-dentistry

- Cost.
- Economical nanorobot mass production technique.
- Simultaneous coordination of activities of large numbers of independent micron-scale robots.
- Social issues of public acceptance, ethics, regulation and human safety <sup>[13]</sup>.

## Conclusion

Nanotechnology is the face of the future. It has the prospective of becoming an important part of dentistry from a basic level to applied level <sup>[13]</sup>.

This should be viewed in the context of other expected developments relevant to oral health in the coming years. Biologic approaches such as tissue and genetic engineering will yield new diagnostic and therapeutic approaches much sooner than nanotechnology. At the same time, continual refinement of traditional methods, development of advanced restorative materials, new medications and pharmacologic approaches will continue to improve dental care <sup>[8]</sup>.

The role of the dentist will continue to evolve along the lines of currently visible trends. Cases evidencing simple neglect will become fewer, while cases involving cosmetic procedures, acute trauma or rare disease conditions will become relatively more common. Diagnosis and therapeutics will be customized to match the preferences and genetics of each individual patient. Identifying precise targets for intervention and delivering the treatment with pin-point accuracy in oral diseases is the futuristic approach in dentistry <sup>[22]</sup>.

Nano-dentistry faces many significant challenges in bringing its promises to fulfillment. Basic engineering problems run the gamut from the precise positioning and assembly of molecular-scale parts, from economical nanorobot mass production techniques to biocompatibility and the simultaneous coordination of the activities of large numbers of independent micron-scale robots. There are larger social issues of public acceptance, ethics, regulation and human safety that must be addressed before molecular nanotechnology can enter the modern medical armamentarium <sup>[30]</sup>. But there are equally powerfully motivations to surmount these various challenges, such as the vision that the 80% of the world 's population that currently receives no significant dental care could enjoy a similar level of oral health to which citizens of the industrialized nations are already accustomed. As with every new technology, the opportunities and the risks have to be weighed. Undeniably, nanotechnology makes possible a large number of innovative products that may be attractive to consumers and beneficial to the environment alike.

*“Nanotechnology in medicine is going to have a major impact on the survival of the human race.”-Bernard Marcus*

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## Student Abstracts

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### Abstract 1

#### Effect of various concentrations of sodium hypochlorite on human whole blood clot structure and kinetics

**ANISHA MISHRA, NATANASABAPATHY VELMURUGAN, NANDINI SURESH**

Meenakshi Ammal Dental College, Chennai, Tamil Nadu, India

**Aim:** The objective of this study was to determine the effect of 0.5%, 3% and 5.25% concentrations of sodium hypochlorite (NaOCl) on human whole blood clot kinetics and structure of blood clot formed.

**Materials and Methods:** Five healthy volunteers were chosen for the study and whole blood was collected from the antecubital fossa from each volunteer and divided into four groups namely, CG: Control (0.5 mL of blood), BN0.5: 0.5 mL of blood with 0.5 mL of 0.5% NaOCl, BN3: 0.5 mL of blood with 0.5 mL of 3% NaOCl and BN5.25: 0.5 mL of blood with 0.5 mL of 5.25% NaOCl. The study assessed the effect of NaOCl on human whole blood clot kinetics using Thromboelastograph (TEG) and on the structure of human whole blood clot using scanning electron microscope (SEM).

**Results:** The samples from CG and BN5.25 only made a graphical representation of the clotting kinetics in TEG. Samples from CG and BN3 could only be processed for SEM and the latter demonstrated neither fibrin formation nor branching of fibres either superficially or in the deeper layers. The surface of the Red blood cells was roughened, distorted and clumping of the cells with BN3 was evident.

**Conclusion:** NaOCl has high oxidative effects on the blood which further lead to the dysregulation of platelet aggregation, thrombin inhibition, erythrocyte lysis, decrease in viscosity and formation of agglomerated, weak and fragile mass of cells. Thus, the use of sodium hypochlorite (in any concentration) as a haemostatic agent in vital pulp therapy must be avoided.

### Abstract 2

#### Efficacy of three different irrigating needles on elimination of multispecies biofilm: An *in-vitro* study

**SHURUTHI JAGADEESH, SANGAVI TAMIZHARASAN**

Sree Balaji Dental College and Hospital, Chennai, Tamil Nadu, India

**Aim:** The aim of the present study is to evaluate the efficacy of three different irrigating needles on elimination of multispecies dental biofilm using cryomilling technique.

**Materials and Methods:** Forty freshly extracted non carious, single rooted mandibular premolars with fully formed apices were selected and divided into three experimental (n=10) and control groups (n=10). Teeth were decoronated to obtain a standard tooth length of 18 mm and inoculated with *E. faecalis*, *P. aeruginosa* and *S. epidermidis* and was incubated for 3 weeks to form multispecies biofilm. The samples were randomly assigned into group 1(Single side-vented needle), group 2(Double side-vented needle), group 3(Open-ended needle) and control group. All the experimental groups were irrigated with 3% NaOCl and 17% EDTA, whereas control group was not irrigated. Cryomilling was performed using a freezer mill operated at liquid nitrogen temperature to cryogenically grind tooth sections. Each specimen was crushed and the pulverized dentin was suspended in 1ml of sterile Mueller Hinton Broth and agitated in vortex for 1 min. Then 10ul were plated onto Enterococcus Differential Agar for enumeration of *E. faecalis* and MacConkey agar for enumeration of *P. aeruginosa* and *S. epidermidis*. Following incubation at 37 C for 24 hours the Colony forming units was enumerated. Statistical analysis was done using one way ANOVA and Post-hoc Bonferroni test.

**Results:** Single side-vented group showed statistically significant reduction of bacterial counts for all the three bacterial species when compared to control group (p<0.05). Open-ended needle showed significant reduction of *E. faecalis* and *P. aeruginosa* only. Significant reduction of bacterial count was not seen for double side-vented group for all the three bacterial species.

**Conclusion:** Within the limitations of this study, it can be concluded that

1. Single side-vented needle performed better than open-ended needle and double side-vented needle
2. Single side vented needle efficiently eliminated all the three tested organisms
3. Open ended needle was efficient in eliminating *E. faecalis* and *P. aeruginosa* but not *S. epidermidis*
4. Double side vented was not efficient in eliminating all the three species.

### Abstract 3

#### Evaluation of synergistic antibacterial effect of different herbal combinations on enterococcus faecalis dental biofilm: An *in vitro* study

**MEGHA RAVINDRANATH, SHOBHANA RAMU**

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**Aim:** 1. To estimate the synergistic antibacterial activity of herbal extracts (Grape seed (GS), Mango Kernel (MK), Jamun seed (J), Green chiretta leaves (GC), Myrobalan rind (MR), Licorice root (L) and Clove flower bud (CB)) in different combinations on planktonic cells and *E. faecalis* dental biofilm in comparison with calcium hydroxide. 2. To compare the resistance of ATCC strain and the Clinical Isolate strain to antimicrobial agents.

**Materials and Methods:** 15grams of each herbal powder (45grams per group) was weighed and mixed with 100ml of distilled water. The aqueous solutions were obtained by hot percolation method and were filtered with membrane filters. Zone of inhibition was assessed

Abstract

by agar well diffusion assay and Minimum inhibitory concentration by broth dilution assay. Statistical analysis was done. 60 teeth were inoculated with *E. faecalis* (ATCC 29212=30, Clinical isolate=30) and were incubated for 6 weeks. The samples were assigned into five groups for intracanal medicaments (n=12; ATCC=6, clinical isolate=6) – Groups B (MK+L+MR), C (GC+MR+L), D (J+MK+GC), E (Ca(OH)<sub>2</sub>) and F (saline irrigation). The medicaments were placed inside the root canals and incubated for 14 days. *E. faecalis* sampling was done with paperpoints and cfu/mL were calculated. Statistical analysis was done.

**Results:** Group A (J+GS+CB) did not show potent antibacterial activity towards *E. faecalis* planktonic cells in agar diffusion assay. Hence, it was excluded from further analysis. Evaluation of intracanal medicaments on *E. faecalis* ATCC 29212 showed that there was no statistically significant difference in antibacterial efficacy between the groups B, C, D and E (p>.05). Evaluation of *E. faecalis* clinical isolate biofilm showed that there was no statistically significant difference in antibacterial efficacy between the groups B, C and E (p>.05). Group D showed significantly less antibacterial efficacy towards clinical isolate strain than Group B (p=0.031) and E (p=0.026).

**Conclusion:**

1. Herbal combinations - MK+L+MR, GC+MR+L and J+MK+GC showed synergistic antibacterial activity against *E. faecalis* biofilm which was equivalent to CaOH.
2. Clinical Isolate strain was more resistant to J+MK+GC combination when compared to ATCC 29212.

**Abstract 4**

**Evaluation of the cyclic fatigue resistance of three different controlled memory nickel-titanium rotary file systems: An *in vitro* study**

**DEVAKAR RAJENDRAN, SAATWIKI LOGANATHAN**

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**Aim:** The aim of this study is to compare and evaluate the cyclic fatigue resistance of three different controlled memory Nickel Titanium rotary file systems Trunatomy, Hyflex EDM, and ProTaper Gold by a static method in three different curvatures, namely at 45°, 60°, and 90°.

**Materials and Methods:** Trunatomy instruments of size 26, 0.04 taper; ProTaper Gold instruments of size 25, 0.08 taper; Hyflex EDM instrument of size 25, variable taper were used. The static cyclic fatigue test was performed using a custom-made jig. The artificial canal is made of stainless steel jig with an inner diameter of 1.5mm, 45°, 60°, and 90° angles of curvature and radii of curvature of 5 mm. All the instruments were rotated according to the manufacturer's recommendations until failure occurred. The time taken to failure was recorded in seconds for each group. The mean time is taken to failure (seconds) and the number of cycles to failure were statistically analyzed using SPSS software 21.0 version (SPSS Inc, Chicago, IL). One-way ANOVA was done to determine significant differences between groups and within groups (p 0.000).

**Results:** All file systems performed the best at 45° than 60° and 90°. At 45°, 60° and 90° angles of curvature Trunatomy had the highest resistance to cyclic fatigue. At 45°, 60° and 90° angles of curvature: Trunatomy>Hyflex EDM> ProTaper Gold.

**Conclusion:** Trunatomy instruments were more resistant to cyclic fatigue than Hyflex EDM and Protaper gold instruments in single curvature canals. Trunatomy instruments were anticipated to survive with a higher number of cycles than the other tested instruments. Trunatomy instrument had the highest fatigue resistance than the other instruments.

**Abstract 5**

**Management of mid root fracture and coronal build-up with compoener: A case report**

**SOURABH SHARMA**

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Root fractures account for only 0.5–7% among all dental traumatic injuries. Root fractures commonly result from a horizontal impact and are transverse to oblique in direction. Incidences of root fracture are more in the middle third of the root than at the apical and cervical thirds. Management of mid-root fractures presents a formidable challenge for clinicians because of the difficulty of achieving a stable reunion of fracture fragments, periodontal communication, increased mobility, difficulty in negotiating canals of fractured fragments, and continued pulpal infection leading to necrosis. This paper describes an old case of oblique crown fracture of maxillary incisors along with horizontal root fracture at the middle third of maxillary right central incisor along with periapical pathosis. After managing the radicular portion with endodontic treatment, aesthetic rehabilitation of the fractured crown was done with prefabricated composite resin veneers (compoener). Short-term follow-up of this case shows promising results both clinically and radiographically.

**Abstract 6**

**Optical coherence tomography: A novel three-dimensional biophotonic imaging technique for definitive endodontic diagnosis and predictable treatment outcome: A case series**

**SUMIT SHARMA**

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3-D assessing intracanal anatomy in the clinical endodontic practice is always challenging. Although computed tomography could visualize intracanal anatomy, they all use harmful ionizing radiation and presented low sensitivity in the detection of fine canal anatomy images. Optical coherence tomography (OCT) is a high-resolution imaging technique that allows micrometer-scale imaging of biologic tissues over small distances, uses infrared light waves that reflect off the internal microstructure within the biologic tissues and gives high-resolution images. In studies, OCT has previously been shown to be a valuable tool in assessing intracanal anatomy, cleanliness of the canal after preparation, and even perforations. Case series: This paper described 3-D intracanal bioimaging using Optical coherence tomography (OCT) in managing micro-perforations and open root apex cases after traumatic injuries, by designing 3D guides to customized gutta-percha and post endodontic restorations. A 3D

Abstract

OCT pullback scan was made with an endoscopic rotating optical fiber probe inside the root canal and based on the intracanal lumen dimensions a 3D guided stent was fabricated, which serves as a guide for diagnosis and treatment. Based on the dimensions of the OCT scan a customized gutta-percha of the same dimension was fabricated to get apical closure.

#### Abstract 7

### Comparison of extent of apical penetration of radiopaque contrast agent in root canals prepared using different contemporary endodontic systems: An *in vitro* study

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Army Dental Center (Research and Referral), Delhi Cantt,  
Delhi, India

**Aim:** To compare the extent of apical penetration of irrigant in canals prepared using different endodontic systems.

**Methodology:** Study was performed on 60 extracted mandibular premolars with single canals. They were allocated into three groups based on the endodontic systems used for preparation of root canal: group 1 – K3XF, group 2: WaveOne, group 3: SAF. After standardised preparation a radiopaque contrast agent mixed with sodium hypochlorite is used as irrigant, in group 1 & 2 30G side vented needle was used for irrigant delivery and in group 3 VATEA irrigation system of SAF was used. Then tooth were subjected for radiography and index of infiltration was calculated. Values were tabulated and statistically analysed.

**Results:** The analysis of variance test (ANOVA) showed statistically significant differences between groups ( $<0.05$ ). Turkey's HSD post hoc tests showed significant statistical differences between group 1 and group 3 and group 2 and group 3. No significant difference was observed between group 1 and group 2.

**Conclusion:** Within the limitations of the study, by using vibratory adaptive file system (SAF) for root canal preparation greater apical penetration of irrigants can be achieved. Further correlation can be done with clinical studies to generalise the results.

#### Abstract 8

### Endodontic management of radix

**ANUBHAV CHAKRABARTY**

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Maharashtra, India

**Background:** The main objective of root canal treatment is the thorough mechanical and chemical cleaning and shaping of the root canals. The present study was conducted to assess the knowledge, attitude and practices towards endodontic management of Radix cases amongst clinicians of varied experience including general dentists, specialists and Endodontists.

**Materials and Methods:** The present study was conducted on 267 participants of both genders. A well-formulated questionnaire of 13 questions was handed to all participants. They were divided into 4 groups. Group I were undergraduate students, group II were postgraduate students, group III were experienced Endodontists and group IV were other specialists.

**Results:** More than 15 years experience was seen in 29%, maximum RCTs done were 41-50 by 22%, no of Radix till date were  $>30$  by 37%, Radix Entomolaris is more common by 80%, 1st molar is associated with Radix in 96%, 76% not maintaining database, 55.8% feel that accurate diagnosis is management of Radix, 75% feel multiple RVG is pre-operative management, 19% feel CBCT is necessary. The difference was significant ( $P < 0.05$ ).

**Conclusion:** The initial diagnosis is of utmost importance, to facilitate the endodontic procedure and to avoid treatment failures. There is a need to improve knowledge and awareness in the management of Radix cases.

#### Abstract 9

### An evidence-based approach to negotiate and treat calcified canals: A literature review

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Human dentition undergoes a continuous change in the internal anatomy by virtue of secondary and tertiary dentin deposition. Sequelae of dentin deposition are calcifications of coronal and radicular pulpal spaces in varying degrees. Endodontic treatment of teeth with pulp canal obliteration presents a challenge given the high likelihood of procedural errors and complications during treatment. Management of calcifications requires adequate knowledge of etiology, pathogenesis, classifications, and management strategies. Calcific deposits blocking access to root canal space could hinder its cleaning, shaping, and obturation. While locating the residual canal, loss of large amounts of radicular dentin increases the risk of root fracture and perforation. Preserving the remaining tooth structure by gaining conservative access and minimal enlargement contributes to the maintenance of the overall fracture resistance of teeth. The advent of science and technology has resulted in various advancements in the field of dentistry, simplifying diagnosis and treatment protocol for clinicians across the world. Artificial intelligence and machine learning also play a significant role in locating calcified canals and instrumenting them efficiently conserving time and resources. This paper aims to review the scientific literature on management strategies for calcified canals, focusing on novel armamentariums and techniques that have grown to become a prime necessity to establish an efficient management strategy that improves the quality of life of clinicians and patients.

#### Abstract 10

### Intentional replantation "the road less taken." A case series

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Uttar Pradesh, India

According to Grossman 1966, Intentional replantation is the intentional removal of a tooth and its reinsertion into the socket after either endodontic manipulation or obturation of the canals or both. The first account of Intentional Replantation was given by an Arab physician Abulcasis in the 11th century; following which,

## Abstract

the procedure has grown more popular over the years. Although Grossman has referred to intentional replantation only as a “last resort” and his opinion has been echoed by authors such as Weine, recent studies disagree with the aforementioned views and believe it to be an apt conservative treatment modality with a mean success rate of 73-77% [Cho et al, 2017] which may be attributed to better root end filling materials and advancements in endodontic surgery. It is being touted as a cost effective alternative to implants and an attempt to save the hopeless tooth. This case series highlight that Intentional Replantation in hopeless teeth might be a successful approach.

### Abstract 11

#### Maleic acid in the arsenal of irrigants in endodontics: A literature review

**CAROL GLORIA MORAS, ARCHANA AMBADAS CHAVAN**

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The success of endodontic therapy relies on the eradication of micro-organisms that harbour inside the root canal system, via chemo-mechanical means. Employing irrigants ameliorates mechanical debridement of organic and inorganic tissues, which can be attributed to their ability to reach complex intricacies of the root canal space while nullifying microbial toxins incorporated in the smear layer. Although controversial, the presence of smear layer on root canal walls has been known to negatively impact the action of endodontic disinfectants and obturating materials, necessitating its removal with the aid of chelating agents or acids. When EDTA was pioneered into Endodontics, it was appraised as the gold-standard chelant for smear layer removal. Taking into account its drawbacks, the search for newer chelating agents led to the implementation of various chemical agents for the same. After gaining popularity in the field of restorative dentistry as an acid conditioner, Maleic acid was then introduced for smear layer removal in root canal therapy. This mild organic acid holds the potential to bring about the demineralization of dentin, alongside the erasure of bacteria. Over the years, researchers have documented various characteristics of Maleic acid as an irrigant in endodontics. Hence, the basis of this literature review is to explore maleic acid as a root canal irrigant and compare its properties to the existing array of irrigating agents.

### Abstract 12

#### Comparing the ability of novel chlorinedioxide on smear layer removal against 2.5% sodium hypochlorite and a herbal irrigant - terminalia chebula

**VB AKSHAYA**

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**Aim:** The aim of this in vitro study was to evaluate and compare the efficacy of 0.5% Chlorinedioxide on smear layer removal against 2.5 % sodium hypochlorite and Terminalia Chebula using scanning electron microscope.

**Methodology:** Thirty single-rooted human mandibular premolar teeth were selected and decoronated.. Working length was established. Biomechanical preparation was done. Teeth were

randomly divided into three groups of 10 specimen each according to the final irrigation solution. Group A- 2.5% sodium hypochlorite, Group B- 0.5% Chlorinedioxide, Group C-Terminalia Chebula, The samples in each group were irrigated with 5 ml of each irrigant. Each specimen was split longitudinally into two halves along the prepared groove on the buccal and lingual aspect. For each split half sample, smear layer removal was evaluated at three different levels namely coronal, middle and apical thirds by scoring the amount of smear layer retained and the opening of dentinal tubules under SEM. The values were tabulated and statistically analysed.

**Results:** No smear layer was noted on the coronal surface of the samples irrigated with Group B (chlorinedioxide). A mild smear layer was seen in middle and apical surface of samples irrigated with Group B. A moderate smear layer was seen in coronal and middle third surface of specimens treated with Group A (NaOCl) and Group C (Terminalia chebula). In the apical section, there was heavy smear layer in both Group A and C. There was a significant difference among the data of groups ( $P < 0.005$ ).

**Conclusion:** Within the limitations of the study, it can be concluded that; among the irrigants tested, 0.5% chlorinedioxide showed maximum cleansing effect followed by 2.5% sodium hypochlorite and the herbal irrigant terminalia chebula.

### Abstract 13

#### Dynamic endodontic navigation system: A narrative review

**M MAGESHWARI, A ARVIND KUMAR, S RAVISANKAR M, PAULIAN BENIN**

Rajas Dental College and Hospital, Tirunelveli, Tamil Nadu, India

Dentists are in search of newer technologies that would enhance the accuracy of their diagnosis. Endodontists, everyday face clinical problems such as calcified canals, multiple canals, difficulty in locating canals. Many complexities associated with Endodontics can be solved to a greater extent with the introduction of technologies such as the Endodontic microscope and Cone Beam Computed Tomography. There is a need for guiding the Endodontist to navigate the canal complexities. So, the Dynamic Navigation technology used in Implant placement (Navident) came to the attention of Endodontists, this technology could be uniquely suited for the treatment of complex cases of both conventional non-surgical and surgical endodontics. ClaroNav (ClaroNav Inc, Toronto, ON, Canada) has been working at creating a similar application with the Trace Registration method (commercially known as “TaP” = “Trace and Place”) which allows the dentist to register the CBCT onto the patient by selecting three to six radiographically distinct, accessible landmarks on the screen, then tracing them in the patient’s mouth. This Real-time (dynamic) navigation is a valuable alternative whereby one can avoid the fabrication of a stereolithographic template resulting in less expensive treatment. So, this system will be a beneficial adjunct for successfully treating root canal complexities, safely and predictably. In addition, this technology can potentially be used to make smaller, less invasive access preparations and can be an effective option in apical surgery also. Hence this non-invasive, digitized, dynamic navigator system will be a promising digital

Abstract

method in times to come. This review presentation shows light on this dynamic navigation system in Endodontics.

#### Abstract 14

##### Indexing the periapex: A review

**M NIRANJANA DEVI, A ARVIND KUMAR, P BENIN, NJ NAGARAJ**

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Root canal treatment is in clinical practice for many decades with proven success. Evaluation of the success of any endodontic treatment outcome is primarily based on the efficiency of evaluation tools like clinical and radiographic examinations. But the sad truth behind the evaluation tools used for assessment of the root canal treatment is the lack of advanced evaluation indices as we still follow the same old periapical index which was introduced in the year 1986. The advantage of having a periapical index is that it helps in monitoring the changes along a disease continuum and it would be of interest to know to what extent the periapical healing is at a certain moment of time which will be predictive of the future status of the tooth. With modern science and technology cone beam computerized technology imaging plays an important role in evaluating the periapical status of the teeth. Cone-beam computed tomographic imaging is a technology that provides multiplanar and 3-dimensional reconstruction imaging of dental hard tissues. Nowadays CBCT is recommended for endodontic diagnostic and treatment planning as well as for assessing the outcome of root canal treatment. Using this technology, several investigators have shown the presence of periapical radiolucencies in cases where no radiographic pathosis is observed. Another advantage is the radiological identification and classification of periapical bone lesions in the case of apical periodontitis and in the endodontic treatment quality radiological evaluation. So this review paper is a compilation of the newly introduced indices which are found to be highly efficient, effective and have proven to be the most acceptable evaluation criteria in modern endodontics.

#### Abstract 15

##### Effectiveness of syringe, endoactivator and passive ultrasonic irrigation on smear layer removal and canal cleanliness: An *in-vitro* stereomicroscopic evaluation

**B O OHA**

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**Aim:** To compare the effectiveness of syringe, endoactivator and passive ultrasonic irrigation methods in removing smear layer from root canal using stereomicroscope.

**Materials and Methods:** Forty four extracted single-rooted human mandibular premolars were decoronated to a standardized length of 12 mm. Specimens were shaped to F3 (SuperEndo, super gold flex files) and irrigated with 17% EDTA. Teeth were divided into 4 groups (1 control group [n = 10] and 3 test groups [n = 10]) according to the final irrigating devices (ie, sonic irrigation, passive ultrasonic irrigation [PUI], or manual irrigation). Root canals were

then split longitudinally and observed under stereomicroscope. The presence of debris and a smear layer at coronal, middle and apical third was evaluated. Scores were analyzed by Kruskal- Wallis and Mann-Whitney U tests.

**Results:** Use of both the EndoActivator and PUI resulted in significantly better scores at all levels. The EndoActivator System (Dentsply Tulsa Dental Specialties, Tulsa, OK) was significantly more efficient than PUI and the control groups in removing the smear layer at the apical third. At the coronal and middle third, Endoactivator and PUI showed similar scores.

**Conclusion:** In our study, endoactivator removed smear layer completely at the apical third. Sonic and ultrasonic irrigation resulted in better removal of the smear layer in all thirds of root canals than conventional irrigation.

#### Abstract 16

##### Criteria for successful root canal treatment: A review

**RS ARJUN**

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Studies assessing the outcome of endodontic treatment is an area of interest is extensively studied. Various terminologies have been coined to define success of root canal treatment. However, these terminologies are often confusing to practicing dentists. Clinical examination, radiographic evaluation, and histopathological findings are commonly used methods to determine the success of endodontic treatment. The absence of clinical symptoms and periapical radiolucency is the key outcome measures to indicate the success of endodontic treatment. In recent years, cone beam computed tomography has emerged as a principal tool for diagnosis and treatment planning. The Cone beam Computed Tomography-Periapical index is developed to standardize the assessment of the severity of apical periodontitis by Cone beam Computed tomography. The inconsistency in defining success and failure led to the proposal of other endodontic outcome criteria. American Association of Endodontics, categorized outcomes as "healed", "non-healed", "healing", and "functional". American association of Endodontics also classified the outcomes of regenerative endodontic procedures based on elimination of symptoms and evidence of bony healing as essential criteria. The evolution of endodontic treatment outcome ranges from Strindberg's criteria to patient-centered values like survival and function of the endodontically treated teeth even in the presence of inflammatory periapical disease. This review paper discusses the various criteria of treatment outcome, providing a better understanding of success and failure of root canal treatment.

#### Abstract 17

##### Nitric oxide in pulp regeneration: A review

**PS SREELAKSHMI**

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Regenerative endodontic therapy incorporates the principles of regenerative medicine and tissue engineering to reproduce functionally viable pulp- dentin complex. According to American Association of Endodontics (AAE), regenerative therapy is indicated

## Abstract

for teeth with necrotic pulp, an immature apex, and when post and core is not advised. Regenerative procedures have been attempted on mature permanent teeth with necrotic and vital pulp tissue. Complete disinfection of root canal space is considered as one of the key factors to successful regenerative endodontic treatment. Irrigants, medicaments and antimicrobial agents have been used for canal disinfection. The right concentration of irrigants and medicaments is crucial for the release of growth factors and for the survival and proliferation of stem cells. Nitric oxide is regarded as a potential therapeutic agent for its antibacterial properties and role in wound healing. Nitric oxide releasing nanoparticles can be utilised to combat biofilm associated bacterial infections and are more efficient than other antibacterial agents. Studies are conducted to incorporate nitric oxide to achieve absolute disinfection of the root canal system. Construction of biomimetic microenvironment that mimics native pulp extracellular matrix and delivers selective bioactive molecules like nitric oxide are being explored. This review article discusses the potential of incorporating nitric oxide in a biomimetic nanomatrix gel for pulp tissue regeneration.

### Abstract 18

#### Pericervical dentin: To remove or to preserve?

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Dentistry has clearly shifted from the traditionalist era of extension for prevention to the more novel concepts of preservation and conservation. From Schilder's laws of Endodontic treatment to the more minimalistic concepts provided by Clark and Khademi, endodontics has shifted, one milestone at a time, moving into a world where operator oriented and visibility driven access opening is no longer the norm. We have evolved into a world of minimalism, where the preservation of sound tooth structure takes precedence over achieving a straight line access or other aspects of traditional endodontic treatment. Three major concepts are covered in minimalistic endodontics: Conservation of the Peri-cervical dentin, the 3D ferrule, and the soffit. This triad of minimalism makes for a stronger, more intact tooth, and a successful endodontic treatment in an anatomically intact root canal system. This paper attempts to showcase the importance of preservation of pericervical dentin in maintaining the structural integrity and strength of the endodontically treated tooth and focuses on the developments that pave the path for the future of endodontic therapy.

### Abstract 19

#### Is endodontically treated teeth a foci of infection for systemic diseases? A review

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A focal infection is a localized or generalized infection caused by the dissemination of microorganisms or toxic products from a distant focus of infection. The concept of focal infection theory was introduced, when W.D. Miller in 1891 identified the human mouth as a focus of infection within the oral cavity. The endodontic focal

infection theory stated that bacteria remaining after root canal treatment could lead to systemic diseases like arthritis, kidney and heart diseases. In the 1920s, this theory was widely taught, and edentulous therapy was considered as a solution for preventing focal infection. This led to an era of extraction of teeth and endodontic practice came under particular scrutiny. In the early 1930s well designed scientific studies disproved this concept, as a result, the theory remained criticized and rejected for years. Despite it being disregarded by scientific research, focal infection theory re-emerged in recent years. Reports started to emerge in the early 1990s addressing the association between endodontic pathology (acute and chronic apical periodontitis) and systemic pathologies such as cardiovascular disease, thromboembolic events & atherosclerosis. Much misinformation has spread among dentists and the public because of charlatanism, through the press, television particularly with the use of social media platforms. In the year 2019, the film 'Root Cause' was shown on Netflix claiming that root canal treatment causes cancer but was later removed because of its ill-based concepts. This review aims to highlight the long history of focal infection and recent realistic perspectives to avoid misinformation.

### Abstract 20

#### Chitosan in regenerative endodontics

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The most desired outcome of endodontic treatment is when the diseased or non-vital pulp is replaced with healthy pulp tissue that would gradually revitalize the teeth through regenerative endodontics. There are various scaffolds that facilitate the regeneration of different tissues. To ensure a successful regenerative procedure, it is essential to have a thorough and precise knowledge about the required scaffold which will be used in the regenerative procedure. Chitosan is a biopolymer made from the N-deacetylation of chitin, a significant component of arthropod and insect exoskeletons and fungal cell walls. It has antibacterial activity against a number of microorganisms, including *Enterococcus faecalis*, a pathogen commonly identified in root canal infections. It possesses a high chelating property in acidic conditions in addition to being biocompatible and biodegradable and lacks human toxicity. Chitosan could thus be a promising antibacterial agent if it retains its antimicrobial characteristics after being incorporated into a fibrin scaffold. Scaffolds made of hydrogel-based injectable materials have been employed in regenerative endodontic procedures. Fibrin gel has been proven to provide superior dental pulp-like tissue development compared to other scaffolds such as self-assembling peptide, collagen, polyethylene glycol-based hydrogel scaffolds. These scaffolds, on the other hand, lack antibacterial characteristics, putting cells at risk of infection. Chitosan has been added to hydrogels to prevent microbes from growing inside the root canal. Research suggests that adding chitosan to a fibrin hydrogel gives it antibacterial characteristics. This could be useful in resolution of endodontic space infections without significantly changing the fibrin scaffold's pro-regenerative qualities. It has also been proven that final irrigation with 1% Chitosan was able to release

Abstract

TGF- $\beta$ 1 from root canal dentin comparable to 17% EDTA with more biological activity. The aim of this review paper is to determine the effectiveness of chitosan scaffolds as well as their ability to stimulate proliferation and mineralization of dental pulp stem cells.

### Abstract 21

#### Pain after nonsurgical endodontic treatment: A review

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The primary objective of endodontic treatment is to preserve the natural dentition with complete relief of pain from pulpal/periradicular infections. But sometimes pain is induced by the treatment itself. So it is important for the clinician to understand the mechanism and causative factors of postoperative pain to give proper treatment to patients. Postoperative pain is multifactorial and the causative factors comprise mechanical, chemical and/or microbial injury to the pulp and periradicular tissues, which are induced or aggravated during root canal treatment. It occurs during treatment (interappointment) or persists after completion of endodontic treatment. Pain duration may range from one day to several weeks and its intensity may range from mild to severe. Main causative factors of pain after root canal treatment are extrusion of debris beyond apex during instrumentation, instrumentation leads to change in the microbiota, over instrumentation of the root canal space, extrusion of obturating material beyond apex through the apical foramen, incomplete removal of pulp, method of which pulp is removed, length of obturation, sealer extrusion beyond apex, root fractures, incorrectly measured working length, perforations, secondary endodontic infections, missed canals during root canal treatment, improper post-endodontic restoration. Referred pain due to any other causes like TMJ disorders and occlusal disturbances should also be discussed. Role of antibiotics and analgesics in the management of postoperative pain gives significant results in reducing pain. The aim of this review is to highlight the important causes of pain after non-surgical endodontic treatment and preventive measures to be taken to reduce pain.

### Abstract 22

#### Revolution in endodontics: Reciprocation – A review

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P BENIN**

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Effective cleaning and shaping of the root canal system will reduce the bacterial load and create a sterile environment which will ultimately lead to better periapical healing and higher success rate of endodontic treatment. In the past, numerous advancements had been developed in endodontic instrumentation to achieve effective shaping and cleaning of the root canals with minimal procedural errors. Introduction of rotary Nickel-Titanium instrumentation has revolutionized the art and science of endodontic practice in the last decade with predictable success. But, the greatest disadvantage of Nickel-Titanium rotary instruments is the risk of instrument

separation which could be attributed to its use in continuous rotation. Instrument separation during the canal preparation might impair proper root canal system disinfection and lead to failure of the root canal treatment. A new type of alternative instrument motion has been suggested which is known as reciprocation, this works on the principle similar to that of the Balanced-force technique. Reciprocating Motion is defined as an alternative backward and forward (Clockwise/counter clockwise) movement. The advantages of this technique are a reduced number of instruments, improved instrument fatigue resistance, the elimination of possible cross-contamination by the single use of reciprocating endodontic instruments, shorter treatment time, better cleaning standards, less root canal deviation, reduce operator fatigue, reduce root canal aberration and improve the safety of shaping procedures. The aim of this review is to highlight the importance of reciprocating instrumentation in endodontics.

### Abstract 23

#### Newer biomimetic materials in direct pulp capping a minimally invasive treatment; preserving vitality for longevity

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When affected pulp is beyond repair, the ultimate treatment is to perform endodontic therapy leaving the tooth non-vital. Removal of pulp may make the endodontically treated teeth susceptible to post-operative fractures and re-infection due to coronal leakage or periapical microleakage. Furthermore, the tooth loses its sensation to thermal changes, stimulation and ability to detect secondary infections. The concept of minimally invasive dentistry bridges the traditional gap between prevention and surgical procedures. Preserving tooth vitality is crucial for tooth homeostasis and durability. Thus, there is a critical need for clinical interventions that enable regeneration of the dentin-pulp complex. Such treatment strategies itself is minimally invasive since it preserves the pulp tissue and maintains the vitality. The ability of dentine-pulp complex to form hard tissue against a variety of materials indicates the inherent capacity for cell reorganization, dentin bridge formation and pulpal healing. The fundamental characteristics of Biomimetic materials are their biocompatibility, which includes an antibacterial capacity and properties that induce tissue healing; its cytocompatibility; and its ability to seal the lesion. The objective of using Biomimetic material in vital pulp therapy is to restore the tooth to its function, esthetics, strength and regenerate lost dental tissues. This review will highlight on variety on newly introduced and experimented biomimetic materials which have a significant success on direct pulp capping.

### Abstract 24

#### Vitality check in traumatic teeth

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## Abstract

Traumatic dental injuries may damage hard dental tissues, pulpal and periodontal structures, compromising function and aesthetics. It can be localized to the crown, root in the form of fracture, concussion, subluxation, luxation injuries, intrusion or extrusion. It occurs most frequently in children and young adults. Immediately after an acute dental trauma, healing events begin in an attempt to regenerate nerves and vessels and to replace damaged pulpal tissue where dental pulp blood supply might be torn or severed/ruptured. This could lead to pulpal edema or ischaemic necrosis, which could result in a negative pulpal response just after injury. It takes approximately 10–14 days for a positive pulpal response to return. For pulp sensation in a dislocated tooth with subsequent rupture of the neurovasculature it might take up to 3 months in immature teeth or several years in teeth with closed apex to return. In a traumatized tooth neural regeneration is slower than vascular regeneration. Proper diagnosis, treatment planning and follow-up are very important to assure a favorable result. Sensibility tests (thermal and electrical tests) are the most commonly used but they have limited diagnostic capacity. The factors that interfere with the effectiveness of sensibility tests in newly traumatized teeth are transient paresthesia, subjectivity of the patient's response, alteration of the pain threshold. On the other hand, pulp vitality tests can suppress such limitations because they are noninvasive methods that evaluate the vascular conditions of the tooth, and these tests provide a more accurate indicator. The most used are pulse oximetry, laser Doppler flowmetry and Cone beam computed tomography. It is generally agreed that Laser Doppler flowmetry assessment for human teeth should be performed at 4 weeks following the initial trauma, and repeated at regular intervals up until 3 months. Hence it is always preferable to check vitality than the sensibility of the pulp.

### Abstract 25

#### Maxillary sinusitis and endodontic infection: A review

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The relationship between dental infections and sinus disease has been widely reported, where the roots of the maxillary posterior teeth lie close to the floor of the maxillary sinus, there is a high prevalence of periapical infection manifesting as maxillary sinusitis. The pathological extension of dental disease into the maxillary sinus was first documented by Bauer in 1943 as maxillary sinusitis of dental origin (MSDO). Dental infections account for approximately 10 to 12% of all cases of maxillary sinusitis. The infections of maxillary posterior teeth have shown maxillary sinus pathology in 60% of the cases and with maxillary sinus mucosal changes in 71.3% of patients with infections originating in the maxillary canines, premolars, and molars. The teeth with an infected necrotic pulp or failure of endodontic treatment will generate Maxillary sinusitis of endodontic origin (MSEO). The current Clinical Practice Guidelines for the Management of Adult Rhinosinusitis was published by The American Academy of Otolaryngology – Head and Neck Surgery Foundation, recommend an endodontic examination to rule out or treat an odontogenic source for sinusitis. Identification of MSEO is

important, failure to identify and remove the source of endodontic infections will result in the persistence of sinus diseases and potential advancement to life-threatening craniofacial infections. MSEO are present with repeated episodes of unilateral maxillary sinus infection. The periapical radiographs are not adequate in observing the anatomical relationship between maxillary molars and the sinus floor, CBCT imaging reveal mucosal soft tissue changes or air-fluid levels in the sinus, which are of great diagnostic value in MSEO. The periapical infections manifesting in the maxillary sinus remain under-appreciated and frequently go undiagnosed by dentists, otolaryngologists, radiologists and are often misdiagnosed as sinogenic sinusitis. This review paper describes the diagnosis, pathophysiology, and treatment options for maxillary sinusitis of endodontic origin.

### Abstract 26

#### Root perforation: A review

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Root perforation is an artificial communication between the root canal and the supporting tissues of teeth. It is caused by procedural accidents or pathological alterations. Tooth malposition, pulp stones, resorption, calcifications, and root anatomy may predispose to this pathologic communication. The incidence of root perforations ranges from 0.6% to 17.6% while accidental perforations account for 2%–12%. 73% of perforations occur in the maxillary teeth. The cause for maxillary anterior teeth perforation is the underestimation of the palatal root inclination, while in multi-rooted teeth, furcal perforations occur in an attempt to locate canal orifices. At the site of perforation an acute inflammatory response leads to destruction of periodontal fibres, resorption of the surrounding bone and granulomatous tissue formation. This presents as a radiolucency at the site of middle and apical root perforations. At the supra crestal region there is proliferation of epithelium, resulting in formation of a periodontal pocket and ultimately loss of tooth; therefore, reducing the success of root canal treatment by 56%. Several key factors are associated with the pathological sequelae and the prognosis of the tooth including the site and size of perforation, time of repair and the material used. Perforations at the critical zone, which is the region at the crestal bone and the epithelial attachment, has the worst prognosis due to bacterial contamination from the oral cavity. Perforations coronal and apical to the critical zone are said to have a good prognosis due to their easy accessibility and lower risk of bacterial penetration respectively. The key factor in perforation repair is the ability to seal the perforation and re-establish a healthy periodontal ligament and may be achieved surgically or non-surgically. Historically, various materials such as amalgam, zinc oxide – eugenol cement, calcium hydroxide, gutta percha, glass-ionomer cement, IRM, composite resin and Super EBA cement were used, but with the advancement in material science bioactive material such as mineral trioxide aggregate has provided with best results. This review presents the etiology and highlights the treatment approaches and prognosis of various root perforations.

### Abstract 27

#### Neural sensibility response of dental pulp to electric stimulus in South-Indian population: A cross-sectional study

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**Aim:** The aim of this study was to compare and evaluate the pulp sensibility response to electrical stimulus in the South-Indian population with a vitality scanner based on age, gender, and tooth morphotype.

**Materials and Methods:** Pulp sensibility was determined among 100 individuals- 41 men and 59 women aged 21-61 years. The control group consisted of 50 individuals with the age range of 21-35 years and the study group had totally 50 individuals of the age range 46-61 years. A total of 2666 teeth were screened using Vitality scanner 2006, Sybron Endo model. The test was carried out by positioning the tip at middle third of the teeth in general to evoke the response and the values were thoroughly recorded. The data obtained were analysed using SPSS v.20. and Mann Whitney U test was used for the group comparison. The analysis of Tau-kendall correlation and logistic regression was also used. The significance level was set at 0.05.

**Results:** The results revealed that there was a statistically significant difference in pulp sensibility scores obtained between the young and aged population groups [ $P < 0.05$ ]. Incidentally, the sensory threshold values of anteriors and premolars in both arches of the elderly population appeared to be lower in comparison with the control group. About gender, there were no statistical significance obtained among males and females. The correlation and regression analysis performed to estimate the association with the manufacturer's said values disclosed that there was a correlation established among all the teeth but the strength of association showed observable variation in different morphotypes of the elderly category.

**Conclusion:** The differences in the pulp sensibility were found in varying age groups but not in varying gender. From the results obtained in the current study, it is evident that the manufacturer's recommended values might function as an endorsed guide, but not a standard tool of reference owing to individual's variation in different age and tooth morphotype. Further research is necessary to corroborate these observations from the study.

### Abstract 28

#### Knowledge and perception of general dentist and endodontist towards the use of endodontic spacer in central India

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**Aim:** To assess the knowledge and perception of General Dentist and Endodontist towards the use of endodontic spacer in Central India.

**Introduction:** Endodontic spacers are the integral part of temporary restoration during multivisit root canal therapy. They have traditionally been used below temporary restorations in order to prevent restorative materials from occluding the orifices, and to aid in efficient removal of these materials. Along with the thickness of temporary restorative material, the type of spacer placed beneath the temporary restoration, may also contribute to microbial leakage. Cotton, as an endodontic spacer, still present a clinical problem. To prevail over complications of cotton, many practitioners have incorporated foam pellets and Polytetrafluoroethylene (PTFE) tape, as spacers. So the present study was conducted to assess knowledge and perception of dentist and endodontist towards the use of endodontic spacer.

**Methodology:** A web based close ended questionnaire survey was conducted among the General Dental Practitioner (GDP) and Endodontists in Central India. The participants comprised of total 288 Dental Health Care Professionals (DHCPs) including General Dental Practitioners (GDP) and Endodontists working in government sector, associated in institutions and having private practice in Central India. The data were statistically analyzed using Pearson Chi square test.

**Results:** The Endodontist who practiced multivisit endodontics were more likely to use PTFE as endodontic spacer ( $p < 0.001$ ). The General Dentist showed more preference towards use of cotton as endodontic spacer ( $p < 0.001$ ), 59% of them lack knowledge of using PTFE as endodontic spacer.

**Conclusion:** Endodontic spacers are integral part of multivisit endodontics. Earlier cotton pellets were preferred as an endodontic spacer. PTFE with its unique properties of inertness, non-biodegradable and non-fibrous is preferred over cotton by many Endodontists. In this survey it was seen that GDP lacked the awareness of using PTFE as endodontic spacer.

### Abstract 29

#### Biocompatibility and anti-inflammatory efficacy of resolvin D2 in healing kinetics of foreign body induced periapical lesion: An animal study

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**Introduction:** Overextension of sealer or gutta percha can occur during obturation or retrieval of GP during re treatment resulting in persisting inflammation and post-operative pain. Resolvin D2 (RvD2) resolves the acute phase of inflammation by targeting the lipid mediators of inflammation. The present study aims to quantify periapical inflammatory reaction induced by foreign body, evaluate the periapical healing and characterize the regulation of pro inflammatory cytokines and Real time PCR to analyze gene expression of GSK 3  $\beta$  axis following administration of RvD2.

**Materials and Methods:** 48 Female Wistar Albino rats (*Rattus norvegicus*) were randomly allocated into 4 groups with  $n = 12$  per group. Group – I: Sham Control (Periapical lesion); Group – II: Lesion + GP; Group – III: Lesion + GP + GP solvent; Group – IV: Lesion +

Abstract

GP + GP solvent + Resolvin D2 (0.5µg/ml). Rats were anesthetized, defect was created in the periapical bone, test materials placed and the tissue flaps were sutured. Animals were euthanized at 7th and 14th day. The periapical tissue specimen was processed for histopathological, immunohistochemical analysis and RT-PCR done to study the effect of RvD2 on GSK-3β mediated anti-inflammatory response on mouse osteoblast.

**Results:** At day 7, Group I and II showed infiltration of inflammatory cells, mainly lymphocytes and macrophages. A significant increase ( $P < 0.05$ ) in the number of inflammatory cells and multinucleated giant cells were seen in Group – III. There was a significant decrease ( $P < 0.01$ ) in the inflammatory cells in Group – IV when compared to Group - I. At day 14, Group - IV showed fewer inflammatory cells and evident reparative reaction to tackle inflammatory process confirmed by immunohistochemistry staining using interleukin 6 (IL-6) as an inflammatory marker. The number of inflammatory cells were quantified and graded as per the severity of inflammation. Effect of RvD2 on gene expression of GSK 3 β – mediated anti-inflammatory response on mouse osteoblast was analyzed to reveal the dynamics of RvD2 using Real time PCR.

**Conclusion:** Resolvin D2 significantly reduced the inflammatory reactions induced by gutta percha and GP solvents in the periapical region in an animal model.

### Abstract 30

#### Role of human amniotic membrane on early pulp biomineralization

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**Aim:** The objective of the study was to compare the role of human amniotic membrane (HAM) in early pulp biomineralization in comparison to Biodentine using tooth culture model.

**Methodology:** Twenty four freshly extracted tooth for orthodontic reasons were transported to biosafety cabinet where the root apex was sectioned leaving 8mm below the CEJ. This was followed by pulp exposure in the central fissure using a No.2 carbide round bur mounted on a slow-speed dental handpiece. Cryopreserved human amniotic membrane was cut into 3x3 mm pieces depending on the size of the exposure and rinsed with saline for 1 minute before placing into the cavity followed by rest of the cavity filled with Biodentine. In group II, the Biodentine was manipulated according to the manufacture instructions and placed over the exposed pulp as a pulp capping agent and was allowed to set for 6 to 9 minutes. At the end of 14 days and 28 days the teeth were fixed using 10 % buffered formalin for three days. Samples were then scanned using the sky scan micro-CT system. Following the micro CT imaging, the histopathology soft tissue sectioning was performed after decalcifying the specimen. The teeth underwent decalcification in a solution containing 10% formic acid with sodium citrate and 5% nitric acid for 20 days. After embedding in paraffin wax, three sections of 3-5µ thickness each was sectioned using a soft tissue microtome.

The sections were stained with haematoxylin and eosin for analysis using optika stereo microscope.

**Results:** The results of this study suggested HAM produced more reparative dentin in comparison to Biodentine. Newly formed dentin in the amniotic membrane group had the characteristics of homogeneous reparative dentin which was confluent where as specimens of Biodentine had discontinuous foci of mineralisation within newly formed hard tissue.

**Conclusion:** Within the limitations of the study, the results of this study suggested that Amniotic membrane can induce favourable effects on the reparative process during vital pulp therapy in comparison to biodentine.

### Abstract 31

#### Proresolving mediators: A future boon to endodontic treatment?

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The success of endodontic treatment is dependent on the prevention and healing of Periapical lesions. Many studies have proved that the resolution of acute inflammation is necessary to prevent the development of chronic inflammation and to promote repair or regeneration. One such cell signaling molecules, are Pro-resolving lipid mediators which are specialized molecules (SPMs), derived from polyunsaturated fatty acids (PUFAs) of arachidonic acid and omega-3 fatty acids including lipoxins, resolvins, protectins and maresins. These are associated with some antimicrobial activity and are adjunct to antibiotic therapy. Their foremost mechanism of action is through the resolution of inflammatory pathosis without predisposing the host to an increased vulnerability to infections, which is a typical side effect of anti-inflammatory medications. Other than this, they also regulate tissue homeostasis. Their effect on endodontic treatment, which were evaluated with multiple, sophisticated analyses, displayed a significant decrease in the inflammation at the periapex of the treated teeth. It also reduces the bacterial load of the infected canals along with the decrease in the size of the lesion together with effective hard tissue repair at the root apices. This descriptive review paper will highlight on the treatment outcomes of SPMs on pulpal -periapical tissues inflammation, degree of periapical bone preservation and regeneration. It will also focus on SPM delivery system, for its use as an intracanal medicament to harmonize cellular and molecular events required in root formation.

### Abstract 32

#### Reinvigorating the tooth by using heparin and nano-hydroxyapatite as pulp capping agent: A case report

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## Abstract

In this holistic era, there is ever increasing demand for materials that trigger the healing potential of pulp in order to maintain and improve its health; as no root canal treated tooth can match its vital counterpart. Numerous studies have shown that endodontic biomaterials, improved pulp health and improved dentinal bridge formation. Biomaterials being biocompatible and /or bioactive need assistance in assembling the biomolecules and releasing them at appropriate temperospatial dimension in order to mimic odontogenic events and also to suppress untoward events. Bioinspired nano-hydroxyapatite introduced to overcome the limitations of hydroxyapatite (HA) [stoichiometric composition as  $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$ ] has excellent biocompatibility and bioactivity with human teeth and bone. Heparin being a polysaccharide from sulfated glycosaminoglycan family, has shown binding affinities with important proteins, such as vascular endothelial growth factor (VEGF), basic fibroblast growth factor (bFGF) and BMP-2. This interaction of heparin with biomolecules allows for their sustained release. Combination of individually tested, nano-hydroxyapatite and heparin will help overcome the limitations of the biomaterial and is hypothesised to improve the treatment outcome. This case report is on management of mandibular molar diagnosed with reversible pulpitis using pulpotomy procedure and a mixture of heparin and nano-hydroxyapatite as pulp capping agent with 6 month follow-up.

### Abstract 33

#### Nonsurgical management of an extraoral submental sinus tract of endodontic origin: A case report

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Cutaneous draining sinus tract of dental origin is often a diagnostic challenge, because of its uncommon occurrence and absence of dental symptoms. Delay by attending clinician to correctly diagnose the primary dental etiology of lesion has often resulted in multiple surgical excision, biopsies, long term antibiotic therapy and electrodesiccation all of which have failed with recurrence of sinus tract. This is a case of 31 year old female referred to our department with the chief complaint of extraoral swelling in her chin region. Past medical history reveals she was treated for the same by a general surgeon by performing surgical excision 15 years and 10 years back. Following this she had recurrence of swelling with multiple episodes of pus discharge for the past 1 year for which she was self-medicating with antibiotics. On Extraoral examination, a small indurated erythematous nodule in submental region was observed, intraoral examination revealed mildly discoloured 31, which was tender on percussion and revealed negative response on pulp vitality testing. Radiographic examination revealed well circumscribed periapical lesion in relation to apical third of root in 31. CBCT revealed complete loss of buccal cortical plate in relation to 31. Diagnosis was chronic suppurative periapical periodontitis with extraoral sinus in relation to 31. Under rubberdam isolation, access cavity

preparation, apical patency establishment and pus drainage was done. Canal was thoroughly cleaned and shaped using saline and 1.5% sodium hypochloride as irrigants. Calcium hydroxide mixed in 2% chlorhexidine was placed as intracanal medicament which was changed at an interval of 14 days, twice. By the end of 1month, the patient was asymptomatic and extraoral sinus healing was evident followed by obturation using cold lateral condensation and bioceramic root canal sealer. On 1 year follow-up, the patient was completely asymptomatic and the extraoral skin defect has closed completely. Radiographic and CBCT examination revealed evidence of bone fill in relation to periapical lesion of 31 showcasing the satisfactory healing of the lesion. This report shows that extraoral sinus can be treated conservatively with RCT whereas a delayed diagnosis or misdiagnosis may lead to more complication.

### Abstract 34

#### Interdisciplinary management of palatogingival groove: A case series

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The palatogingival groove is a developmental anomaly which is usually found on the palatal aspect of the maxillary incisor teeth, which can be a suitable environment for microorganisms and plaque accumulation. Palatogingival grooves are mostly associated with deep periodontal pockets allied to a periapical lesion. A deep pocket that reaches the apex of the tooth can affect the pulp vitality and causes a combined periodontal-endodontic lesion. Timely diagnosis, prevention and management are highly suggested to prevent tooth loss due to complications arising secondary to palatogingival groove presence. This case series presents the management of three cases of palatogingival groove in maxillary lateral incisor using a combination of endodontic and periodontal therapy.

### Abstract 35

#### Postoperative pain in nonsurgical endodontic treatment

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The primary goal of endodontic treatment is preventing and treating apical periodontitis, which involves mechanical and chemical means to debride pulp tissue, reduce microbial load and proper obturation of the radicular spaces. Even when performed with highest standard of care, some patients experience pain or flare up after undergoing root canal treatment. This post-operative pain is not only an unpleasant experience for the patient, it often makes them question the clinician's skill and ability. Therefore, prevention and successful management of post operative pain should be considered as an integral part of any endodontic practice. Post operative pain in non surgical root canal treatment is a multifactorial phenomenon that requires thorough understanding of the potential causes, pre, intra and post treatment factors and host immune response. A number of factors such as gender, type of tooth, preoperative

Abstract

pulpal and periapical status, single/multiple visits, instrumentation and irrigation protocols, obturation techniques and materials etc., have been implicated in the incidence of post operative pain. This review focuses on various factors that influence postoperative pain and treatment protocols that could be best suited to minimize the postoperative pain in nonsurgical endodontic treatment.

### Abstract 36

#### Continuous chelation-panacea or problem?

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Endodontic therapy aims to prevent and/or treat apical periodontitis by chemo-mechanical debridement of infected root canal systems using instruments and a combination of root canal irrigants. An ideal irrigant should act on biofilms as well as the smear layer produced during root canal instrumentation. However, traditional irrigation has always combined two or more irrigating solutions, in a specific sequence in order to achieve adequate disinfection & debridement of the root canal system. Sodium hypochlorite in concentrations ranging from 0.5-6%, is irreplaceable as the main irrigant due to its unique tissue dissolution capacity but it only acts on biofilms and organic portions of the smear layer. A chelating agent such as ethylenediaminetetraacetic acid (17% EDTA) is used to remove the inorganic portion of the smear layer. This “sequential irrigation” protocol is the current gold standard but has certain limitations. Interactions between these two solutions result in instant loss of hypochlorite activity due to reduction in free available chlorine content. Hence, remnants of the irrigants need to be thoroughly flushed out in between applications to minimise such reactions, which increases armamentarium and time needed to complete the endodontic procedure. Furthermore, sodium hypochlorite, if used as a final rinse following EDTA, leads to widening of the dentinal tubules & intertubular tunnelling due to dentin erosion. “Continuous chelation”, a novel irrigation protocol, is being proposed as an “all-in-one” solution to these problems. It combines 5.25% sodium hypochlorite and weaker chelators like 1- hydroxyethylidene-1, 1-bisphosphonate (HEDP) or disodium clodronate in a single mixture to be used for the entire duration of instrumentation. They are compatible with sodium hypochlorite & have minimal to no effect on its proteolytic or antimicrobial activity. Being weaker chelators of calcium, it is suggested that they are less aggressive on the dentin. This review paper aims to discuss the various properties, merits and demerits of these combined irrigating solutions in comparison to traditional sequential irrigation protocols.

### Abstract 37

#### Evaluating the effectiveness of three different irrigant agitation devices in eradicating enterococcus faecalis biofilm in human mandibular premolars: An *in vitro* study

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**Objective:** To evaluate the effectiveness of different irrigant agitation devices namely EndoActivator (EA), Passive Ultrasonic Irrigation (PUI) and XP-EndoFinisher (XPF) in eradicating *E. faecalis* biofilm from the root canals by quantifying the cultivable bacteria using colony-forming units (CFU), and to compare live/dead bacteria within the dentinal tubules using confocal laser scanning microscopy (CLSM). **Materials and Methods:** The study was conducted after obtaining ethical clearance from the IRB of Sathyabama University (Ref no: IHEC/Study no 042). The sample size estimation was done priori as  $n = 40$ , with a power of 0.99. Root canals of 59 human mandibular premolars were inoculated with *E. faecalis* for 4 weeks and biofilm formation was confirmed through Scanning Electron Microscope (SEM). The root canals were prepared with MTwo NiTi files to size 35/0.04% and the teeth were randomly assigned to 4 groups consisting of different irrigant agitation devices, Group 1- Syringe needle irrigation(SNI), Group 2- EA, Group 3- PUI, Group 4- XPF for canal disinfection. Samples for estimation of CFU ( $n = 10$ /group) were collected from the root canals before instrumentation (S1) and after instrumentation and irrigant agitation (S2). The ratio of live/dead bacteria within the dentinal tubules in the coronal, middle and apical third at 50 $\mu$ m, 100 $\mu$ m and 150 $\mu$ m into the dentinal tubules were measured post-intervention using CLSM ( $n = 4$ /group).

**Results and Statistical Analysis:** The Wilcoxon-signed-rank test revealed that all evaluated irrigant agitation devices produced a significant reduction in the CFU post instrumentation and agitation ( $P < 0.05$ ). Kruskal-Wallis test showed no statistically significant difference in CFU reduction between the groups ( $P$ -value 0.67). For CLSM analysis, the Kruskal-Wallis test and Mann-Whitney U test revealed no statistically significant difference in the percentage of live/dead bacteria between and within the groups at coronal, middle and apical third, at all depths into dentinal tubules. Although not statistically significant, SNI showed the least percentage reduction in bacterial count compared to others (EA, PUI, XPF) at all thirds and at all depths.

**Conclusion:** All irrigant agitation devices significantly reduced the bacterial count from the root canal lumen but none could completely eradicate it. None of the irrigant agitation devices studied demonstrated superiority over the others.

### Abstract 38

#### A pilot study on awareness, knowledge and attitude towards common traumatic dental injuries among physicians in the emergency rooms in Chennai: A questionnaire-based cross-sectional survey

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**Aim:** To investigate the awareness, knowledge and attitude of physicians in the emergency rooms (ER) towards the management of traumatic dental injuries (TDI) in Chennai.

Abstract

**Materials and Methods:** The questionnaire containing 22 questions was prepared to assess awareness, knowledge and attitude. The questionnaire was validated by 5 individual experts with an agreement of 80%. The sample size was estimated to be 110 using Open-Epi software with a 95% two-sided significance level (1- alpha). After obtaining approval from Institutional Ethical Committee, (Ref. no – 172/IRB-IBSEC/SIST) the questionnaire was distributed to 200 participants anticipating a response rate of 50%, via google forms and in person. A total of 6 questions with a maximum score of 15 were used to test the knowledge on the most common TDI. The knowledge levels were scored as limited (0-5), moderate (6-10), and high (11-15).

**Results:** Descriptive statistics were used and cross-tabulations using the Chi-square test (P-value < 0.05) were performed to compare categorical data. Among 110 participants, there were 19% specialists, 36% residents, 32% interns, and 12% duty doctors. Sub-urban private and urban government institutes/hospitals encountered TDI on a daily basis. Overall, 51.8% of the participants exhibited moderate knowledge, 37.3% showed high knowledge, and 10.9% had limited knowledge. Only 30.4% of the participants had received formal TDI education. No significant correlation could be established between knowledge levels, the type, experience, and status of TDI education of the participants. A statistically significant correlation was noted between the knowledge level and the confidence of the participants in handling TDI victims (P-value < 0.001).

**Conclusion:** Most physicians (89.1%) in hospital ERs of urban and suburban Chennai, possessed moderate to high knowledge levels in managing TDI. The level of knowledge was found to influence the confidence in managing TDI in ERs. Therefore, formal training and continuing medical education in the form of collaborative symposiums and workshops on TDI with the dental faculty may aid in timely detection and management of TDI in emergency rooms.

#### Abstract 39

**Comparative evaluation of effect of remaining coronal tooth structure on fracture resistance of endodontically treated permanent mandibular molars: An *in-vitro* study**

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**Objective:** To compare and evaluate the effect of remaining coronal tooth structure on fracture resistance of endodontically treated permanent mandibular molars restored with short fibre reinforced composite.

**Materials and Methods:** Forty freshly extracted intact permanent mandibular molars were selected and randomly allocated into 4 groups (n= 10). In groups I, II and III, a traditional access cavity was prepared. In group I, all four axial walls were kept intact whereas groups II and III had three remaining walls with missing mesial and buccal wall, respectively. In group IV (control group), teeth were kept intact. In all the samples of group I, II and III, endodontic treatment was performed and were restored with EverX Posterior and composite resin. After thermocycling (5–55°C, 5000cycles), fracture resistance for the samples were tested using Universal

testing machine. Statistical analysis was performed using one way ANOVA and Scheffe test.

**Results:** Group IV (control group) had significantly higher fracture resistance (1956.2522.41 N) than other groups (p<0.05). Among all the experimental groups, group 1 has the maximum fracture resistance. The intergroup comparison showed a statistically significant difference in fracture resistance among all groups except between group I and group II (p>0.05).

**Conclusion:** Teeth in the control group had statistically significant fracture resistance than teeth in experimental groups. Also, the fracture resistance of endodontically treated teeth with one missing wall was not significantly affected by the site of the missing coronal wall.

#### Abstract 40

**A stabilized splint on time saves the smile**

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An external impact causing traumatic tooth lesion leads to luxation injuries displacing the neurovascular bundle and damaging the periodontal fibres. This hampers post-traumatic healing which negatively impacts the quality of life in esthetic, social and functional domains. Thus, emergent and timely stabilization and splinting of luxated tooth leads to revascularization and reinnervation of the pulp as well as reorganisation of periodontal ligament fibres leading to favourable treatment goals and outcomes. Here we present the case of traumatic tooth luxation and novel use of pulse oximetry to assess pulp vitality at long term follow up. A 23year old female presented with pain and displaced tooth in the upper anterior tooth region within 12 hours of an alleged history of collision with the two-wheeler and fall. Clinical Examination revealed sutured lower lip elsewhere and labial luxation of maxillary left central incisor, contusion of surrounding labial gingiva, positive cold test response and tenderness on percussion, widening of periodontal ligament radiographically. As she presented within the “window period” of intervention, immediate treatment by repositioning, stabilization followed by splinting with flexible fibre splint was done. The patient was followed up once weekly to ensure tooth and splint stability and it was removed after 4 weeks. Monthly follow up showed clinically aligned tooth without any discolouration, positive response to pulp sensibility test and radiographically intact lamina dura and healed periodontium. Moreover, Pulse oximetry done at the 10th month of monthly follow up visit revealed that pulp was vital. The patient is asymptomatic at follow up after 2 years. We conclude that immediate repositioning and stabilization with flexible fibre splint followed by scheduled timely re-examination conserve the tooth vitality.

#### Abstract 41

**Impact of access cavity designs and instrumentation on pericervical dentin thickness: An invitro cbct analysis**

**ANEESHA MARY VARGHESE, SWATHY SUKUMARAN,  
RAJESH PILLAI, A AFZAL, SHEILA GEORGE,  
NIKHIL MURALI**

Abstract

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**Objective:** Primary objective of this invitro study was to determine the effect of mandibular premolar pre and post access cavity preparation and shaping on pericervical dentin thickness [PCD] and the secondary objective was to compare the remaining PCD thickness among experimental groups shaped with different files based on varying cross sectional designs and principles.

**Materials and Methods:** Twenty seven permanent mandibular first premolar teeth with closed apices were used for the study. Preoperative CBCT scan of each sample was done. PCD thickness was measured at the level of CEJ, as an average of shortest distance from the canal outline to the closest adjacent root surface, measured on facial, lingual, mesial, and distal surfaces. Samples were divided into three groups of nine teeth each. Group 1: Traditional access cavity Group 2: Conservative access cavity Group 3: Ultra-conservative access cavity Each group was again be subdivided into three (three teeth per subgroup). Subgroup 1: K File (Dentsply Maillefer) Subgroup 2: ProTaper Gold (Dentsply Sirona) Subgroup 3: TruNatomy (Dentsply Sirona) Cleaning and shaping of pulp space were done for all the specimens in each group [Subgroup 1 - apical enlargement up to ISO K file size 25 and stepback up to ISO K file size 45, Subgroup 2 – up to ProTaper Gold F2, Subgroup 3 – up to TruNatomy PRIME]. For all groups 3% NaOCl, 17% EDTA and 0.9% Isotonic Saline solution were used as irrigants. Post instrumentation CBCT scans were made and PCD thickness was measured as mentioned.

**Statistical Analysis:** One-way ANOVA test.

**Results:** Different access cavity designs and instrumentation impact the remaining PCD thickness. Pericervical dentin was preserved more in ultra-conservative group using TruNatomy file system.

**Conclusion:** Different access cavity designs and instrumentation impact the remaining PCD thickness. In this study, pericervical dentin was preserved more in ultra-conservative group using TruNatomy file system.

#### Abstract 42

#### Crack formation in root dentin associated with four different rotary instrumentation systems: An *in vitro* study

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**Objective:** The objective of this study was to compare the incidence of crack formation on root dentin after shaping with four shaping files based on offset shape in cross section, thermal treatment, variable cross - section and slim NiTi wire design.

**Materials and Methods:** Forty freshly extracted permanent mandibular first premolar teeth were selected. Samples were divided into four groups (n = 10), Group 1 – One-curve (Micro-Mega) Group 2 – TruNatomy (Dentsply Sirona) Group 3 – ProTaper Gold (Dentsply Sirona) Group 4 – ProTaper Next (Dentsply Sirona) Shaping of pulp space were done for all specimens in each group [Group 1 – with One-Curve, Group 2 -TruNatomy PRIME, Group 3 - up to ProTaper

Gold F2, Group 4 – up to ProTaper Next X2] Roots were sectioned horizontally of length 4mm, from coronal, middle and apical third using diamond disc. All slices were then viewed under CBCT.

**Statistical Analysis:** Chi-square test.

**Results:** TruNatomy files inflicted less dentinal cracks, followed by one curve, ProTaper Next and ProTaper Gold. Crack formation were more in the apical third when compared to middle and coronal thirds.

**Conclusion:** All shaping files might inflict dentinal cracks. In this study, single file system induced less dentinal cracks in coronal, middle and apical third of the pulp space than multiple file system.

#### Abstract 43

#### Effect of different irrigation agitation techniques on postoperative pain in permanent anterior teeth with symptomatic irreversible pulpitis: A randomized controlled trial

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**Aim:** The randomized controlled trial compared the effect of Conventional needle irrigation (positive pressure irrigation) and EndoVac irrigation (true apical negative pressure irrigation) on the incidence of postoperative pain following biomechanical preparation in the permanent maxillary anterior teeth with symptomatic irreversible pulpitis.

**Materials and Methods:** Fifty patients of the age group 18-50 years, with symptomatic irreversible pulpitis were selected for the study. The subjects were randomly allocated to two groups, Group 1 (Conventional needle irrigation) and Group 2 (EndoVac irrigation) according to the final irrigation methods performed during root canal preparation. The preoperative pain was assessed prior to the procedure. In group 1, root canal irrigation was performed using a syringe and a 27-G open-ended needle (Dispovan). In group 2, the EndoVac system (Kerr Endodontics) was used for irrigation. Postoperatively, the patients were prescribed ibuprofen 200 mg to take every 8 hours if required. Pain levels were assessed by an analog scale questionnaire after 6, 12, 24, and 48 hours. The amount of ibuprofen taken within these intervals was recorded.

**Results:** The data were subjected to Mann-Whitney test and Chi-square test for intergroup analysis and Repeated Measures ANOVA for intragroup analysis. At 12-, 24-, and 48-hour time intervals, group 1 patients reported more intense postoperative pain than patients in group 2 (p <.05). There was no significant difference between the 2 groups at the first 6- hour time interval (p >.05), and in both groups the intensity of postoperative pain decreased over time. The number of analgesics taken was significantly higher in the conventional needle irrigation group (p <.05).

**Conclusion:** The use of the apical negative pressure irrigation system, EndoVac, resulted in significantly less postoperative pain and necessity for analgesic medication than a conventional needle irrigation protocol. From the results of this study, it was concluded

Abstract

that it is safe to use a negative apical pressure irrigation protocol for antimicrobial debridement up to the full working length.

#### Abstract 44

##### Lateral canals and its relation to success in endodontics

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Root canal system comprises of diverse anatomical variations like lateral canals, apical delta/ramifications. Literature reports incidence of lateral canals approximately 8.3 to 19%. The lateral canal is usually reported perpendicular anywhere along the length of the main root canal which are not always detectable radiographically. The detection of lateral canal can only be achieved by advanced modalities like CBCT, Fiberoptic Endoscope and Tuned Aperture Computed Tomography (TACT). Hence for successful endodontic therapy, understanding its complexity and treating them aptly is important. Lateral canals open directly into the periodontium which unlocks a pathway to periodontal as well as endodontic infections. One of the common causes for endodontic reinfection are the presence of residual microbes within the root canal. The propagation of microbes and their by-products occurs not only within the main root canal but also in lateral canals, apical delta/ramification. Insufficient sealing of lateral canals can lead to failure of endodontic treatment which may further require a non-surgical or surgical re-treatment. The discernment of lateral canals, its disinfection and sealing of lateral opening exactly like the main apical foramen will add to the success of root canal treatment. The objective of this narrative review is to highlight the importance of lateral canals in terms of diagnosis, treatment and its significance on success of endodontic therapy.

#### Abstract 45

##### Incidence of postoperative pain following partial and full pulpotomy in cariously exposed mature molars with signs of symptomatic irreversible pulpitis

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**Aim:** To evaluate the incidence of post-operative pain following partial and full pulpotomy in cariously exposed mature molars with signs of symptomatic irreversible pulpitis.

**Materials and Methods:** Fifty mature permanent molar teeth with carious exposures showing signs and symptoms of Symptomatic Irreversible Pulpitis were randomly allocated equally into two groups. Partial Pulpotomy and Full Pulpotomy was performed in the first and second group respectively following standardized protocols. Pain was recorded using 10-point Visual Analogue Scale (VAS) preoperatively and postoperatively at 24 hours, 72 hours and on the 7th day. Use of analgesics, if any, to relieve post-operative pain was also recorded. The data was statistically analyzed.

**Results:** There was statistically significant reduction noted in both

the groups for preoperative and post-operative pain scores. On subsequent days, mean pain scores decreased in both groups, with the full pulpotomy group experiencing slightly less pain compared with the partial pulpotomy group on all days. However, the difference in the pain scores reduction between both the groups was not statistically significant at any time intervals ( $p > 0.05$ ). 3 patients (12%) and 2 patients (8%) in the partial and full pulpotomy group respectively gave the history of analgesic intake postoperatively ( $p = 0.6$ ).

**Conclusion:** Pulpotomy is a viable aid for effective pain relief. Significant reduction in post-operative pain is demonstrated by both the Partial and Full Pulpotomy procedures in cases of Symptomatic Irreversible Pulpitis.

#### Abstract 46

##### Comparative evaluation of efficacy in removal of guttapercha cone and sealer with different rotary and hand instruments: An *in vitro* study using cone-beam computed tomography

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**Objective:** Inadequately prepared and obturated root canal systems will conceal remaining necrotic tissues or bacteria that may be responsible for periapical inflammation. The aim of the study was to compare the efficacy of hand system, rotary retreatment system and combination of hand and rotary retreatment in removing gutta-percha and sealer from pulp space.

**Materials and Methods:** 77 single-rooted, non - carious mandibular premolar teeth with similar sizes and mature apices were selected. Pulp space were prepared using Protaper universal system. Canal space was then obturated using the corresponding master cone and AH PLUS root canal sealer. Removal of gutta percha was done using Protaper retreatment universal file in group 1, D RaCe in group 2, TF adaptive in group 3, Protaper retreatment universal file and H-file in group 4, D RaCe and H-file in group 5, TF adaptive and H-file in group 6, H-file in group 7 The roots were then scanned using CBCT. The canals were divided into coronal, middle and the apical third and were evaluated separately. The volume percentage of remaining filling material was calculated.

**Statistical Analysis:** ANOVA and post hoc test.

**Results:** The results were analysed based on the remaining volume of gutta percha. Protaper retreatment system in combination with hand file was found to be most effective in the coronal aspect of the tooth followed by Protaper retreatment system, D-RaCe and hand file combination, D-RaCe, TF adaptive and hand file combination, TF Adaptive and least was found to be with H-file. Statistically significant result was not seen in the middle and apical third.

**Conclusion:** It was found that no system was able to completely eliminate filling material from the root canal system.

- Combination of systems was found to be superior than the individual systems

Abstract

- Statistically significant results were obtained between the 7 groups only in the coronal aspect of the tooth
- Canal cleanliness was showed by middle and apical third but they were statistically insignificant

**Abstract 47**

**Management of grade 3 furcation with root separation and crown placement**

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The aim of dentistry is to conserve the natural dentition. Modern advances in all phases of dentistry have provided the opportunity to maintain a functional dentition for lifetime. The management and long term retention of teeth with furcation invasions possess a challenge in terms of anatomic particularities of each tooth, bone and gingiva. This case report describes the management of grade 3 furcation with root separation followed by crown placement which provides an overview that regardless of the furcation defects, some teeth can be salvaged and used in oral rehabilitation.

**Abstract 48**

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The field of endodontics is constantly evolving to deliver the best possible treatment for the patient. There is a constant look out for new and emerging therapies to make patient's experience and dentist's work as comfortable as possible and Cryotherapy is one such treatment modality. The word "cryo" is derived from the Greek language, which means very cold or ice cold and cryotherapy uses freezing or near freezing temperatures. Historically the use of cold has been practiced for many decades to manage pain and swelling. Cryotherapy slows down neural signals and reduces the release of chemical mediators which are responsible for pain reduction. The application of this property has thus been explored in pain management in endodontics. The common problem faced by patients after root canal procedure is, post-operative pain which ranges from 1.5%-53%. Studies show that constant intracanal delivery of cold solution reduced the external root surface temperature to produce a local anti-inflammatory effect in periradicular tissues, thereby reducing post-operative pain. The initial physiological response of the tissue to cryotherapy is a drop in local temperature that decreases cellular metabolism, so less oxygen is used. Furthermore, vasoconstriction occurs, which reduces blood flow and limits inflammatory damage. Cryotherapy provides a local anaesthetic effect by lowering the conduction speed of pain signals. Intracanal cryotherapy application is currently being suggested as a simple and cost-effective technique for the management of postoperative pain after endodontic therapy. The temperature of the cryotherapeutic agents used varies between 2°C and 5°C. This review paper describes various cryotherapeutic

agents used in root canal therapy and its current standing in clinical practice.

**Abstract 49**

**Effect of novel intracanal medicament on microhardness of root dentine: An *in vitro* study**

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**Aim:** To assess the effect of novel intracanal medicaments on the root dentine microhardness.

**Materials and Methods:** A total of 40 extracted mandibular premolars were standardized and prepared using Protaper Gold rotary files. The premolars were divided into three groups (n 10 each) and one control group (n 10). In three groups, the intracanal medicaments used were combination of calcium hydroxide and silver nanoparticles, combination of graphene oxide and silver nanoparticles, calcium hydroxide respectively and a control group(n=10). After 7 days medicaments were removed using Endo activator. Mean Vickers hardness numbers were calculated after removal of intracanal medicament.

**Results:** All the group except graphene oxide and silver nano particles showed reduction in mean microhardness and was statistically significant ( $p < 0.05$ ). Data were analysed using SPSS software version 21. ANOVA test and Post Hoc tukey was used to compare between the groups. p value of less than .05 was considered significant. There was a significant differences among the groups at coronal third, middle third and apical third. ( $P < 0.05$ ). In between groups the coronal third and middle third region graphene oxide and silver nano particles showed the highest mean microhardness values, In the apical third region control group showed the highest mean microhardness values.

**Conclusion:** Graphene oxide and silver nano particles shows least effects on microhardness of the root dentin compared to calcium hydroxide and calcium hydroxide with silver nanoparticle based intracanal medicaments.

**Clinical Significance:** Elimination of most of the bacterial infection from the root canal and very minimum to no effect on the microhardness of the dentin in the root part are the basics of success in any endodontic treatment.

**Abstract 50**

**Comparative evaluation of marginal adaptability of custom cast post using different pattern material: An *in vitro* study**

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**Introduction:** Marginal adaptability is of key concern while determining the longevity of a post and core in endodontically treated teeth. The present study compares the two commonly used materials used for fabrication of patterns for custom cast post  
**Aim:** To evaluate the marginal adaptability of custom cast post using inlay wax pattern and resin pattern.

**Materials and Methods:** 10 single rooted teeth were selected for each group for the study. Teeth were decoronated. The teeth were

Abstract

mounted on wax occlusal rim and were scanned with CBCT in all the planes. Root Canal treatment was done and the canal were prepared for post space. 10 Patterns were fabricated with inlay wax and resin pattern respectively and custom made cast post was done for the study once again CBCT was taken to find out the marginal adaptability of cast post to the tooth surface.

**Conclusion:** The marginal adaptation was analysed in the coronal, middle and the apical third of the prepared post space of teeth. It was found that the marginal adaptation of cast post was more in the coronal and middle third of post space with cast post made by resin pattern compared to the one made with inlay wax pattern.

### Abstract 51

#### Endocrown: An evidence based update!

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Post-endodontic coronal restoration has been reported to reduce microleakage and subsequently decrease the risk of endodontic treatment failure, while cuspal coverage and preservation of the remaining coronal tooth structure have been reported to improve fracture resistance and the outcome of the endodontically treated tooth. Endo-crowns are a mono-block type of restoration that use the pulp chamber and remaining coronal tooth structure as a means of retention. Endo-crown appears to be promising conservative restorative option for endodontically treated posterior teeth. However, data on their long-term survival and success rates as compared with conventional crowns are lacking. The purpose of this review is to determine whether endo-crowns are a reliable alternative to full crowns for endodontically treated teeth based on various criteria, such as resistance, clinical longevity, coronal leakage etc.

### Abstract 52

#### Comparative evaluation of efficacy of herbal irrigants in eliminating enterococcus faecalis colonies from pulp space as against sodium hypochlorite: A fluorescence confocal laser scanning microscope study

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**Aim:** To compare & evaluate antimicrobial efficacy of herbal extracts of Moringa oleifera, a cocktail mix of *Ossimum sanctum*, *Curcuma longa*, *Allium sativum* and *Piper nigrum*, apple cider vinegar in eliminating *E. faecalis* as against sodium hypochlorite using confocal laser scanning microscope.

**Methodology:** Sixty extracted single rooted mandibular premolars were collected and disinfected. Samples were sectioned at the level of CEJ using a sectioning disk. Vertical grooves placed on either side of the tooth samples and sections were made using chisel. Further divided into 5 groups and each group received 12 samples. All the samples were sterilized using autoclave at 120°C for 20 mins. One

colony of *E. faecalis* American Type Culture Collection (ATCC 29212) was raised in Tryptone Bile X-Glucuronide Agar and transferred to 50 ml of all culture media. The culture was allowed to grow overnight under stationary aerobic conditions at 37°C. All the tooth samples were inoculated with the *E. faecalis* broth using micropipette. Moringa oleifera leaves were collected and ground in a blender, the extract was collected in a ratio of 1:1. Similarly, *Ossimum sanctum*, *Curcuma longa*, *Allium sativum*, *Piper nigrum* were collected and ground to a paste, extract was collected in the ratio of 1:1. Apple cider vinegar was store brought.

Group 1 - Moringa oleifera,

Group 2 - Cocktail mix

Group 3 - Apple cider vinegar,

Group 4 - 3% NaOCl

Group 5 - Saline.

following irrigation samples were subjected to staining using fluorescent dyes Propidium iodide and Acridine orange and scanned using CLSM. A qualitative assessment was done depending on remaining biofilm. The results were analyzed using One-way Anova and Tukey Post hoc test.

**Results:** The CLSM finding reveal that cocktail mix has a comparable result to that of 3 % NaOCl with highest antimicrobial efficacy compared to others. Amongst herbal irrigants, cocktail mix showed highest antimicrobial efficacy followed by moringa oleifera.

**Conclusion:** NaOCl ≥ cocktail mix > moringa oleifera > apple cider vinegar > saline.

### Abstract 53

#### Vital pulp therapy using bioactive scaffolds: A case series

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The maintenance of pulp vitality is paramount to the tooth's long term survival. Vital pulp therapy is a treatment intended to preserve, protect and sustain a healthy pulp that has been compromised by caries, trauma or restorative procedures. It includes direct or indirect pulp capping and pulpotomy. These therapies prevent further pulpal injury from detrimental stimulus. Direct pulp capping is the procedure in which exposed vital pulp is covered with a protective material that is placed directly over the site of pulpal exposure in an attempt to preserve the pulp vitality. A wide range of materials are suggested as pulp capping agents from traditional calcium hydroxide to current biomaterials. The most visible and successful reparative response to pulp exposure is the deposition of reparative dentin induced by the pulp capping material. Recently, a shift towards biomaterial based scaffolds for dental pulp- dentin complex regeneration are been tried due to their biocompatible nature, healing capacity and excellent regenerative potential. These have showed a positive response as the growth factors present in these scaffolds can stimulate dental pulp cells leading to cell growth, differentiation and stimulating odontoblast differentiation, leading to reparative dentin formation. This is a presentation of three cases of direct pulp capping which was carried out in molars, with radiographic evidence of deep caries approximating the pulp

Abstract

chamber and absence periapical pathology. Caries was excavated and the pulp exposure of about 0.5 to 1 mm was capped with either chorion membrane or placental extract gel or mineral trioxide aggregate, over which a glass ionomer cement liner was placed and the final restoration was done with light cured composite. Patients were periodically followed over 3, 6 and 12 months for evaluation and assessment of clinical and radiographic parameters. Cone-beam computed tomography was taken after three months, to assess dentin bridge formation. Thus these bioactive scaffolds showed promising results as direct pulp-capping agents with favorable outcomes and opened a new avenue in vital pulp therapy procedures.

#### Abstract 54

**Comparative evaluation of the effect of bleaching on enamel with H2O2, aqueous pineapple extract and lemon extract using spectrophotometer: An *in vitro* study**

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The aim of manufacturers is to produce a bleaching agent which has minimum side effects on tooth but can produce exemplary results. The aim of the present study was to compare the efficacy of bleaching using 30% Hydrogen peroxide, Pineapple extract, Lemon extract and their combinations as an additive or independently on enamel using spectrophotometer.

**Methodology:** A total of 54 Maxillary Premolars were collected. They were stained using tea solution for 24 hours and the samples were randomly divided into 6 groups with 9 samples in each group.

GROUP 1- HYDROGEN PEROXIDE

GROUP 2- PINEAPPLE EXTRACT

GROUP 3- LEMON EXTRACT

GROUP 4- HYDROGEN PEROXIDE + PINEAPPLE EXTRACT

GROUP 5- HYDROGEN PEROXIDE + LEMON EXTRACT

GROUP 6 – DISTILLED WATER

The samples in each group were treated with respective bleaching solutions for 30 minutes. The shade of the samples were assessed after staining and after bleaching using vita easy shade spectrophotometer.

The testing will be done with spectrophotometer over a white background, which recorded color variables L\*,a\*,b\*in accordance to CIE L\*a\*b color system using formula

$$\Delta E = ([\Delta L^*]^2 + [\Delta a^*]^2 + [\Delta b^*]^2)^{1/2}$$

**Results and Statistical Analysis:** It was found that hydrogen peroxide followed by combination of pineapple and lemon extract and pineapple extract independently showed significant results. The data were analyzed based on independent sample t test.

**Interpretation and Conclusion:** Hydrogen peroxide, (positive control) in this *in vitro* study showed excellent bleaching.

- Vegetative enzymes like bromelain in pineapple is responsible for the remarkable bleaching in samples treated with pineapple extract
- Citric acid is present in higher concentration in lemon

extract and this group did not produce any significant results after bleaching and the samples showed decalcification and pitting which may be attributed to higher concentration of citric acid

- Combination of Pineapple extract & Lemon extract with Hydrogen peroxide produced exemplary results after bleaching and thus adverse effects due to hydrogen peroxide can be lessened
- Statistically significant results were obtained in Group 1, 4, 5 & 2

#### Abstract 55

**Flow cytometric analysis on the bactericidal effect of diode lasers of varying wave lengths, octenidine hydrochloride and traditional techniques**

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**Aim:** To evaluate whether the 'photothermal efficacy of Diode lasers' is superior to Sodium hypochlorite and the emerging antimicrobial Octenidine hydrochloride on Enterococcus faecalis eradication.

**Materials and Methods:** 70 extracted single rooted mandibular premolars were decoronated and standardized to 15mm. The root canals were enlarged up to K-file size 50 and irrigated with 2ml of 2.5% NaOCl followed by 17% EDTA solution and final rinse with normal saline.

Preparation of Inoculation and Contamination of Specimens:

Roots and apical foramina were sealed and all the specimens were placed into Eppendorf tubes and autoclaved. Enterococcus faecalis (ATCC 29212) inoculum was grown in the BHI medium and sterilized tooth samples were placed in the medium and the culture was incubated at 37° Celsius for 21 days.

Group Preparations: 5 groups with 14 specimens.

GROUP-I 810nm Diode Laser

GROUP-II 980nm Diode Laser

GROUP-III 5.25% NaOCl

GROUP-IV 0.1% Octenidine hydrochloride

GROUP-V 0.9% Normal Saline

The apical thirds of the treated roots(5 mm) were obtained and dentin shavings collected were immersed in BHI broth in Eppendorf tubes and vortexed for 2minutes. 10-fold dilutions were prepared and 1ml aliquots were seeded in BHI agar plates for 48hours. Seven samples from each group were subjected to bacterial culture for evaluating the CFU.

For Flowcytometry, seven suspensions from each group were immersed in BHI broth and incubated for 48hours. 1ml samples of bacterial cultures were micro-centrifuged and treated with SYTO 9 nucleic acid stain and Propidium Iodide. 10µL of the microsphere suspension was added to the stained cell samples, mixed well and subjected to Flow Cytometry using 488nm Argon Laser.

**Results and Statistical Analysis:** The results were expressed as the number of CFU and viability percentage of Enterococcus faecalis bacteria in the apical third of root canal. One-way ANOVA analysis

Abstract

and Tukey post hoc tests were used for intergroup comparison.

**Conclusion:** Among the various disinfection regimens used in the present study, 810nm Diode Laser exhibited the most efficient bactericidal effect on *E.faecalis* biofilm, with the lowest viability of 19% followed by 980nm Diode laser, 5.25% NaOCl and 0.1% Octenidine hydrochloride being the least.

### Abstract 56

#### Effectiveness of various agents on rapid chemical disinfection of gutta-percha cones: An *in vitro* study

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**Aim:** The aim of this study was to evaluate and compare the efficacy of Sodium hypochlorite, Chlorhexidine, Grape seed extract, Aloe vera juice and Saline to disinfect gutta-percha cones.

**Materials and Methods:** The gutta percha ( GP) cones used in this study were initially contaminated by immersion in a culture of *E. faecalis* (ATCC 29212). All samples were incubated at 37°C for 72 h. After the incubation period, the cones were dried using sterile gauze and divided into five groups of 10 samples each. In each group, 5 GP cones were immersed for a period of 1 min, which the other 5 were immersed for 10 min. The cones were then dried and inserted individually into test tubes containing sterile BHI broth and incubated at 37°C for 72 h. Bacterial growth was evaluated by the presence of turbidity in the BHI broth and the growth in chocolate agar media. Pearson Chi-Square test was used to assess the effectiveness of the irrigants to decontaminate the GP.

**Results:** After immersion for 1 min and 10 min, the growth of *E.faecalis* on the GP cones were significantly reduced in the Sodium hypochlorite group ( $p < 0.05$ ). The Aloe vera group did not showed any significant effect against *E.faecalis*, whereas the Grape seed extract showed a moderate ability to reduce the growth, but both were not able to show complete disinfection.

**Conclusion:** In the present study, Sodium hypochlorite was clearly the most effective of the options for rapid disinfection of gutta percha cones.

### Abstract 57

#### Antibacterial efficacy of calcium hydroxide combined with lansoprazole and hydroxyapatite nanoparticles against enterococcus faecalis in human root dentin

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**Aim:** To compare the antibacterial efficacy of Calcium hydroxide with nanohydroxyapatite against *E.faecalis* in root canal by assessing the Microbial colony count and Zone of Inhibition and assessment of medicament penetration depth via SEM analysis.

**Materials and Methods:** Forty extracted single rooted maxillary central incisors were decoronated to length of 15mm and

biomechanically prepared upto F3 Protaper gold. The root canals were inoculated with *E.faecalis* to form a 3 weeks biofilm. Based on the medicament placed, the specimens were randomly divided into 3 groups (n= 10): Group I-Calcium hydroxide [ $Ca(OH)_2$ ], Group II-  $Ca(OH)_2$  with Lansoprazole, Group III-  $Ca(OH)_2$  & Lansoprazole with hydroxyapatite nanoparticles. *E.faecalis* Colony forming units (CFUs) were assessed after 24 hours and 3 days and Percentage reduction of microorganisms was calculated for all the groups. SEM analysis was used to assess the penetration of medicaments into the dentinal tubules. Each medicament was placed into five wells, in a total of six *E.faecalis* inoculated agar plates and incubated at 37°C. Zone of inhibition was measured after 24, 48 and 72 hours by Agar well diffusion test. The data were analysed using Kruskal Wallis and One way ANOVA test.

**Results:** At 24 hours Group III showed least number of CFUs followed by Group II and Group I with significant difference seen between Group I and III only whereas there was significant difference seen in all the three groups with Group III showing the highest percentage of reduction of microorganisms of 99.7% at 72 hours ( $p < 0.05$ ). At 24, 48 and 72 hours there was statistically significant growth inhibition in Group III followed by Group II and then Group I ( $p < 0.05$ ). Based on SEM analysis, Group III was more efficient than Group I and Group II in the elimination of *E.faecalis* in the dentinal tubules.

**Conclusion:** Placement of medicament in the root canals for 72 hours showed significant increase in the antibacterial activity of all the 3 groups. The Calcium hydroxide & Lansoprazole with hydroxyapatite nanoparticles showed the highest antibacterial efficacy against *E.faecalis* at both 24 and 72 hours, thus making it as an effective intracanal medicament for dentinal tubule disinfection eliciting a new paradigm shift to nano endodontics.

### Abstract 58

#### Phytochemical analysis and antioxidant activity of vanilla planifolia leaf extract

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**Aim:** To explore the prospective applications of vanilla planifolia leaf extract as an active ingredient for root canal disinfection.

**Materials and Methods:** Vanilla planifolia leaves were collected, shade dried and powdered. The powdered leaves (100gm) were then extracted three times by cold percolation method with 300ml Ethanol at room temperature for 72hrs. The filtrates were concentrated under reduced pressure at 40°C and stored in refrigerator at 2-8°C for use in subsequent experiments. The ethanolic extract was tested for various phytochemical agents by reagent method in test tubes. The extract was also tested for antioxidant properties by DPPH radical scavenging activity test and nitric oxide radical scavenging activity. The activity was measured at 550nm and results expressed in percentages.

**Results:** The ethanolic extracts tested positive for tannins, saponins, flavonoids, alkaloids, Cardiac glycosides, terpenoids and phenols. Quercetin equivalence of given Ethanol extract was 7.08%. Gallic acid

Abstract

equivalence in ethanol was 17.6% and tannic acid equivalence was 3.14%. The extract also showed considerable antioxidant properties. In the nitric oxide scavenging activity test a dose dependent increase in the antioxidant capacity was seen. It was the highest ie.70 % at 0.5mg/ml. In the DPPH scavenging activity test a concentration of 0.3mg/ml showed optimal antioxidant activity. At 0.4 and 0.5mg/ml the antioxidant property remained unchanged.

**Conclusion:** The extract of vanilla planifolia has a good composition of essential phytocompounds such as Gallic acids. These compounds are known to have a positive and benefitting effect on the oral microenvironment. Additionally, the extract has considerable antioxidant properties that can be beneficial to be used as a root canal disinfecting agent.

#### Abstract 59

##### Current and emerging trends in root canal disinfection

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A paradigm shift that reinforces biology in various aspects of endodontics has become the tenet of evolving technology. This evolution happened with the goal of dentin conservation to improve the structural integrity of endodontically treated teeth. The main challenge on the face of these minimally invasive instrumentation systems is in achieving optimum canal disinfection. Mechanical instrumentation can be minimised if an antimicrobial and proteolytic irrigant solution like sodium hypochlorite, can be delivered and evacuated in an effective way throughout the root canal space. The movement and subsequent cleaning of the root canal system produced by the irrigant fluid has found to be more efficient with the use of sonic, ultrasonic, or laser-activated irrigation. The advancements in disinfection of the root canal system to eliminate biofilm present deep within the microtubules, would revolutionize the future era of endodontic practice. The future trend would be to efficiently disinfect the root canal space with minimal intervention that would significantly enhance the clinical outcome of non-surgical endodontic therapy. This review presents an overview of currently available technologies of root canal disinfection that support minimal intervention approach and the potential future directions.

#### Abstract 60

##### Chemokine RANTES as an unknown link between wound healing in the jawbone and systemic disease and prognostic indicator for endodontic therapy

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Dental procedures like Root filling and Tooth removal leads to chronic inflammation in jaw bone. Dental clinicians while carrying out these procedures ignore there connection with inflammatory mediators and become a hidden cause of chronic systemic disease. Incomplete wound healing in the jaw bone might act as a hyperactivated signalling pathway leading to "silent inflammation". Silent inflammation during

root canal therapy, implant procedure etc leads to activation of immune system. The intraoral interferences created by the root canal bacteria, metals produce highly toxic hydrogen sulfide and consist of increased inflammatory mediators like RANTES, FGF-2, IL-1ra. So, assessment of RANTES can be a useful indicator for the identification of patients with poor prognosis. Once a chronic disease has been established because of silent inflammation, it creates a set of pathological condition that worsens the overall condition. Thus, endodontist can help by not only subsiding the symptoms of acute inflammation but can also avoid the devastating effects of chronic inflammation which occur below the threshold of perceived pain and progress silently for years.

#### Abstract 61

##### Evaluating the performance of nickel titanium endodontic post with the conventional stainless steel post: A finite element analysis

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**Introduction:** Prefabricated metal and fiber posts are commonly being used in clinical practice. Prefabricated metal posts are widely used in posterior teeth and the most common mode of failure of these posts is by the fracture of the root. The reason for this is the mismatch in the modulus of elasticity of both the root dentin and the post. To overcome this failure, a post with modulus of elasticity similar to that of dentin has to be studied and hence this study.

**Methods:** 4 FEA models were constructed (maxillary and mandibular molars with nickel titanium and stainless steel posts). The material properties were assigned and occlusal load was applied along the long axis of the teeth. Analysis was run and stress distribution patterns were studied on the post, on the tooth-post assembly and at the post-dentin interface.

**Results:** Stresses exerted on the nickel titanium post, on the tooth-post assembly and at the post-dentin interface were markedly less when compared to its stainless steel counter parts.

**Conclusion:** Nickel titanium post can be used as an alternative to stainless steel post in endodontically treated teeth in order to minimize failures.

#### Abstract 62

##### Comparative evaluation of calcium ion quantification from radicular dentine with various root canal irrigants using inductively coupled plasma atomic emission spectroscopy: An *in vitro* study

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**Introduction:** Shaping and cleaning is one of the most important step in endodontic therapy. During this process an amorphous smear layer is produced in root canal. Different root canal irrigants are used to remove organic and inorganic portions of smear layer. Aim of this study is to compare the calcium ion quantifying ability of Sodium hypochlorite, 17% EDTA, 0.2% Chitosan, MTAD and QMix using Inductively Coupled Plasma Atomic Emission Spectroscopy.

**Methodology:** Sixty extracted mandibular premolar teeth

## Abstract

were selected for the study. Teeth were decoronated at the cemento-enamel junction. Size 10 K file was used to maintain the apical patency and to determine working length. The canal was prepared with rotary instruments using crown down technique and irrigated using NaOCl between each instrument change. The prepared teeth were randomly divided into five groups and irrigated in such a way that the irrigant flows through entire length of canal and exits through patent apical foramen into the collection tube below. The collected solutions were forwarded for the ICP-AES system to analyze the calcium ions present in each solution.

**Results:** The mean values of Group 1 (17% EDTA), Group 2 (0.2% Chitosan), Group 3 (MTAD), Group 4 (QMIX), Group 5 (NaOCl) are 35.38, 14.74, 33.8, 22.76, 0.03 respectively. Intergroup comparison shows that the difference in calcium ion quantification values between all groups are statistically significant ( $p < 0.01$ ) except between Group 1 (17% EDTA) and Group 3 (MTAD).

**Conclusion:** 17% EDTA has the maximum calcium ion quantifying ability among the used irrigants. Calcium ion quantifying ability of MTAD was slightly less than that of 17% EDTA but there was no significant statistical difference between EDTA and MTAD groups. Chitosan also showed significant calcium ion quantifying ability, it was lesser than that of QMix group but it was significantly higher than that of sodium hypochlorite. Sodium hypochlorite showed the least amount of calcium ion quantification values implying that it has minimal action on the inorganic portion of the smear layer.

### Abstract 63

**Evaluation of root re-inforcement by different cervical restorations for the management of external cervical resorption: An *in-vitro* study**

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**Aim:** To compare and evaluate the fracture resistance of teeth restored with different cervical restorations for the management of external cervical resorption.

**Materials and Methods:** Forty eight freshly extracted human permanent maxillary central incisors were selected and endodontically treated. Artificial cavities (4mm diameter X 2mm depth) were prepared on the labial root surface near the CEJ according to Patel's Classification (Class 1Bd or 2Bd) and restored with different materials. Teeth were randomly allocated into 3 groups with two subgroups each: Group 1A (Reverse Sandwich Restoration without Thermocycling), Group 1B (Reverse Sandwich Restoration with Thermocycling), Group 2A (Composite Restoration without Thermocycling), Group 2B (Composite Restoration with Thermocycling), Group 3A (Control- No restoration without Thermocycling) and Group 3B (Control- No restoration with Thermocycling). Reverse Sandwich Restoration comprised of 1.5mm composite layer followed by a 0.5mm superficial RMGIC layer. 24 samples from 3 subgroups of 8 samples each were subjected to thermomechanical ageing 2,50,000 cycles of 5kg

force and 500 thermal cycles (1 year period). Finally, the fracture resistance to oblique loading at 45° was tested on a Universal Testing Machine. Failure was defined as a first sharp 25% drop in the applied load. The load at failure was measured in Newton. One way ANOVA and Posthoc Tukey test was done for inter-group comparison. Paired t-test was done for comparison within each group. A p value  $< 0.05$  was considered statistically significant.

**Results:** There was a significant difference in the fracture resistance between all the 3 groups. Among the non-thermocycled groups, Group 1A and 2A showed a significantly better resistance to fracture than the control. Group 1A showed significantly better fracture resistance than Group 2A. Thermocycled groups portrayed similar results. The thermocycled groups resulted in a significantly lower resistance to fracture than the non-thermocycled groups.

**Conclusion:** Reverse sandwich restorations are more fracture resistant even after thermocycling and hence may be considered as a better alternative for management of external cervical resorption defects as compared to composite restorations.

### Abstract 64

**Ozone: A revolutionary treatment in conservative dentistry and endodontics**

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In today's world dentistry is quite dynamic as new materials and protocols are developing at a rapid pace. Ozone (molecular weight of 47.98 g/mol) is a triatomic, endothermic and thermodynamically highly instable oxygen compound. Ozone therapy is based on the assumption that ozone (O<sub>3</sub>) rapidly dissociates into water and releases a reactive form of oxygen that may oxidize cells, thus having antimicrobial efficacy without inducing drug resistance. As ozone is a strong oxidant, it can remove proteins from the carious lesion. A minimal amount of carious tissue needs to be removed before the restoration, unlike conventional drill and fill technique. Furthermore, ozone facilitates calcium and phosphate ions to penetrate the lesion and enables the remineralization potential of the carious lesion. Ozone has a broad spectrum antimicrobial activity in water and is biocompatible with human oral epithelial cells and fibroblast cells of gingiva because of this property it can be used to decontaminate the avulsed tooth. Ozone is produced naturally by the following natural methods: - From electrical discharges following thunderstorms. - From ultraviolet rays emitted from the sun. Ozone has a high oxidation potential and is effective against bacteria, viruses, fungi, and protozoa. It also has the capacity to stimulate blood circulation, platelets, and immune response. Ozone has limitation as it is irritating to the respiratory system, cause headache, and irritation or dryness of the nose, throat and eyes, lung congestions, oedema, haemorrhage, changes to the blood and loss of vital lung capacity. Contraindications of Ozone include Pregnancy, Glucose 6 phosphate dehydrogenase deficiency (favism), Hyperthyroidism, Severe anemia, Severe myasthenia. In spite of this, Ozone is used in dentistry in gaseous, ozonated water and as ozonated oils. Ozone was shown to be biocompatible and is used in all aspects of Conservative dentistry and Endodontics. Application of ozone include remineralization

Abstract

of recent caries-affected teeth and is used as a preventive therapy in caries, root caries, and intracanal irrigants in endodontic treatment, Teeth whitening, Periodontitis Peri-implantitis, ANUG, Herpes Labialis, Aphthous Ulcer, Dental Stomatitis, Osteomyelitis, Cyst, Dry Socket.

**Abstract 65**

**Evaluation of cyclic fatigue resistance of several endodontic file systems used in continuous and reciprocating motions: An *in vitro* study**

**ANSHU GUPTA**

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**Aim:** To compare and evaluate the cyclic fatigue resistance of different continuous motion and reciprocating motion of endodontic file systems.

**Materials and Methodology:** 60 new rotary Nickel Titanium instruments 25mm in length were selected and were divided into 4 groups (n=15); Group 1: Neolix, Group 2: Hyflex EDM, Group 3: WaveOne and Group 4: WaveOne Gold. Each group was used according to manufacturer's recommendation of specific torque and speed and were then subjected to static loading and tested for instrument fracture using a cyclic fatigue testing device and 16:1 reduction hand-piece powered by a torque-controlled motor. The time and number of cycles to fracture was calculated and analyzed statistically.

**Results:** Values of mean cyclic fatigue testing showed that the difference between the various study groups was statistically significant ( $P < 0.01$ ).

**Conclusion:** Hyflex EDM exhibited significantly high cyclic fatigue resistance and WaveOne exhibited least resistance to cyclic fatigue among all the tested groups.

**Abstract 66**

**Three-dimensional printing in endodontics**

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CAD and CAM applications came to the fore in the 1960s and 1970s. CAD and CAM technologies can hold CBCT data for construction of images used in surgical and nonsurgical endodontics. The aim of this article was to review all contemporary applications of 3D printing in endodontics and to think upon future directions for research and clinical use. Current applications of 3D printing in endodontics include guided endodontic access with pulp canal obliteration, surgical guide (stent-guided Endodontic microsurgery), rapid prototyping of anomalous teeth, autotransplantation, educational models and clinical simulation, regenerative endodontics, accurate location of osteotomy perforation sites etc. Attainment of technical expertise within endodontic practices is intimidating hindrance to widespread deployment. As knowledge advances, endodontic postgraduate programmes should think about implementing 3D printing as part of their curriculum. Increased expertise within the

specialty will pave the way for a more strong evidence allowing endodontists to make informed decisions regarding implementation in clinical practice. Future research directions should include clinical outcomes evaluation of treatments using 3D printed objects.

**Abstract 67**

**Guided endodontics as an useful tool for mapping access to success: A case series**

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Pulp canal calcification is one of the factors that makes endodontic treatment challenging by compromising the sound tooth structure during conventional orthograde root canal access along with the impossibility to disinfect the root canal effectively. Another risk in such cases is a high chance of gouging and root perforations during the search for the root canal in a blinded scenario. Considering these drawbacks, formulating 3D guides by overlaying a Cone Beam Computed Tomography (CBCT) scan and patient's 3D model obtained with a bench scanner seems to be a promising technique. Further, by superimposition of CBCT based on radiographically visible structures, the virtual implant surgery software (DDS Pro in our case) can be programmed to project a physical bur used for access virtually superimposed on PCC. Based on these data, customized 3D guides were prepared enabling us to achieve straight line access to partially/completely obliterated canal. The present case series represents 4 cases of PCC, 2 of them in maxillary lateral incisors, 1 being a Maxillary central incisor and the last one in a maxillary canine using a guided endodontic technique. All cases were treated with different burs and the pros and cons of each of burs actually experienced during performing the cases will be discussed.

**Abstract 68**

**Synergistic combinations and developments in calcium hydroxide as an intracanal medicament: A narrative review**

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The essential towards the success of a nonsurgical root canal treatment depends on the interplay between a good chemico-mechanical preparation and prevention of reinfection between appointments. The role of an intracanal medicament is to achieve this feat besides attaining rapid pain relief post-treatment. Calcium hydroxide (CH) is one of the most favored intracanal medicaments owing to its bactericidal property, stability, and capacity to stop inflammatory exudates compared to other medicaments, especially in multiple-visit endodontics. Its favorable actions are attributed to its alkaline pH (12.5–12.8) and the presence of calcium and hydroxyl ions. However, its difficulty in handling, removal, reported inactivity due to E. faecalis and dentin, and inability to sustain in long-standing cases due to the rapid liberation of ions promoted by the aqueous vehicle in routinely available CH pastes, are concerning and

Abstract

pose a challenge to the clinician. Recently, various combinations of CH have been studied, that enhance its efficacy. However, there is limited literature assessing these combinations together. Hence, there lies a need to evaluate the recent combinations with CH which have a synergistic effect, with levels of evidence. Thus, this review paper describes the three most acceptable combinations with CH and one newer potent addition to CH, namely iodoform, ciprofloxacin, lidocaine hydrochloride and, ozonated olive oil respectively, which have a prospective to be a great addition to the list of medicaments already present.

**Abstract 69**

**An *in-vitro* study on biocompatibility of a biomimetic material (pulpotec cement) with immune cells**

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**Aim:** To assess the *in-vitro* cytotoxicity and biocompatibility of pulpotec cement at cellular levels using immune cells (macrophages).

**Materials and Methods:** Sample preparation of pulpotec cement was done by mixing, 500 ug of powder with 1000 ul of liquid then dispersing with 9000 ul of distilled water. This solution was then allowed to settle down for 24 hours. Followed by incubation and treating the prepared samples with various antibiotics like penicillin and streptomycin. There after, the supernatant was collected and divided into two groups:

Group I: Control group - untreated RAW 264.7 cells.

Group II: Test group - RAW 264.7 cells treated with pulpotec cement. Group II was further sub-divided into seven sub-groups: X (Original concentration), X/2 (diluted twice), X/4(diluted four times), X/6(diluted six times), X/8(diluted eight times), X/10(diluted ten times), X/20 (diluted 20 times with distilled water).

After cell culture, to assess the morphological changes of RAW 264.7 cells, Vibrant MTT cell proliferation assay kit and bright field microscopy was used. The samples were statistically analysed using Graph Pad Prism v6.1.

To assess the toxicity of the test material, ROS analysis was carried out using DHE stain and flow cytometry and the data was analysed using Facsxpress (Denovo, CA).

Further, apoptosis of the cells were analysed using Acridine orange stain and fluorescent microscope. To evaluate significance of difference two way ANOVA was used.

**Results:** The survivability of cells found to decrease with increasing concentration. Increase in induction of ROS and increased level of apoptosis in RAW 264.7 cells observed with increasing concentration i.e as we progress from X/20 to bulk concentration X leading to highest permeability of RAW 264.7 cells at X(original concentration).

**Conclusion:** Within the limitations of this study the following conclusion was drawn, pulpotec cement can be applicable in dentistry majorly for procedures falling under the paradigm of vital pulp therapy in a dose dependent manner.

**Abstract 70**

**Multifarious bone cement and its applications in endodontics: A review**

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Polymethyl methacrylate (PMMA), commonly known as bone cement, is widely used in orthopedic surgery mainly for prosthesis fixation, stabilizing compressive vertebral fractures or filling bone defects. Bone cement is a potentially new repair material that has been investigated recently in dentistry because of its properties like low cytotoxicity, excellent biocompatibility and resistance to moist environment. In Endodontics, bone cement can be used as a furcation repair material, retrograde filling material and apexification. Modified bone cements are introduced by adding fillers, adhesives, antibiotics or nanoparticles that make it well suited as an endodontic repair material. Bone cement lacks the ability to directly bond with tooth structure and hence needs to be modified by the addition of bioactive filler particles like hydroxyapatite, MTA to incorporate bioactivity in the cement. These bioactive bone cements are osteoinductive and act as a medium for apatite crystal growth and nucleation. They can be effectively used in apical re-surgery cases and furcation perforation repair. Kryptonite is a castor oil-derived polymer adhesive, biocompatible and was developed as radiopaque bone adhesive cement. It provides an optimal seal in 24 hours when used as a retrograde filling material. Kryptonite also possesses osteoconductive properties and does not interfere with normal healing. PMMA bone cements are functionalized with mesoporous silica nanoparticles (MSN) to enable a highly efficient and sustained release of antibiotics upto 80 days. This antibiotic-loaded bone cement with gentamycin can be used in apical re-surgery cases after failed apical surgery as a bone void filler. It provides adequate protection against bacterial infection in all those challenging, at-risk patients supporting the bone healing process. 6-8 gm of gentamycin, cefuroxime or vancomycin can be incorporated into 40 gm of bone cement considering the effectiveness and local concentration of the drug. Bone cement with nanoparticles of magnesium oxide and barium sulphate reduced harmful exothermic reactions of PMMA during solidification and increased radiopacity, respectively. Chitosan, gold and silver nanoparticles are added to the bone cement to improve the antimicrobial properties. This review paper highlights the importance of bone cement and its possible applications in the field of Endodontics.

**Abstract 71**

**Injectable platelet rich fibrin: The emerging regenerative trend**

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Periapical lesions develop as a sequelae to pulpal disease. Elimination of the microorganisms in such cases of periapical lesions, has been a challenge for the clinician. Endodontic therapy has been the

## Abstract

conventional treatment option in any situation involving periapical lesion. However there are situations where only root canal therapy does not suffice and disinfect the canal adequately. Such non healing periapical lesions irrespective of mature or immature apices usually have their own challenges. Various methods can be used in the nonsurgical management of periapical lesions like conservative root canal treatment, decompression technique, active nonsurgical decompression technique, method using calcium hydroxide, Lesion Sterilization and Repair Therapy, and the Apexum procedure. Monitoring the healing of periapical lesions is essential through periodic follow-up examinations. Along with this one innovative technique which is drawing attention is the Platelet concentrations therapy. Platelet concentrations have been utilized in dentistry for over three decades as a regenerative tool capable of releasing supraphysiological doses of growth factors responsible for inducing tissue regeneration derived from autologous sources. Various case reports and studies have shown the synergistic effect of PRF and MTA having healing potential in such lesions. MTA seals the apex providing a three dimensional hermetic seal, promotes biologic repair by creating an ideal environment for healing. Injectable Platelet-rich fibrin (i-PRF) developed in France by Choukroun and Dohan represents a new step in the platelet gel therapeutic concept which can be used in mature apices. Dr. Choukroun advocates iPRF as an autologous fibrin containing a large quantity of platelet and leukocyte cytokines, which enhance healing by release of higher levels of growth factors like PDGF-AA, PDGF-AB, EGF, and IGF-1 after 10 days thereby demonstrating its regenerative potential. This paper demonstrates a series of case reports highlighting the nonsurgical management of symptomatic teeth with large periapical radiolucencies using iPRF and MTA as an obturating material to promote periapical healing, with the aim of delivering to clinicians an easy to use platelet concentrate in liquid formulation which forms a therapeutic gel which can be either utilized alone or combined easily with various biomaterials like MTA in healing of periapical lesions.

### Abstract 72

#### Enhancement of interfacial adhesion by surface modifications of fibre post: A review

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Extensive tooth loss after cavity preparation represents a real challenge in the restoration of endodontically treated teeth. In such a specific clinical scenario, the use of intra-canal posts may be indicated to increase the retention of the core and/or of the coronal restoration. Due to the higher rigidity and tendency to cause root fractures on usage of metallic post, recently fiber reinforced composite (FRC) posts have been replaced due to its dentine like elastic modulus and aesthetic properties. Several fibers such as carbon, glass, quartz, E-glass and ultra-high molecular weight polyethylene (UHMWPE) fibers have been used with varying degree of success. One of the most common failures of fiber posts prior to fracture is debonding of the post/core assembly. The available evidence indicates that the coronal region of the root canal, bonded better to the glass fiber post than apical

regions. Among various surface treatment strategies; phosphoric acid, hydrogen peroxide, and silane application enhances the post retentiveness to root dentine.

In light of the current evidence, surface modification strategies increase the bond strength of glass fiber post to root dentine. However, recommendations for standardized testing methodology and reporting of future clinical studies are required to maintain clinically relevant information and to understand the effects of various surface modification of glass fiber post and their bond strength with dentine walls of the root canal.

### Abstract 73

#### Effect of preoperative administration of corticosteroids in post-operative pain reduction in patients with irreversible pulpitis undergoing endodontic treatment: Systematic review and meta-analysis

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**Aim:** To evaluate the efficacy of pre-operative use of single dose corticosteroid in reducing post-operative pain in patients with irreversible pulpitis undergoing root canal treatment compared to other pre-operative medications at different time intervals.

**Methods:** A protocol was prepared and a literature search of studies was conducted using various electronic databases such as PubMed/MEDLINE, Scopus, LILACS, clinicaltrials.gov, CTRI and Cochrane till May 2021. The PICO question for the search strategy was “Does the preoperative use of corticosteroids (I) lead to reduction in post-operative pain (O) in patients with irreversible pulpitis (P) following root canal therapy in comparison to other pre medications (C)? Randomized controlled trials evaluating the efficacy of oral pre medications, whether given alone or in combination, compared with other agents or placebo, in patients before root canal therapy were included. The quality of the studies was assessed using the revised Cochrane risk of bias tool-2 (RoB 2). Meta-analysis of pooled data was conducted for applicable studies and Forest-plot was prepared.

**Results:** 1381 citations and 26 citations were identified through database search and manual search respectively. After removing duplicates and going through abstracts, 28 full-text articles were chosen and 9 articles met the inclusion criteria. Risk of bias analysis revealed 4 studies had some concerns of bias, 1 study had high risk of bias and 4 studies had low risk of bias. Meta-analysis showed that corticosteroids administered preoperatively alleviated postoperative pain at 6, 12, and 24 hour time intervals compared to placebo. None of the patients in the studies reported adverse effects due to the drug administered.

**Conclusion:** Pre-operative corticosteroids were more efficacious than placebo in relieving postoperative endodontic pain in patients with irreversible pulpitis undergoing root canal treatment.

### Abstract 74

#### Removal of calcium hydroxide intracanal medicament from apical third of root by ultrasonically activated irrigation: systematic review and meta analysis of *in vitro* studies

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**Objective:** The aim of this study was to review systematically the effectiveness of ultrasonically activated irrigation and conventional irrigation technique for the removal of calcium hydroxide from the apical third of the root canal system.

**Materials and Methodology:** A protocol was prepared and a literature search of studies was conducted using various electronic databases such as PubMed/MEDLINE, Embase, LILACS, TRIP and Cochrane till May 2021. The PICO question for the search strategy was “Does (I) ultrasonically activated irrigation remove more intracanal Ca (OH)<sub>2</sub> than the (C) conventional technique from the (P) extracted fully formed mature human teeth? “Outcome(O): Ca (OH)<sub>2</sub> removal from the apical third of the root canal, Study design (S): In vitro studies examining the effects of ultrasonically activated irrigation by comparing with conventional technique. The quality of the studies was assessed using the Joanna Briggs Institute Clinical Appraisal Checklist for Experimental Studies. For relevant studies, a meta-analysis of pooled data was performed, and a forest plot was created.

**Results:** 953 citations and 9 citations were identified through database search and manual search respectively. After removing duplicates and going through abstracts, 16 full-text articles were read by two reviewers and 7 articles met the inclusion criteria. The overall risk of bias in the selected studies was moderate. The pooled effect size was 0.04 with 95% confident interval of 0.02-0.10 for the included studies. The I<sup>2</sup>=0%, no heterogeneity was included in the meta-analysis.

**Conclusion:** Within the limitations of this study, it can be concluded that Passive ultrasonic irrigation technique is more effective than the conventional syringe irrigation technique in removal of Calcium hydroxide from the apical third of root canal system.

**Abstract 75**

**Three-dimensional printing: A paradigm shift in endodontic treatment planning**

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India

Stereolithography or 3D printing was invented by Chuck hall in 1983. Today, in 2021, 3D printing is emerging as a technology available at a fraction of the cost without sacrificing of quality, accuracy, or material versatility. Dental 3D printing is an additive process of layering the material in thin horizontal cross-sections, along with a computer program to print solid objects. The objective of this poster is to discuss the various applications of 3D printing in dentistry and explore in brief the role of Stereolithographic 3D printed guides in management of complex endodontic cases such as dens invaginatus, pulp canal obliterations etc. Apart from stereolithography, 3D printing also encompasses technologies such as fused deposition modelling, multi-jet printing, photopolymer jetting, color-jet printing, digital light processing and selective

laser sintering also known as selective laser melting. There are several emerging applications of 3D Printing, specifically in Endodontics such as: to gain guided endodontic access to root canals in complicated cases (Dens invaginatus, pulp canal obliteration, Dens invaginatus), role in regenerative endodontics (3D printing of dentin pulp complex, 3D printed scaffolds), role in surgical endodontics – to determine osteotomy and root resection site, to custom fabricate surgical 3D guides to locate extruded root filling material, separated instrument etc, to fabricate tooth replicas of complex cases for study purpose and as haptic simulators, providing realistic simulation of various surgical and non surgical endodontic procedures. Now, in 2021, we are witness to the rise of material science as a key success driver for the 3D printing in dental industry. Research work is being done in developing biocompatible resins, or plastics that can interact safely with the human body. Focus is on developing Resins that are produced in ISO 13485 certified and FDA-registered facilities and tested for biocompatibility and sterilization compatibility. 3D printing is a boon to dentistry, with yet many more milestones to be conquered in the years to come.

**Abstract 76**

**Nonsurgical root canal treatment of an anterior tooth with necrotic pulp and an open apex using platelet rich fibrin**

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India

A 32-year old female patient has reported to the Department Of Conservative Dentistry and Endodontics, Awadh Dental College and Hospital, Jamshedpur, Jharkhand, India with the chief complaint of having fractured teeth in the upper front tooth region. On examination, the permanent maxillary left central and lateral incisors were found out to be fractured and non-vital. Additionally, the upper left lateral incisor was having an open apex, which was confirmed radiographically. Tenderness on percussion was absent. It was decided to render root canal therapy to both the upper left incisors; placement of Platelet Rich Fibrin (PRF) after complete removal of necrotic pulp from the upper left lateral incisor (regenerative therapy), followed by apexification using Mineral Trioxide Aggregate (MTA). On the first visit, the access cavity was prepared for both the teeth, followed by determination of working length(s) and calcium hydroxide dressings were given and changed after a week. The biomechanical preparations were completed in subsequent visits under local anaesthesia. After three weeks, 12ml blood was drawn intravenously from the patient`s right ante-cubital vein and centrifuged under 3000 rpm for 13 minutes to obtain PRF (jelly-like consistency). Under rubber dam isolation, the PRF was then condensed into the cavity using a hand plugger (Dentsply Maillefer, Switzerland). Apexification of the upper left lateral incisor was done with MTA-Fillapex (Angelus Dental, Brazil) to a thickness of 3mm to create the apical barrier, followed by moist cotton pellet and Cavit placement. After one month, the respective obturations were completed, and the coronal sealing was done for both the upper left incisors using GC Fuji II LC (GC India). After 3 months, the patient

Abstract

was recalled, pain and mobility were assessed to be absent. Crown preparations were made for both the upper left incisors and metal-ceramic crowns were seated on both the upper left incisor teeth using GC Gold Label 1 - glass ionomer (Type-1) cement (GC India).

### Abstract 77

#### Restorative fortification of endodontically treated teeth: A narrative review

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The long-term success of endodontically treated teeth depends upon skilled unification of endodontic and restorative procedures. An adequate post endodontic restoration has a stronger impact upon the prognosis of root canal treatment than the treatment itself. A good coronal restoration prevents the ingress of microorganisms into coronal pulp space, which would lead to re-infection. It also replaces the missing tooth structure and strengthens the remaining, thus restoring the original morphology and function. Endodontically treated teeth exposed to oral conditions without an optimal restoration can result in treatment failure. Loss of tooth structure due to decay, dental procedures and endodontic therapy decreases fracture resistance of the tooth. Poor quality of temporary restoration, delay in permanent restoration and poor marginal integrity of final restoration are some of the causes which can jeopardize the favorable outcomes of an endodontic treatment. Therefore, it is crucial to seal the root canal system during or after treatment. A restorative material which minimized tooth preparation, provided adequate strength to the remaining tooth structure and sealed the cavity from percolation of oral fluids and bacteria was considered ideal. This justified the religious use of resin composites and glass ionomer cements (GIC) for post endodontic restorations. However, blooming advancements in restorative materials provided the clinician with efficient alternatives. Newer formulations with claimed ion release properties have been proposed. These smart materials, apart from catering to the basic needs of a restoration, also have properties that inhibit the growth of *S.mutans* or prevent biofilm formation, thus decreasing the chances of secondary caries. Based on the evidence available, this review aims to compare the potential use of newer materials like Caredyne Restore (GC Corporation, Tokyo, Japan), Activa BioActive Restorative (Pulpdent Corporation, Watertown, MA, USA), Cention N (Ivoclar-Vivadent, AG, Schaan, Liechtenstein), and Surefil One (Dentsply-Sirona, Konstanz, Germany) while highlighting their bulk-fill properties and ion release abilities to precisely describe their characteristics and their eventual bioactivities.

### Abstract 78

#### Intentional reimplantation: A salvaging endeavor

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Intentional replantation (IR) is considered as a treatment alternative that can maintain the ingenuity of a tooth. IR is an age-old concept and is defined by Grossman (1966) as a procedure in which an intentional tooth extraction is performed followed by reinsertion of the extracted tooth. Many authors consider that IR should be reserved as the last resort to save a tooth after other procedures have failed or would likely fail. Although the success rate is not always high, IR may be a treatment alternative that deserves consideration to maintain the natural dentition and avoid extraction of the tooth. Furthermore, this decade has shown a rising interest in IR with the development of various biomaterials which can be used as root-end filling materials, and periodontal regenerators. This paper highlights an original case report along with a two year follow up of an attempted intentional reimplantation of a maxillary central incisor with a fractured buccal cortical plate which was carried out in an innovative approach. This was carried out successfully as an alternative to extraction, in order to salvage the natural tooth. Atraumatic extraction was performed followed by root canal treatment, along with retrograde filling. Biomodification of the root surface was done preceding reimplantation of the tooth in its alveolar socket which was further treated with bone graft and other biomaterials.

### Abstract 79

#### *In silico* analysis: A new age predictor in understanding biocompatibility of a biomimetic material – Pulpotec cement

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**Aim:** To assess the mechanism of toxicity along with biocompatibility of Pulpotec cement using *In silico* analysis.

**Materials and Methods:** Molecular docking studies are used to determine the interaction of the ligand and the protein to know the preferred binding orientations of a ligand that confers a minimum binding energy. The analysis was performed using Autodock 4.2 with pulpotec cement comprising of powder and liquid formulation, wherein the formulation consists of polyoxymethylene, iodoform, dexamethasone acetate, formaldehyde, phenol, guaiacol, and excipient. These constituents are taken as ligand and Sod1, p53 as receptor protein. Sod1 was chosen to understand the influence of Pulpotec on oxidative stress metabolism of cells while P53 was chosen for the effect on Apoptosis.

Chemical structures of ligands and receptor proteins were retrieved from software PubChem and visualized using Chimera and their geometries were optimized using a Gaussian 03 program. The receptor proteins were subjected to energy minimization using the Chimera program. Parameters for the chemical structures were set for Autodock 4.2.

**Results:** A comparative analysis of bond energies of interaction of different components has been presented. The interacting bond energy was higher in case of Sod1 than P53 interpreting the influential role of interaction leading to determining the levels

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biocompatibility of Pulpotec with RAW 264.7 macrophages. Upon internalization, pulpotec cement interacts with Sod1 and other proteins influencing their functionality leading to the imbalanced induction of reactive oxygen species. Along with that, the internalized pulpotec also interact with the apoptotic protein like p53 and influence their activities. The combined effect of ROS and malfunctioned proteins, the cells lead to their fate towards apoptosis at higher rate determining levels of toxicity.

**Conclusion:** The study concluded on the fact that the active mechanism of pulpotec cement is derived from binding of dexamethasone acetate, polyoxymethylene and phenol binding to Sod1 and P53 through Vander wall interaction, and H-bond.

### Abstract 80

#### Elevating margin to protect core collapsing

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India

Root canal treatment is incomplete until the tooth has been restored. Bacteria have shown to be etiology of endodontic failure. Goals in restoring tooth after root canal treatment should be to prevent recontamination of root canal system and eliminating chances of fracture because of reduced tooth structure left. In clinical settings, teeth with greatly lost structure are commonly found affecting atleast one proximal area. Reconstruction of such cavities is a challenge in the endodontic and restorative field and also in periodontal field. Endodontically treated teeth are prone to fracture and this is attributed to loss of tissue. Thus, considering the amount of healthy tooth structure remaining in treatment plan is important and crucial to success. Endodontically treated tooth have least structural weakening that has lost roof of pulp chamber with marginal ridge intact when compared with an intact chamber roof with loss of one or both marginal ridges (as class II cavity). Not only dimensions of cavity or lack of tissues, also depth of aggression that reaches periodontal tissue are important key points in restoration. Subgingival position of margin hinders clinical management, and sealing can be challenged by the complexity of the isolation, sometimes becoming almost unreachable. In these extreme cases we perform a deep margin elevation (DME) or periodontal treatments, such as crown lengthening, in an attempt to return a manageable cavity margin and thus aiding in proper isolation, impression taking, and the adhesive procedure required for ideal post endodontic restoration providing proper marginal seal and resistance to fracture. DME is necessary when the healthy tooth remnant is in the sulcus or at the epithelium level. Replacing class II restorations with their larger size and subgingival margins require restorations with inlay/onlay or crowns. Poor isolation may result in a suboptimal marginal seal, which in turn may lead to secondary decay and damage to periodontal tissues. This review will enlighten the importance of DME in post endodontic restoration helping to deal with marginal seal and fracture of endodontically treated teeth with reduced tooth structure.

### Abstract 81

#### Biomimetic approach: New era in endodontics

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India

Newer scientific technological advancement in dentistry provides an array of projects like cell culturing, tissue grafting, molecular biology and tissue engineering. Conventional root canal treatment, apexification with biomaterials are the procedures of choice to treat a nonvital tooth but they do not give predictable outcomes in pulp tissue regeneration. New technology of minimally invasive biomimetic endodontics, which is photon induced photo acoustic streaming has come into existence these days. The term "bio" means life and "mimetic" means imitate, biomimetics is basically the study of structure formation and function of biologically produced materials and also about the biological mechanisms especially for the purpose of synthesizing similar products by artificial mechanisms which mimic natural ones. Biomimetic materials, with their biocompatible nature and excellent physico-chemical properties are widely used nowadays. They can function as long lasting esthetic and restorative materials, cements, root repair materials, root canal sealers and filling materials, which have the advantages of enhanced biocompatibility, high strength, sealing ability and antibacterial properties. This review paper describes various biomimetic materials including MTA, bioceramic sealers and bioceramic gutta percha and their biological properties in the field of endodontics along with the biomimetic approaches for regeneration as in pulp implantation, root canal revascularization.

### Abstract 82

#### "The tough gets going" clinical case series on management of complicated crown - root fractures

**GIFTLIN DENNY XAVIER, G SAICHARAN**

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Complicated crown-root fracture is an alarming clinical condition which requires immediate damage assessment of the affected tooth. It accounts for about 2-13% of all traumatic dental injuries. The maxillary central incisors are most prone to the traumatic injuries followed by premolars. The treatment planning and long-term prognosis depend on various factors such as fracture line location and extension, biologic width, root development, alveolar bone fracture, soft-tissue injury, occlusion, and esthetics. Preservation of natural dentition should take precedence over artificial means. It is with this motive that a clinician should take tough challenges and get going. In the presentation we will discuss two complicated crown-root fractures involving the maxillary central incisor and premolar.

### Abstract 83

#### Recent rotary file design and its impact on separation: A review

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India

Abstract

Cleaning and shaping of the root canal system is essential for successful endodontic treatment. The fracture of endodontic instruments is a procedural problem creating a major obstacle to normally routine endodontic therapy. However, despite improvements in file design and metal alloy, intracanal file separation is still a problematic incident and can occur without any visible signs or permanent deformation. With emerging technology, we see endodontics being swept away in the latest wave of technization. There is plethora of different systems available with modifications in the design, manufacturing, thermomechanical and surface treatment of alloys and advancements in movement kinetics which have shown to improve the fatigue properties of the alloys, reducing the incidence of separation. This review will give an account on the advances in NiTi endodontic instruments with an emphasis on metallurgy, mechanical properties and design features and will summarize the most recent trends in NiTi technology. Also, it will enlighten various factors which may have an impact on the fatigue properties of rotary NiTi instruments such as manufacturing process, surface treatment, cross-sectional area, tip, pitch, radial land, rake angle, helical angle, movement kinematics, and will also provide an insight into scientific causes of instrument separation, prevention strategies, and clinical recommendations for safer and efficient rotary endodontics.

**Abstract 84**

**The diagnostic dilemma –Vertical root fractures: A review**

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In endodontic therapy, detecting and diagnosing vertical root fracture (VRF) can be challenging, and it's frequently more of a forecast than a diagnostic. Accurate diagnosis regarding the distance and localisation of the separated fragments is required to determine the most appropriate treatment technique. The interpretation of root fracture on radiographs is intricate as two-dimensional intraoral radiography systems fail to provide information regarding teeth and adjacent structures in the third dimension. The inability of conventional imaging techniques to visualise VRFs correctly necessitates the development of alternative imaging systems such as cone beam computed tomography (CBCT) or digital volume tomography. Although CBCT is an innovative and promising technology, a high radiation dose, high cost, and lack of availability might preclude the use of CBCT in some cases. Digital subtraction radiography (DSR) is an imaging technique that determines qualitative changes between 2 radiographs taken at different times. The subtracted image is coloured in neutral Gray and reveals features that differ between the first and the second images. Endodontically treated teeth are at higher risk of experiencing VRFs than vital teeth, most likely because of loss of moisture, excessive root canal instrumentation, excessive pressure during gutta-percha filling, or inappropriate placement of posts. This review paper will brief about the advantages of CBCT and digital subtraction radiography over traditional radiography, particularly in dealing

with VRF in endodontically treated teeth and diagnosing VRF way before it becomes severe by using digital subtraction radiography to find the distance between fractured segments.

**Abstract 85**

**Healing of bony cavities using flavonoids, BMP9, and leptin**

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Failure of root canal treatment of preexisting periapical lesion or the development of a new one is considered as an undesired, unsuccessful outcome that requires nonsurgical endodontic retreatment or surgical approach which is addressed when Non-Surgical Endodontic Retreatment is not possible. Surgical approaches incorporate debridement of apical lesions with reshaping of the surrounding bone, the establishment of a proper seal between root canal system and the periradicular tissues. Unfortunately, following endodontic surgery, periapical bone healing can be directed toward repair or regeneration, depending on various issues, such as the size of the lesion, the availability of cells from the host and biological factors possibly stimulating the healing process in this area. This has directed researchers to focus on different methods to promote adequate healing by bone regeneration rather than fibrous repair. One of these methods is the usage of bone-replacing biomaterials (bone grafts) as an adjunct to endodontic surgery. However, some cases do not resolve satisfactorily with this technique. For these cases, Morin, a flavonoid having pro-osteogenic efficacy can be used in combination with BMP9 and leptin. Previous studies have shown how Leptin enhanced the activity of BMP9-Induced Osteogenesis and Morin has facilitated osteoblast development, thus resulting in bone healing. Though no such literature has been identified in the Surgical endodontics till now.

**Abstract 86**

**A cone beam computed tomography analysis of root canal anatomy of permanent mandibular first molars in South Indian population**

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**Aim of the Study:** The aim of this study was to determine the prevalence of the middle mesial (MM) canal and isthmus and the correlation of middle mesial canal with the presence of extra distal root and the distance between the mesio-buccal (MB) and mesio-lingual (ML) canal orifices in a South Indian population using CBCT imaging modality.

**Materials and Methods:** CBCT images of 105 patients were randomly selected from a database. Multiplanar images of mandibular 1st molars were examined in a sequential fashion in all 3 dimensions. Teeth with previous root canal treatment and full coverage restorations, open apices, root resorption / calcification were excluded from the study. Age and sex of the patient was recorded. Number of roots and number of root canals in mesial and distal root were determined. The apical confluence

Abstract

between the canals was determined. The distance between the ML and MB canals was calculated from the lingual aspect of the MB canal orifice to the buccal aspect of ML canal orifice. Presence/absence and location of isthmus was recorded from the axial view. The correlation between the variables was analyzed using Pearson chi-square tests along with post-hoc and Tukey HSD tests and the mean average of variables were calculated using one-way ANOVA tests. The intra-observer and inter-observer reliability were calculated with a Cohen kappa coefficient during the calibration period in the study.

**Results:** No significant correlations between the variables were found in this study except in the apical third where presence of isthmus was significantly associated with the presence of MM canal.

**Conclusion:** The prevalence of MM canals in mandibular first molar teeth in south Indian population was 52.41% and had separate exit in 4.6% of the teeth investigated. Presence of isthmus in apical third was significantly associated with presence of MM canal. No significant correlation was found between other factors evaluated in this study.

#### Abstract 87

##### Evaluation of garlic extract as rapid disinfectant for gutta percha cones: An *in vitro* study

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C NISHANTHINE**

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Tamil Nadu, India

**Aim:** The purpose of this study was to compare the efficacy of 20% and 100% garlic extract with 2% Chlorhexidine, 5.25% Sodium hypochlorite and 2% Glutaraldehyde in rapid disinfection of gutta percha cones.

**Materials and Methods:** The bacterial strains, *Enterococcus faecalis* and *Staphylococcus aureus* were grown on Brain Heart Infusion Agar and then sub cultured in BHIA medium. The cell cultures were harvested, washed twice with Phosphate buffered Saline (PBS) and adjusted to 0.5McFarland Standard. Gutta percha cones were immersed in prepared suspensions of *Enterococcus faecalis* and *Staphylococcus aureus*. The cones were then immersed in 100% garlic extract, 20% garlic extract, 2% Chlorhexidine, 5.25% NaOCl and 2% glutaraldehyde for 1 minute and 5 minutes separately. After disinfection the cones were then individually transferred to sterile test tubes containing 1ml sterile saline and vortexed vigorously for 5 minutes. 100µl of the saline suspension plated onto Brain heart infusion agar by spread plate method. The plates were then incubated for 48 hours at 37°C and the total colony forming units/ml were calculated manually by placing Petri dish on a grid background.

**Results:** Among the study groups 2% Chlorhexidine was found to have lesser mean total colony forming units than 5.25% NaOCl, 100% garlic extract, 2% glutaraldehyde and 20% garlic extract. There was no statistically significant difference among 2% Chlorhexidine, 5.25% NaOCl and 100% garlic extract at both the time periods.

**Conclusion:** Within the limitations of the study, it can be concluded that 100% garlic extract possesses efficient disinfection property

similar to 2% Chlorhexidine and 5.25% NaOCl. 100% garlic extract possesses superior disinfection property than 2% glutaraldehyde and 20% garlic extract.

#### Abstract 88

##### Knowledge, attitude and practice based survey on endocrowns among dental practitioners: A cross-sectional survey

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Tamil Nadu, India

**Introduction:** Post Endodontic restorations should include preservation of tooth structure as well as providing a proper coronal seal to prevent the ingress of microorganisms. Endocrowns are categorized under post endodontic restorations. They provide a good amount of esthetic and functional rehabilitation for grossly damaged teeth. They have a circular butt joint margin preparation without a ferrule thereby preserving the surrounding tooth structure.

**Objective:** To assess the knowledge, attitude & practice on endocrowns among dental practitioners, endodontists & post-graduate students.

**Materials and Methods:** A set of 30-closed ended questionnaire was prepared & validated and sent through google forms to the following groups- General dental practitioners (GDP), endodontists, and post-graduate students (endodontics) within Chennai. There were two sections, the first one represented demographic details and the other section included questions on knowledge, attitude & practice towards endocrowns. The questionnaire was sent to 200 dentists of the above-mentioned groups.

**Results of the Data and Statistical Analysis:** There was a total of 151 responses acquired. Obtained data was formulated and tabulated using MS Excel. Analysis was done using SPSS software. Chi-square test was performed at significant levels. Out of the total respondents, endodontists were well acquainted with endocrowns in contrast to the general dental practitioners ( $P < 0.05$ ) which was statistically significant. 17.3% of endodontists and 13.3% of general practitioners practiced endocrowns previously.

**Conclusion:** In the present study, the majority of the endodontists were aware and practiced endocrowns. Within the limits of this study, there was a lack of knowledge and practice among the general dental practitioners on endocrowns when compared to endodontists in the city. If this minimally invasive approach could be discussed more in the curriculum, it would have a better reach among practitioners.

#### Abstract 89

##### Estimation of salivary total protein, flow, and pH in dental practitioners before and after the use of personal protection equipments

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Abstract

**Introduction:** The physical environment in the dental office is more taxing than ever. Most of dental practitioners are experiencing dehydration and decrease in salivary flow while working with personal protective equipment.

**Aim:** The Aim of this study was to estimate the change in salivary total protein, flow and pH in Dental practitioners after the use of Personal protective equipment.

**Materials and Methods:** The unstimulated salivary total protein, flow and pH of 30 Dental practitioners before and after use of personal protective equipment for 3 hours was estimated. The subjects were advised to refrain from intake of any food or beverage one hour before the session. The unstimulated saliva was collected in graduated cups using draining method for 5 minutes. Collected saliva was first estimated for salivary pH using pH meter and then quantity of saliva was noted. Then, collected saliva was estimated for salivary total protein in laboratory. Data was tabulated using MS Excel and the statistical analysis was done using SPSS software. The Wilcoxon Signed-Rank Test was used to compare between the before and after study groups. The statistical significance was kept at p – value less than 0.05.

**Results:** There was significant reduction in salivary total protein, flow and pH in dentist after using personal protective equipment's for 3 hours ( $P < 0.05$ ).

**Conclusion:** Within the limitations of the present study, it can be concluded that use of personal protective equipment showed a reduction in salivary total protein, flow and pH among the dental practitioners. This may be due to dehydration and inadequate intake of fluids.

#### Abstract 90

### Single-cone with bioceramic sealer obturation on postoperative pain incidence after root canal treatment: A systematic review

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Tamil Nadu, India

**Objective:** To evaluate the influence of single-cone obturation technique using bioceramic sealer (BCS) on postoperative pain after root canal treatment, by systematically reviewing the published literature.

**Materials and Methods:** Based on the PICOS strategy the research question was formulated. A comprehensive literature search was performed electronically in PubMed, Cochrane Library, Google Scholar and Microsoft Academic by two evaluators independently. A manual search of the reference lists of identified articles was also additionally performed. All randomized clinical trials (RCTS) assessing postoperative pain incidence and intensity following root canal treatment with single cone obturation technique using BCS was identified from 1994 till May 2021. Inclusion and exclusion criteria were applied to the selected articles. A customized data extraction sheet was formulated. The articles selected were then subjected to quality valuation, and assessed concerning the risk of bias using the Cochrane Collaboration's 'risk-of-bias' assessment tool employing RevMan software.

**Results:** Four studies were included in the qualitative synthesis. Within the 4 studies, 1 study was considered to have "high risk of bias" and the rest 3 studies were considered to have "moderate risk of bias". The overall certainty of evidence of the included studies was classified as moderate.

**Conclusions:** Based on the limited quality evidence, the included studies reported no significant increase in incidence and intensity of postoperative pain after single-cone obturation technique with bioceramic sealer. However, paucity of standardized RCTs and lack of standardization in recording of pain scores as well as moderate certainty of evidence of the available studies signposts the need for well-designed RCTs.

#### Abstract 91

### Broken instrument retrieval: A riddle during endodontic treatment

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India

Fracture of endodontic instruments is an annoying complication during root canal treatment. The prevalence is between 1.83% and 3.3%. This is more common among extremely curved canals and retreatment cases. There is limited information based on high-level evidence about the management of separated instruments and this complicates the decision making process. The management of such complications should be based on thorough knowledge of each treatment option, considering the success rates, well balanced against the potential risks of leaving or removing the fragment. The retrieval rate of separated instrument in anterior teeth is 81.8%, for premolars it is 78.6% and for molars it is around 77.3%. This paper clearly reviews about the various techniques that are available till date for the successful retrieval of various endodontic and non endodontic separated instruments within the root canal.

#### Abstract 92

### Knowledge, attitude, practice in maintenance of dental unit waterlines among dental surgeons: A cross sectional study

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**Aim:** This survey aims to assess the knowledge, attitude and practice in Maintenance of Dental unit waterlines among Dental surgeons.

**Materials and Methods:** A Cross sectional study design was used. Self administered Questionnaire with 30 questions was designed and validated. The questionnaire consisted of questions pertaining to demographic details, knowledge on maintenance of dental unit waterlines (DUWLs), attitude towards maintenance of DUWLs and practice on maintenance of DUWLs. The questionnaire was formulated using google forms and an online link was circulated among 250 participants belonging to 4 categories (undergraduates, postgraduates, BDS practitioners and MDS practitioners). This survey analysed knowledge score, attitude score and practice based on Qualification and Workplace of dental surgeons. Survey data was

Abstract

collected, tabulated using MS Excel and statistically analysed using SPSS software. One-way ANOVA was used for intergroup analysis followed by Post HOC Tukey's test and Kruskal Wallis test was used for evaluating the knowledge and attitude score. Independent t-test for intragroup analysis and Mann Whitney test was used for evaluating the knowledge and attitude score.

**Results:** Out of 250 participants 238 had responded. The response rate for the survey was 95%. The knowledge score based on qualification, workplace showed statistically significant differences. MDS Practitioners had higher knowledge scores when compared to UG & PG students. Dental practitioners working in both clinic and hospital had more knowledge than non-practitioners regarding maintenance of Dental unit waterlines. There was significant correlation between knowledge and attitude. Whereas there were no statistically significant differences in attitude score and practice. **Conclusion:** A larger number of dental surgeons who responded were not familiar with methods for maintenance of DUWLs, but they were ready to follow guidelines if given. Hence, by conducting workshops or continuing dental education programs may improve the knowledge, attitude and practice towards maintenance of dental unit water lines among dental surgeons.

#### Abstract 93

**Evaluation of smear layer formation following final irrigation activation using XP-endo finisher and passive ultrasonic irrigation device: An environmental scanning electron microscopy study**

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**Aim:** To evaluate whether final irrigation protocol with XP-endo Finisher (XPF) and Passive ultrasonic irrigation (PUI) leads to the formation of smear layer.

**Materials and Methods:** 20 mandibular premolars (10 samples in each group) were instrumented with Protaper Gold from S1 up to F3 (30.09) and encased in condensation silicone forming a customized flask system providing a closed irrigation and aspiration system. The roots were split open with a chisel to facilitate assembly and reassembly of the specimen and the buccal half of the root was used. Four sequential indentations were prepared from 1mm short of the working length on the inner wall of the root canal. The specimens were agitated in ultrasonic bath initially with 3% NaOCl and then with 17% EDTA for 1 minute each to enable debris removal, following which samples were washed in running water for 1 minute. Initial images of the observation site were captured with Environmental scanning electron microscopy (ESEM) at 1200X magnification and digitally stored as control group. The same specimens were then reassembled in the flask and subjected to experimental irrigant agitation protocol using XPF or PUI. Following this imaging was done using ESEM to evaluate the formation of smear layer and classified using a 4-point scoring system. The comparison between the groups at any given level was made using Kruskal Wallis Test followed by Mann Whitney U test for the post hoc analysis. P value of <0.05 was considered statistically significant.

**Results:** XPF group samples presented significantly more amount of smear layer at apical levels compared to the control group. XPF group had significantly more amount smear layer compared to PUI group.

**Conclusion:** Within the limitations of this in-vitro study smear layer formation was observed in all the samples in both the experimental groups.

#### Abstract 94

**The ultimate game finisher in endodontics - XP-endo® finisher: A review**

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Root canal system is extraordinarily complex with numerous intricacies, including dentinal tubules, accessory and lateral canals, apical ramifications and isthmuses. These complexities allow for multiple spaces to be left untreated. It thereby leaves behind, bacteria and bacterial by-products, smear layer, intra-canal medicament and also obturation material during re-treatment. In spite of using a plethora of endodontic instruments and a combination of chemical agents, till date 100% sterile canals haven't been achieved. This doesn't stop us; rather, drives us to invent newer techniques and instruments to achieve as uncontaminated canals as possible. XP-endo® solutions [FKG Dentaire, La Chaux de Fonds, Switzerland] has delivered three unique instruments made of MaxWire® technology; XP-endo® Shaper, XP-endo® Finisher and XP-endo® Finisher R. They are effective in 3D cleaning and shaping by adapting to the canal morphology and preserving dentin. XP-endo® Finisher is one such instrument which is studied enormously regarding its positive outcomes in various steps of chemo-mechanical preparation of root canal systems. The aim of this review paper is to present and discuss the clinical characteristics of XP-endo® Finisher in terms of smear layer removal, bio-film/microbial load reduction, activation of irrigants and retreatment.

#### Abstract 95

**Effect of route of administration of preoperative analgesics on postoperative pain following non-surgical root canal treatment in symptomatic irreversible pulpitis: A systematic review and meta analysis**

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**Objective:** Post-operative pain after root canal therapy is a major concern for which pre-operative analgesics have been administered through different routes such as oral, intra-ligamentary, sub-mucosal, intra-nasal and transdermal. The aim of this systematic review was to summarize the available clinical evidence to find the effect of route of administration of pre-operative analgesics on pain following non-surgical root canal treatment in patients with symptomatic irreversible pulpitis and to perform a meta-analysis to assess post-operative pain at baseline, 12, 24 and 48 hours.

## Abstract

**Materials and Methodology:** The formulated PICO was (P) Patients with symptomatic irreversible pulpitis undergoing non-surgical root canal treatment; (I) Pre-operative analgesics administered through parenteral routes; (C) Pre-operative analgesics administered orally and (O) Post-operative pain following non-surgical root canal treatment. An electronic search of the literature was performed from inception till April 2021 in the PubMed, Cochrane and EBSCOhost databases. Quality assessment of the included studies was assessed using the Cochrane Risk of Bias 2.0 tool. A random effects meta-analysis was conducted to assess post-operative pain.

**Results:** Three articles were included for the qualitative synthesis of which two articles were included for the quantitative synthesis. The included articles highlighted the efficacy of intra-ligamentary and transdermal routes of administration of pre-operative analgesics over the conventional oral route. Meta-Analysis suggested that 12 hours after endodontic treatment, the mean level of post-operative pain was lower in individuals who received pre-operative analgesic through intra-ligamentary route than those individuals who received through oral route.

**Clinical Significance:** This systematic review showed alternative routes of administration of pre-operative analgesics can be promising in managing post-operative pain following non-surgical endodontic therapy.

**Conclusion:** Pre-operative analgesics when administered through parenteral routes resulted in less post-operative pain during all time intervals, among which a statistical significance was obtained at 12 hours post-treatment.

### Abstract 96

#### Prevalence of musculoskeletal disorder among endodontists in India: A systematic review

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**Objective:** Musculoskeletal disorder (MSD) is significant health problem associated with muscles, tendon, joints, inter-vertebral discs and peripheral nerves. MSD is a work-related well being issue for dental specialists, especially Endodontists who utilize precise, repetitive hand and wrist movements. Hence, the purpose of our systematic review was to evaluate the prevalence of MSD among Endodontists in India.

**Materials and Methods:** The studies that were included provided the following PEOS components: Population (P): Indian Endodontists; Intervention (I): working conditions/ergonomics/prolong static exposure; Outcome (O): musculoskeletal disorder and Study design (S) – cross sectional studies. The literature search was conducted from inception to April 2021, using the databases PubMed, Cochrane, Google Scholar and hand search from the included articles. Quality assessment of the included studies was performed with STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist for cross sectional survey.

**Results:** A total of 5 studies were included in this systematic review.

Among the included articles, 3 studies showed low risk of bias and 2 studies had moderate risk of bias. Prevalence rate of musculoskeletal disorder and pain among Endodontists in India ranged from 8.2% to 88.2%. Among the body region the neck was most commonly affected followed by shoulder and upper back regions. Potential occupational risk factors associated were working posture of operator and the number of patients treated. Due to the heterogeneity of the included studies meta-analysis could not be performed.

**Conclusions:** Musculoskeletal disorders and pain are significant health burden for dental professionals. Our systematic review showed a high prevalence rate of musculoskeletal disorders among Indian Endodontists with neck and shoulder being more commonly affected.

**Clinical Significance:** Musculoskeletal disorders is one of the important causes for long-term pain and disability affecting dental professionals. Our systematic review showed a high prevalence rate of MSD associated with several regions of the body among the Endodontists in India. Therefore, suitable interventions for preventing MSD and pain are needed.

### Abstract 97

#### A canal less known: Assessing the prevalence of canalis sinuosus and its features using cone beam computed tomography

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**Aim:** The aim of this study was to observe and evaluate the prevalence and location of Canalis Sinuosus (CS) and its features in the premaxillary region using Cone Beam Computed Tomography.

**Materials and Methods:** This study was designed as a retrospective analysis of 100 CBCT images. Patients in age group of 20 to 60 in and around Mumbai were included in the study. A single 360° scan collected the projection data for reconstruction. Only high resolution images were included. The scans were viewed axially and sagittally to identify and locate Canalis Sinuosus and its features. The following parameters were registered: Sex, Presence of CS, location of CS in relation to the nasopalatine foramen, unilateral or bilateral, presence of branches and accessory canals. All the obtained images were evaluated twice by the same observer at a 1-month interval. A Chi-square test was used to analyze obtained values.

**Results:** 92% of the cases showed presence of CS. All cases showed bilateral occurrence of CS. There was no significant association seen between presence of CS and gender of the patient ( $p > 0.05$ ). A significant difference was seen when related to the position of CS and Gender ( $p < 0.05$ ). The most common location of CS was anterior and lateral to nasopalatine foramen.

**Conclusion:** CBCT analysis showed a high prevalence of CS with bilaterality and presence of accessory branches in most of the cases.

### Abstract 98

#### Effect of calcium hydroxide on fracture resistance and microhardness of dentin in human teeth: A systematic review

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**Objective:** Calcium hydroxide to date is a widely used intracanal medicament during endodontic treatment. The long duration of exposure of dentin to calcium hydroxide may influence the fracture resistance and microhardness of dentin thereby affecting the tooth. This review aimed to identify and systematically analyze the effect of calcium hydroxide on fracture resistance and microhardness of dentin in human teeth.

**Methods:** Data sources - A PubMed search was performed using keywords 'fracture resistance' and 'microhardness' along with MeSH terms 'Calcium hydroxide' and 'dentin' and 'tooth' from 1956 to 10th June 2021. The search was expanded by the inclusion of the Scopus database using the same keywords and timeline. The reference list of each selected article was also explored to identify additional articles. An inclusion criteria was set that had to be met by each study for it to be selected for the review. The review was conducted according to the PRISMA checklist. Study eligibility and data synthesis – The protocol of the review was registered with Open Science Framework (OSF) with DOI No. 10.17605/OSF.IO/ZU8V4. Ten in-vitro studies that fulfilled the inclusion criteria were included in this review of which, 1 study evaluated both fracture resistance and microhardness, 4 studies evaluated only fracture resistance, and 5 evaluated only microhardness. The eligible studies were then analyzed by two evaluators and subjected to assessment of the risk of bias and data extraction.

**Results:** Analysis showed that increased duration of exposure of dentin to calcium hydroxide decreased the fracture resistance and microhardness of dentin thereby affecting the fracture resistance of the tooth. Further, 1 week of exposure to calcium hydroxide did not show any significant change in fracture resistance.

**Conclusion:** Based on the analysis of the studies included in this review, it can be concluded that the increased duration of exposure of dentin to calcium hydroxide negatively affects fracture resistance and microhardness, thereby weakening the tooth.

#### Abstract 99

##### Tooth structure loss associated with different full coverage restorations: A systematic review

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Tamil Nadu, India

**Objective:** The objective of this systematic review was to assess the tooth structure loss associated with different full coverage restorations.

**Materials and Methods:** A systematic literature search was conducted for studies from inception till April 2021, using the electronic databases PubMed, Cochrane, LILACS, Ebscohost and Google Scholar. Hand searching was also performed from the included articles. Both anterior and posterior tooth preparations on extracted human teeth and typhodont teeth were included as population. The outcome evaluated

was the amount of tooth structure loss associated with different full crown restorations. A modified Joanna Briggs criteria for in vitro studies was used to assess the quality of the included studies.

**Results:** A total of nine studies were included in this systematic review. The loss of tooth structure was 24.6% for metal crowns in posterior teeth. For all ceramic anterior crowns, the amount of tooth structure loss ranged from 30.41% to 70%. For posterior all ceramic restorations, amount of tooth structure lost ranged from 21.51% to 72.3%. For anterior porcelain fused to metal crown preparations, the minimum amount of tooth loss was 18.3% and the maximum was 71.9%. For posterior porcelain fused to metal crown, the least amount of tooth structure removed was 44.23% and the maximum amount was 75.6%.

**Conclusion:** Tooth preparation for a full metal posterior crown resulted in the least amount of tooth structure removal compared to other full coverage restorations. Porcelain fused to metal resulted in the greatest amount of tooth structure loss in both anterior and posterior teeth.

**Clinical Significance:** The clinician should choose a full coverage restoration whenever possible with a least invasive preparation design to preserve maximum amount of tooth structure that is already weakened by caries/trauma/endodontic intervention.

#### Abstract 100

##### Applications of three-dimensional printing in endodontics

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3D printing is a recent advancement in dentistry utilized for the management of complex cases. In the field of Endodontics, 3D printing aids in preparing access guides to orient burs in obliterated canal spaces, provides preformed 3D guides for accurate auto transplantation of teeth and preparation of surgical stents in periapical surgeries to replicate the preplanned access route in complicated cases. Students, clinicians, and patients often desire for realistic models to understand the clinical scenario. With 3D printing, it is possible to print these models with unusual anatomies for easy perception and better understanding. This review paper explores and discusses the evolution of the printing systems and the current and potential applications of 3D printed models and guides in Endodontics.

#### Abstract 101

##### Management of split tooth: A novel approach

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Longitudinal fractures of the tooth/teeth are linear fractures that tend to extend over a period of time. Occlusal wedging forces, impact trauma, and dental procedure can result in anterior and posterior teeth fractures. A split tooth falls under the classification of longitudinal

Abstract

fractures. Prognosis and treatment for split tooth depends on the site and extent of the fracture. This case presentation involves the management of split in the maxillary central incisor. This presentation highlights an innovative treatment approach. On clinical examination, 11 exhibited a fracture which was running mesiodistally separating the labial and the palatal fragments, and the fracture extended to the middle third of the root. The fractured coronal segments were approximated using bonded composite. To maintain the canal patency and ensure adequate depth of light penetration, a light transmitting post was used. The tooth was then endodontically treated. After endodontic therapy, a rectangular flap was raised between the distal of 12 to the distal of 21. The entry point was made on the labial side of the tooth. The channel created, transversed through the root canal and involved the entire labial and palatal sides. The bone screw was introduced into the channel and the split was stabilized. The flap was then repositioned with simple interrupted sutures. Follow up was done at 3, 6 and 12 month intervals. Considering split in anterior teeth, an attempt to salvage the tooth could be of greater significance if a definitive diagnosis and treatment plan could be achieved.

**Abstract 102**

**Comparative evaluation of the fracture resistance of re-attached tooth fragment using biological dentin post with fiber reinforced composite post: A pilot study**

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**Aim:** To evaluate and compare fracture resistance of reattached tooth fragment using biological dentin reinforcement with fiber reinforced composite post.

**Materials and Methods:** Three sound permanent maxillary central incisors were selected and mounted in acrylic blocks. Teeth were sectioned through the middle third of the crown at a distance of 3mm from the incisal third using a diamond disc to simulate Ellis Class II fracture and randomly divided into 3 groups (n = 1), Groups A, B and C. In Group A, fractured fragment was reattached using composite. In Groups B and C, two vertical grooves 2 mm deep, 2 mm wide, and 5 mm in length were placed on the palatal surface perpendicular to the fracture line. Group B was restored with two biological dentin reinforcements whereas Group C was restored with two fiber-reinforced composite (FRC) posts. The remaining part of the vertical grooves were filled using composite. The fracture resistance of all the teeth were tested in a universal testing machine with load applied along the long axis of the teeth at a crosshead speed of 1mm/min on the buccal surface. The force required to fracture the reattached teeth were recorded Newton (N).

**Results:** Teeth in Groups A and C required lesser force to fracture when compared with the tooth of Group B.

**Conclusion:** This preliminary study indicates that reattachment by vertical grooves with biological dentin reinforcements may help in improving the fracture resistance and can be a preferred method. To the best of our knowledge there is no literature where in attempt was made to reattach fractured fragment using vertical grooves and further restoring with dentin reinforcements.

**Abstract 103**

**Intentional replantation – An intercountry knowledge, attitude and practice survey**

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**Objective:** The aim of this study was to examine the practice of Intentional replantation as a treatment modality among Endodontists and postgraduate students in India, United Kingdom and United States of America.

**Materials and Methods:** The sample size was calculated according to the pilot study with 30 participants and final sample size was obtained as 228. A total of 22 questions were finalized after validation by two endodontic experts. An invitation to participate in the survey along with the weblink was circulated through various online social platforms. Survey participants were asked about the case selection, antibiotic coverage, extraction methods, hydration medium, root end preparation & filling materials, prognostic indicators and patient acceptance level of Intentional replantation treatment modality.

**Statistical Analysis:** The data was statistically analysed using chi square test. Descriptive and Inferential statistics were analysed by IBM SPSS version 20.0 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp). Throughout the study, a P value of <0.05 was considered as statistically significant difference.

**Results:** There was a significant difference (P<0.05) in the knowledge, attitude and practice among the practitioners in different countries. About 72.8% of the respondents view Intentional replantation as another treatment modality. Many participants choose Intentional replantation as a cost effective treatment when compared to extraction followed by single tooth Implants (86.4%). Most of the respondents prefer ultrasonics for root end preparation (75.4%) and commonly used root end filling material was Biodentine (62.3%). Of the total participants, 45.3% have done a case of Intentional replantation with follow up, in which the majority of the participants was from UK followed by USA. Patient acceptance level was found to be better in Western countries when compared to India.

**Conclusion:** There has been a continuous evolution in techniques of Intentional replantation through the years with consistency in following the modern endodontic surgical principles. The trend over Intentional replantation is slowly blooming as another treatment modality than last resort with the increased number of practitioners doing cases. There was a increased patient acceptance level shown in UK and USA when compared to India.

**Abstract 104**

**Comparative evaluation of volumetric substance loss and precision in selective re-treatment of maxillary premolars with guided versus conventional access cavity preparations: An *in vitro* study**

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**Aim:** To compare the volumetric substance loss and breach of dentin in selective retreatment cases between conventional and 3d guided access opening in maxillary premolars.

**Materials and Methods:** 22 freshly extracted two rooted upper first premolars were selected and divided into two groups. (n= 11). Pre-treatment cone beam computed tomography (CBCT) imaging of all teeth were done. Root canal treatment was completed for both the groups and final restoration was done using occlusal stamp technique to obtain the original anatomy.

Group 1: Re-access cavity preparation was done to locate the palatal canal orifice with the conventional method under magnifying loupes. Group 2: Re-access cavity preparation was done with 3D printed guide devised from pre-operative CBCT and customized bur was used to locate the palatal canal orifices.

After the selective retreatment, post-operative CBCT images were taken for both the groups. Substance loss was measured checked using Ez3D-i-3D software (VATECH) and precision was determined by calculating the number of teeth in which dentin was breached using the same software.

**Results:** The substance loss was significantly higher in Conventional access opening with a t value of 4.591 & is statistically significant with P value of 0.001. Dentin involvement was significantly higher around 72.7% in conventional access opening with P value of 0.033.

**Conclusion:** Guided endodontic access along with a customized bur leads to significantly less substance loss. The technique was precise as it prevented breach of dentin during access cavity preparation when compared with the conventional method.

### Abstract 105

#### Preparation of novel zinc oxide, silver and chitosan based nanocomposite and its antimicrobial effectiveness against enterococcus faecalis: An *in vitro* evaluation

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**Introduction:** The use of green mediated synthesis of nanoparticles in recent era have shown a greater interest for their biocompatibility and reduced overall cost of the production process. The aim of present study was to evaluate a novel nanocomposite made using Zinc Oxide (ZnNP), Silver (AgNP) and Chitosan (CNP) using Lemon as a cross linking agent and to evaluate its antimicrobial effectiveness against Enterococcus Faecalis.

**Material and Methods:** The nanoparticles were prepared individually and developed to form a nanocomposite. The analysis of the properties of the nanocomposite was done by subjecting it to characterization using UV-Vis Spectroscopy (UV-Vis) and Trans electron Microscopy (TEM). The antimicrobial action was evaluated for minimum inhibitory concentration (MIC) and maximum bacterial

concentration (MBC) using Tube Assay. A time kill assay was also done to evaluate the potency against Enterococcus Faecalis at different time intervals. For statistical analysis, Friedman's test was used to compare absorbance at different time intervals.

**Results:** Novel nanocomposite has shown a homogenous nanoparticle size under TEM and showed an absorption range of 350-420 nm making it similar to the individual counterparts. The MIC was seen at 62.5 mg (p<0.05) and MBC was seen at 250 mg (p<0.05).

**Conclusions:** Within the limitations of the present study, the novel Silver-Zinc-Chitosan-based nanocomposite (AgZnCNC) showed an improved antimicrobial action against Enterococcus Faecalis than its individual components under-tested laboratory conditions.

### Abstract 106

#### Impact of chemomechanical preparation of the root canal on periapical healing: A systematic review

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**Introduction:** The extent of preparation during root canal treatment is a matter of debate. Some studies have showed that aggressive preparation can allow better removal of infected dentin, enhance the flushing action of irrigants in the apical region and significantly reduce the bacterial load in the canal system and promote periapical healing.

**Aim:** The purpose of this systematic review was to determine the effect of chemomechanical preparation on the healing of periapical tissues in patients undergoing root canal therapy. An electronic search was done using PubMed database, Cochrane, Open grey and Scopus. Inclusion criteria were human *in vivo* studies comparing influence of different root canal treatment protocols on clinical and radiographic outcome of root canal treatment. Exclusion criteria included animal or lab studies. Risk of bias was measured and tabulated using the Cochrane tool.

**Results:** Based on inclusion and exclusion criteria, 5 articles from a total of 169 articles were identified that met the inclusion criteria. Of these 5 studies, 2 studies showed low risk of bias and 3 studies demonstrated high risk of bias over all.

**Conclusion:** Evidence from studies with low risk of bias have shown that for patients with necrotic pulps and periapical lesions, chemomechanical preparation of the canal would result in an increased healing outcome in terms of clinical and radiographic evaluations. The results of this systematic review confirmed that more evidence-based research is needed.

### Abstract 107

#### Accuracy of determination of working length by apex locators: A systematic review

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**Introduction:** Apical constriction has been proposed as the apical limit for the endodontic working length. This systematic review

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aimed to evaluate the accuracy of electronic apex locators (EALs) in determining the working length.

**Methods:** An electronic search in databases was performed for relevant articles. Studies comparing accuracy of electronic apex locators in human teeth were included in the review.

**Results:** From 193 articles, only 8 studies met the inclusion criteria. The mean distance from apical constriction to major foramen was 0.4mm. Apical foramen more than 1mm was more than 90%. The average apical foramen diameter was 0.45mm and apical constriction diameter was 0.3mm.

**Conclusion:** There was no significant difference in accuracy of working length determination among the apex locators evaluated.

### Abstract 108

#### Effect of calcium hydroxide vehicle on post operative pain: A scoping review

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**Objectives:** This review aimed to identify the influence of vehicle and its concentration used to carry calcium hydroxide (CH) medicament on post-operative pain.

**Methods:** The protocol of this study was registered in the open science framework (Registration DOI- 10.17605/OSF.IO/4Y8A9) and followed the Joana Briggs Institute guidelines. Reporting was based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR). The literature search and screening were performed in PubMed/Medline and Scopus, and additional records were analysed manually through various sources. The selected studies were published in English and included the use of any vehicle in adjunct to CH to evaluate post-operative pain with the help of any qualitative and quantitative pain assessment tools. A descriptive analysis was performed to consider the study design, the characteristics of vehicle and the effect of vehicle.

**Results:** Initial search yielded 6469 studies out of which 10 were included after removal of duplicates and full text screening. On the basis of collected data, the commonly used vehicles for CH were chlorhexidine (CHX), normal saline, Camphorated paramonchlorophenol (CPMC)/ glycerine and lidocaine, which showed a profound effect on post-operative pain.

**Conclusion:** The majority of studies corroborated a positive effect on use of vehicle on post-operative pain. Although, higher concentrations of vehicles used were found to alter pain levels postoperatively, further randomised controlled trials are required to reach a definitive conclusion. Our scoping review indicates that future studies should focus on using different vehicles at various concentration and application time to check for viable and safe exposure in addition to providing pain relief.

### Abstract 109

#### The role of cryotherapy in reduction of post-operative pain in patients with irreversible pulpitis and/or apical periodontitis: A randomized controlled clinical study

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**Aim:** To compare and evaluate the role of cryotherapy in reducing post-operative pain after biomechanical preparation in irreversible pulpitis and/or apical periodontitis.

**Methodology:** 30 patients with single rooted tooth with irreversible pulpitis and/or apical periodontitis were randomly divided into 2 groups. Group 1(Control group)(n=15) final irrigation done with normal saline stored at room temperature. Group 2(Study group) (n=15) final irrigation done with normal saline refrigerated at 2-5° c. Irrigation was performed with 5ml side-vented 30 gauge needle with sodium hypochlorite and it was warmed using fast-pack device for 5 seconds and final irrigation was performed respectively according to the group. Pain scores were recorded using Heft Parker visual analogue scale pre-operatively, 24 and 48 hours. The data was analyzed with SPSS software version 20.0. Repeated measure ANOVA and unpaired t test was used for inter-group analysis at all three levels:- Pre-operatively, 24 and 48 hours.

**Results:** Pain reduction was more in study group than control group from pre-operative to 24 and 48 hours period. Statistically significant difference was observed in pain between control and study group.

**Conclusion:** Using normal saline irrigation stored at 2-5°c as final irrigant reduces post-operative pain in patients with irreversible pulpitis and/or apical periodontitis.

### Abstract 110

#### Comparative evaluation of gel based regenerative scaffolds in vital pulpotomy procedures on permanent posterior teeth: A randomized controlled clinical study

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**Aim:** To compare the performances of Platelet-rich fibrin (PRF) and Chitosan-Gelatin scaffolds as regenerative agents in pulpotomy procedure for mature permanent posterior teeth with pulpitis.

**Materials and Methodology:** Forty-eight patients were recruited as per the inclusion criteria of this randomized controlled clinical study. The teeth were divided into two groups: Platelet rich fibrin (PRF) (n=24) and chitosan gelatin scaffold (n=24). Clinical examination after 48 hours, 7 days, 3 months and 6 months and radiographic examination at three months and six months interval were carried out after treatment. Mann-Whitney U test was done for comparison of pain scores between the two groups. The clinical and radiographic outcomes between the two study arms were compared using Pearson Chi-square test.

**Results:** Visual analogue scale (VAS) for pain revealed higher scores for PRF group as compared to chitosan-gelatin group, however the difference was not statistically significant. Radiographic success rate at three months for PRF and chitosan-gelatin groups were 70.83% and 87.5% respectively and at six months it dropped to 63.6% and

Abstract

87.5% for PRF and chitosan-gelatin groups respectively (p value: 0.219). Clinical success rate at six months for PRF and chitosan-gelatin groups were 68.18% and 83.3% respectively (p value 0.114). Six months overall success rate for PRF and chitosan-gelatin groups were 65.89% and 85.4% respectively (p value: 0.1376).

**Conclusion:** Pulpotomy can be considered as a treatment option for permanent teeth with deep caries and diagnosis of reversible or irreversible pulpitis as it has an acceptable success rate. There exists no statistically significant difference between the overall success rates of PRF and chitosan-gelatin groups as pulpotomy agents.

### Abstract 111

#### Comparison of antibacterial efficacy of madhuca longifolia seed extract and sodium hypochlorite as an intracanal irrigant: A randomized controlled trial

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**Aim:** To compare the antibacterial efficiency of Madhuca Longifolia Saponin seed extract and 3% Sodium hypochlorite as an intracanal irrigant.

**Materials and Methods:** In this randomized controlled trial, 26 teeth were selected with a mean age group between 18-65 years according to the inclusion and exclusion criteria. Based on block randomization, the teeth were divided into groups. Group I-Madhuca Longifolia Saponin -Test irrigant (n= 13) and Group II-3% Sodium Hypochlorite (n=13). Access cavity preparation was done, working length was determined, pre irrigation sample (S1) was taken, cleaning and shaping was done with the respective irrigants. Later post irrigation samples (S2) were obtained. Samples were sent for microbiological analysis.

**Results:** Madhuca longifolia group showed 73% and 58% reduction in aerobic and anaerobic groups respectively. Sodium hypochlorite showed 66% and 55% reduction in aerobic and anaerobic groups respectively. The results were not statistically significant.

**Conclusion:** Within the limitations of this randomized controlled trial we can conclude that Madhuca longifolia saponin seed extract has been proven to have antibacterial effect. However, it was less effective than the Sodium hypochlorite. More clinical trials are required to explore its other properties as an endodontic irrigant and its interactions with endodontic materials.

### Abstract 112

#### Comparison of intraoral periapical and cone-beam computed tomography for diagnosing horizontal root fractures: Systematic review

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**Introduction:** Horizontal root fractures (HRF) are the most common type of traumatic injuries. The radiologic evaluation of root fractures is usually performed with periapical and occlusal radiographs. However, the introduction of cone beam computed tomography (CBCT) has created new diagnostic possibilities in dentistry.

**Aim:** The aim of this review was to compare conventional radiograph and CBCT in diagnosing horizontal root fracture.

**Methods:** An electronic search was conducted for relevant articles. Studies comparing CBCT and conventional radiograph for diagnosing horizontal root fractures were included and screened. Quality assessment diagnostic accuracy studies-2 tool (QUADAS-2) was used to assess the screened articles

**Results:** From 326 articles 3 studies met the inclusion criteria. Risk of bias showed 2 articles in patient selection domain had low RB and low applicability concern. All selected articles had unclear RB in index test and with flow and timing.

**Conclusion:** There is low evidence indicating CBCT being a good tool for diagnosing horizontal root fracture in comparison with IOPA.

### Abstract 113

#### Autologous demineralized dentin matrix - The game changer in regenerative endodontics

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Dental pulp is a loose connective tissue that is encased in a low compliance mineralized tissue. Pulp tissue can be damaged by various routes like bacterial, chemical, and mechanical, and its low compliance against damage results in removal of pulp during the endodontic procedure which makes the tooth fragile. Thus the preservation of pulp vitality is very important for tooth viability as it helps in retaining all its functions, including vascularity, innervation, neurosensory, immuno-competency, and proprioceptive functions of teeth. Over the years various materials like calcium hydroxide and bioceramics are being used for pulp therapies which have certain limitations like tunnel defects and mild to moderate cytotoxic effects when placed in direct contact with the pulp tissues. The most important issues with these materials are the biological response of these materials are reparative rather than regenerative. Hence with the advent of research and technology, there is a dire need of biologically based autologous materials for the repair and regeneration of the dentin pulp complex. An autologous demineralized dentin matrix is a scaffold material with exciting regenerative properties. So this review illustrates the various prospects of the Demineralized dentin matrix and its clinical insight into regenerative endodontic therapy.

### Abstract 114

#### Phage therapy in enterococcus faecalis colony dysbiosis: An unexplored novel avenue

**ROMA KOTIA**

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Resistance to antibiotics is a fast-growing issue faced by all major sectors of health care, including dentistry. The various recurrent infections related to multidrug-resistant bacteria in hospitals are remediless and question the effectiveness of drugs. Two major causes for these recurrent infections are acquired antimicrobial resistance genes and biofilm formation, although the conventional techniques failed to resolve these issues. Hence, new techniques to resolve antibacterial practice have become inevitable. In dentistry enterococcus faecalis is the most challenging pathogen to eradicate

Abstract

and a major cause of recurrent root canal treatment failures. Bacteriophages (phage therapy) can be an effective remedy for such infections. They are viruses that are skilled to destroy bacteria and were discovered in 1915, but the importance of their study has been limited since the advent of antibiotics. Their use in endodontics is still very limited. *Enterococcus faecalis*, is the most common threat which is observed in recurrent root canal treatment failures is a hard-to-eradicate pathogen in dentistry of which the most problematic to treat is its biofilm-forming vancomycin-resistant strains. Studies have shown an effective response against such infections by the use of bacteriophages. The potential of bacteriophages, in particular against *Enterococcus faecalis* biofilms in root canals, is almost unexplored. This article reviews bacteriophage structure, mode of action, use in endodontics and the efforts to develop phage therapy against *Enterococcus faecalis* biofilm as well as the advantages and limitations of phage therapy.

**Abstract 115**

**Regenerative endodontic treatment or mineral trioxide aggregate apical plug in teeth with chronic apical periodontitis and open apices: A systematic review**

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Regenerative endodontic therapy holds the promise of prolonged use of natural dentition through predictable maintenance of dental root structure. Moreover, the absence of an apical constriction makes root canal treatment problematic because of the difficulty to obtain a seal with conventional obturation methods. Regeneration of an infected immature tooth with apical periodontitis had once been thought to be impossible. However, if a suitable environment could be achieved, i.e. absence of intracanal infection and presence of a scaffold conducive to tissue ingrowth, then regeneration might take place. Mineral trioxide aggregate has been known to show acceptable long term clinical outcomes. However, comparative studies of MTA and Regenerative endodontic treatment in the cases of chronic apical periodontitis are scarce. The aim was to conduct a systematic review of the literature on the role of Regenerative endodontic treatment in treating chronic apical periodontitis and open apices. The literature search was performed in 4 electronic databases PubMed/Medline, Google Scholar, COCHRANE Library, SCOPUS in English language up to December 2020 to include studies that evaluated regenerative endodontic treatment approach in teeth with chronic apical periodontitis and open apex. In this systematic review, any organized attempt to revitalize an immature tooth to induce root development was considered as Regenerative Endodontic Therapy. If the clinician filled the apical part or the entire root canal space with MTA without the intention of revitalizing the tooth, the treatment was considered as MTA Apical Plug.

**Results:** In all, 1397 studies were identified and after considering the inclusion and exclusion criteria 17 studies were selected for qualitative synthesis. In the Regenerative Endodontic Therapy group, out of 52 teeth (across 13 studies), 43 teeth showed Success & 9

teeth showed Functional Retention whereas in the MTA apical plug group, out of 36 teeth (across 4 studies) 30 teeth showed Success and 6 teeth showed Functional Retention.

**Conclusion:** Root development is considered a major advantage of Regenerative Endodontic Therapy over apexification using MTA Apical Plug.

Regenerative endodontic therapy could be effective for managing immature permanent teeth with apical periodontitis with appropriate case selection.

**Abstract 116**

**Comparative assessment of anti bacterial effect of iron oxide nanoparticle with 3%hydrogen peroxide and silver nanoparticle with 3%hydrogen peroxide irrigants against enterococcus faecalis**

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**Aim:** To evaluate and compare the antibacterial efficacy of iron oxide nanoparticle with 3% hydrogen peroxide and silver nanoparticle with 3% hydrogen peroxide irrigants against *Enterococcus faecalis* in root canal by assessing the microbial colony count.

**Materials and Methods:** 60 extracted mandibular premolar teeth were decoronated and chemomechanically prepared. Biofilm was allowed to be formed inside the root canals of specimens by incubating it for 21 days in BHI broth infected with *E.faecalis*. Based on the mode of treatment, the specimens were randomly divided into 4 groups (n=15): Group I- Phosphate-buffered saline (PBS) (negative control), Group II- 3% H<sub>2</sub>O<sub>2</sub> (positive control, Group III- Silver nanoparticle with 3% H<sub>2</sub>O<sub>2</sub> (0.5 mg/mL) (Ag-NP+3% H<sub>2</sub>O<sub>2</sub>) and Group IV- Iron-oxide nanoparticle with 3% H<sub>2</sub>O<sub>2</sub>(0.5mg/mL) (IO-NPs+3% H<sub>2</sub>O<sub>2</sub>). The Samples were obtained by scrapping # 35 Headstrom file inside the root canal, cultured and were subjected to microbiological analysis to count the total number of colony forming units. Inter group comparison was done using ONE WAY ANOVA test. TUKEY'S POST HOC test was used for multiple comparison of colony forming units for each group.

**Results:** The Ag-NP+3% H<sub>2</sub>O<sub>2</sub> group showed least number of CFUs after irrigation, and was followed by IO-NPs+3% H<sub>2</sub>O<sub>2</sub> group and least effective was 3% H<sub>2</sub>O<sub>2</sub>. The saline group exhibited maximum number of CFUs. Between Ag-NP + 3% H<sub>2</sub>O<sub>2</sub> and IO-NPs+3% H<sub>2</sub>O<sub>2</sub> groups, there was no statistically significant difference (P>0.05) in mean colony forming units showing that they have comparable effects. All the experimental groups showed a very significant difference in the mean number of CFUs (p<0.01) when compared to the control group.

**Conclusion:** The utilization of silver nanoparticle with hydrogen peroxide and iron oxide nanoparticle with hydrogen peroxide combinations as root canal irrigants proved to be effective against *E.faecalis* biofilm and could be considered as a promising adjunct in antimicrobial endodontic therapy.

### Abstract 117

#### Vital pulp therapy: A review of failed cases

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In contemporary endodontics, vital pulp therapy (VPT) has been considered as an ultra-conservative treatment modality for mature permanent cariously or traumatically exposed teeth that preserves the remaining pulp tissues, but long-term outcomes of the pulp and the restoration are unknown. Based on the level of pulp preservation, VPT includes stepwise excavation, indirect pulp capping (IDPC), direct pulp capping (DPC), miniature pulpotomy (MP), partial/Cvek pulpotomy and coronal/complete pulpotomy (CP). The success rates of vital pulp therapy described in the literature vary significantly, especially for direct pulp capping after carious exposure. The diagnosis and therapy regimen regarding the state of the pulp and the resulting therapy are increasingly questioned, hence, it is required to evaluate the prognostic value of factors with regard to treatment outcome of vital pulp therapy. The aim of this review is to analyze failed cases of vital pulp therapy reported in the literature in terms of case selection, diagnosis, treatment protocols, signs of failure, factors affecting failure and additional endodontic interventions.

### Abstract 118

#### Incidence of pulpal necrosis in tooth with full coverage restorations: A systematic review

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**Objective:** Full coverage restorations may be given in vital teeth when the tooth is cracked or damaged by extensive decay or when it needs correction of occlusion or to anchor fixed prosthesis in place. The tooth itself having a reduced amount of residual tooth structure, undergoes a stressed pulp syndrome when subjected to further procedures like tooth preparation and impression taking, leading to pulpal necrosis. This loss of vitality is therefore the most common adverse effect of using a full coverage restoration. In this review, we aimed to systematically evaluate the incidence of pulp necrosis and the need for endodontic intervention in teeth that have previously received a full coverage restoration.

**Materials and Methods:** The systematic review was registered in PROSPERO and conducted following the PRISMA guidelines. The focused research question was framed according to PICOS as 'In human permanent vital tooth undergoing full coverage restoration what is the incidence of pulpal necrosis?' Electronic database and hand search was performed in five databases, MEDLINE PubMed, Cochrane, LILACS, Scopus and Clinicaltrial.gov to extract published literature from inception to June 2021. The quality of the included studies was assessed systematically using MINORS tool

for observational studies and the results will be interpreted and evaluated.

**Results:** A total of 13 articles were finally included in the systematic review after eligibility assessment. The risk of bias showed high credibility and low risk for all the studies. From the included studies with follow up periods of upto 25 years, it is evident that irrespective of the type of full coverage restoration, the method of preparation, temporisation material and luting cement the incidence of pulpal necrosis remains high.

**Clinical Significance:** Clinicians should heed caution in each clinical procedure required to deliver a full coverage restoration to avoid pulpal necrosis and extra caution should be taken in cases of a tooth that are restored previously to avoid aggravating an already stressed pulp.

### Abstract 119

#### Does increase in temperature of sodium hypochlorite have enhanced antibacterial efficacy and tissue dissolution property? A systematic review and meta-regression of *in vitro* studies

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**Objective:** Sodium hypochlorite (NaOCl) being one of the most efficient root canal irrigant, has antibacterial and tissue dissolution property and is dependent on the concentration at which the solution is used. Literature has shown that increasing the temperature of NaOCl can accentuate the potency at lower concentrations. So, the aim of this systematic review was to determine whether increase in temperature of NaOCl irrigant improved its antibacterial efficacy and tissue dissolution property.

**Methodology:** The PICO format being Population(P) - extracted human teeth, bovine tissues and human pulpal tissues. Intervention(I) - increase in temperature of sodium hypochlorite, Comparison (C) room temperature sodium hypochlorite. The outcome(O)- Antibacterial efficacy and tissue dissolution property. To analyse the methodological quality of the selected articles, the critical appraisal checklist for quasi-experimental studies by JBI was modified and evaluated. A meta-regression analysis was performed for the articles evaluating the tissue dissolution property.

**Results:** A total of 292 articles were obtained after initial screening out of which 11 articles were included in this systematic review; five articles evaluated antibacterial efficacy and six articles evaluated tissue dissolution property. The risk of bias for articles included in both the outcomes was moderate. An increase in temperature of sodium hypochlorite increased the antibacterial efficacy in two of the included studies and three studies showed no statistical significance. Due to the heterogeneity in the included studies for antibacterial efficacy, meta-analysis was not performed. Quantitative analysis and meta-regression performed for articles evaluating tissue dissolution property showed sodium hypochlorite had 2.36-unit times increase in tissue dissolution property with a degree rise in temperature.

Abstract

**Conclusion:** Considering the limitations of the included studies, increase in temperature has a positive synergistic effect on sodium hypochlorite's tissue dissolution property and has inconclusive evidence on antibacterial efficacy. Future studies should be performed by standardizing all aspects of irrigation, temperature and evaluation methods for conclusive evidence.

**Clinical Significance:** Increasing the temperature of NaOCl from room temperature has a better tissue dissolution property. Thereby, clinicians can choose to use a lower concentration of NaOCl at higher temperatures to avoid adverse hypochlorite accidents.

**Abstract 120**

**The effect of chitosan hydroxyapatite on mechanical properties of dentin**

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Nanotechnology has been applied to dentistry as an innovative concept for the development of materials and treatment strategies. The potentials of dental nanomaterials are to eliminate biofilms, inhibit demineralisation and promote remineralization, to combat disease causing bacteria and repair previously diseased dentin matrix. Chitosan nanoparticles (CSs), a derivative of chitin (the second most abundant natural biopolymer), are ideal Non collagenous protein (NCP) analogs with advantages such as biocompatibility, antimicrobial property and structural similarity to NCP. Carboxymethyl chitosan (CMCS) is a water-soluble form of chitosan that stabilizes the dentin matrix and can be chemically grafted with molecules of interest to form nanocomplexes, which perform desired tasks in tissue engineering. One such example, chitosan-grafted hydroxyapatite precursor (CS-HA) nanocomplexes, has been previously used to facilitate biomimetic remineralization of collagen matrix, demineralized enamel, and dentin. When applied to dentin, CS- HA not only forms hydroxyapatite on the surface but does so in the reverse fashion as well which allows deeper penetration of mineralization while inducing inter- and intrafibrillar mineralization. In this review we will discuss in detail about CS-HA on the mechanical properties of dentin during conditioning since the mechanical properties of dentin are of paramount importance in all discussions of tooth strength so an understanding of this is essential to the proper interpretation of physical measurements of failure.

**Abstract 121**

**Regenerative endodontic treatment of an immature tooth with a necrotic pulp and apical periodontitis using blood clot and mineral trioxide aggregate: A case report**

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The management of immature permanent teeth with pulpal necrosis is challenging as the root canal system is often difficult to debride and the thin dentinal walls are at an increased risk of a

subsequent cervical fracture. Regenerative endodontic treatment is a biologically based treatment that is designed to replace damaged structures and cells in the pulp-dentine complex with live viable tissue which restores normal physiological functions. This approach unlike apexification and artificial apical barrier techniques allows continuation of root development resulting in an increase in both root wall thickness and the length of the root. This case report presents a Regenerative Endodontic treatment of an Immature tooth with a necrotic pulp and apical periodontitis using blood clot and mineral trioxide aggregate (MTA).

**Abstract 122**

**Management of vertucci Type V pattern in distal canal of mandibular first molar: A case report**

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Complex anatomy of the root canal should be thoroughly understood for proper management and better diagnosis that will lead to successful root canal treatment. The anatomy and morphology of the root canal can be classified according to the Vertucci root canal classification system. In the Vertucci Type V classification, apical third of root canal is divided into two separate root canals with two different apical foramen. Possibility of additional canal should be considered even in teeth with low frequency of abnormal root canal anatomy. Case report. The diagnosis of tooth 46 was symptomatic irreversible pulpitis with a normal periapical tissue. In the radiograph, distal canal was observed to be short, subsequently occurrence of another distal canal was suspected. Configuration of the root canal was established as Vertucci Type V. The distal canal orifice was extended buccolingually by using ultrasonic tips ET25 (Satelec) under high magnification dental operating microscope (DOM), thus the other was found in slightly distolingual direction. Bifurcation of the distal canal space was successfully located. Both distal canal was prepared using ProTaper Gold (Dentsply) and was obturated with warm vertical condensation technique, followed by class I composite restoration. Conclusion: Successful endodontic outcome in such case is dependent upon knowledge of root canal anatomy, careful interpretation of angled radiographs, proper access preparation and adequate treatment armamentarium for this anatomical variation.

**Abstract 123**

**Influence of apical patency in endodontic treatment outcome: A systematic review**

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**Objective:** Apical Patency is a technique where the apical portion of the root canal is maintained free of debris by recapitulation with a small file through the apical foramen. The purpose of this systematic review was to evaluate the influence of apical patency in endodontic treatment outcome.

## Abstract

**Materials and Methods:** The studies that were included provided the following PICO components: Population (P): patients receiving root canal treatment; Intervention (I): apical patency technique (AP); Comparison (C): non-apical patency technique (NAP); and Outcome (O): assessment of periapical healing. The literature search was conducted from inception to June 2021, using the electronic databases PubMed, Cochrane Library, LILACS, LIVIVO, Open Grey literature and an additional hand search was done from the included articles. Quality assessment of the included studies was performed with Newcastle-Ottawa quality assessment scale.

**Results:** Initial screening of databases resulted in 616 studies. Following the duplicates removal and abstract screening, 12 studies met the inclusion criteria and were selected for full text reading. Further, 8 studies were excluded since the treatment outcome was not evaluated. A total of 4 studies included in this systematic review for quantitative analysis. Among the included articles, two studies had low risk of bias and 2 had moderate risk of bias. Endodontic outcome was evaluated both clinically and radiographically in the included studies with a follow up period ranging from 1 to 4 years. Maintaining apical patency favored the endodontic treatment outcome by twofold with long term follow up. Due to the heterogeneity of the included studies meta-analysis could not be performed.

**Conclusions:** Within the limited clinical evidence available, it can be concluded that maintaining the apical patency is likely to enhance the endodontic treatment outcomes. However, more long term prospective clinical studies are required to further evaluate the possible influence of apical patency.

**Clinical Significance:** Apical patency prevents many complications, thus increasing the clinical survival and periapical healing of endodontically treated tooth. Achieving apical patency at the root canal terminus significantly increased the treatment outcome.

### Abstract 124

#### Nonsurgical endodontic treatment procedure followed by an intracanal bleaching in nonvital tooth with large radiolucency: A case report

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Tooth discolouration and a periapical abscess could occur on a non-vital tooth after a traumatic event. Patient's awareness about the change in colour of the tooth usually brought them to the dentist. The absence of pain after a traumatic event involving a tooth may mislead patients to think that their tooth is still vital. Patients often came with large radiolucency on the periapical tissue or after the condition became acute exacerbation. This case report describes the material and techniques utilized for non-surgical endodontic treatment followed by intracanal bleaching and direct composite resin restoration. A 22-year-old woman had a complaint regarding the colour of her upper tooth. She noticed the colour difference three months ago and stated that it had become more apparent. Clinical examination revealed that the tooth had a crown fracture, and a periapical

lesion has occurred with a fistule appeared on the apical region of tooth 11. Radiographic examination showed a large periapical lesion occurred in the periapical region of the tooth. Endodontic treatment performed on the tooth using Protaper Next as a mechanical instrument. Chemical irrigant of 5,25% sodium hypochlorite, 17% EDTA and 2% chlorhexidine used with sonic activation. Calcium hydroxide sealer applied using lentulospirals. Canal obturation was performed using the continuous wave compaction technique. Wing barrier using glass ionomer cement was made to prevent leakage of the 35% hydrogen peroxide used for intracanal bleaching. The final restoration was done using direct composite restoration. Periapical healing observed during the final radiograph one month after obturation. Endodontic treatment followed with intracanal bleaching and direct restoration is still viable in managing a single non-vital fractured tooth. Intracanal bleaching using 35% hydrogen peroxide effectively removes discolouration pigments from the tooth when controlled carefully. Direct composite restoration could still be an option for crown-fractured teeth with a satisfactory result. Non-surgical endodontic treatment for a tooth with a large periapical lesion has a great success rate using the latest materials and techniques. Endodontic treatment followed with intracanal bleaching and direct composite restoration is a viable option in managing a single non-vital fractured tooth.

### Abstract 125

#### Efficacy of autologous platelet concentrates in vital pulp therapy procedures: A systematic review of human studies

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**Introduction:** Current systematic review aimed to evaluate the efficacy of the various autologous platelet concentrates compared to other capping agents in vital pulp therapy (VPT) procedures in human teeth.

**Methods:** After raising a PICO question; review was planned, conducted, and reported in adherence to PRISMA standards of quality for reporting systematic reviews and meta-analyses. Protocol was registered a priori at PROSPERO (CRD42020213072). Electronic search was carried in five databases and three trial registries, published up to 31st December 2020. Protocol registries and references of selected articles were also searched. Data extraction and risk of bias assessment was performed individually by two reviewers using piloted extraction forms and modified ROB tool developed keeping in mind Cochrane checklist as given in Cochrane Handbook for Systematic Reviews of Interventions.

**Results:** The overall search resulted in six hundred twenty one records; after exclusion, a total of six papers with 276 participants were included in the present review. PRF is the only autologous platelet concentrate studied, with pulpotomy being the treatment modality of choice. Owing to the high heterogeneity of the data set, meta-analysis was not carried out. High risk of bias was found in one study.

**Discussion:** No significant difference reported in the studies

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comparing autologous platelet concentrates with other materials in VPT procedures. Limitations of the present review - cost effectiveness was not studied as a parameter and clinical recommendations could not be made.

**Conclusion:** The number of publications exploring autologous platelet concentrates as capping agents are very limited. In future, more homogenous randomized clinical studies following recommended research protocols should be carried out. Cost-effectiveness analysis with alternative capping agents and treatment options should be carried out rather than analysis based solely on treatment outcomes.

### Abstract 126

#### Efficacy of sonic activation on irrigant solution for cleaning lateral canals: Case report

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Cleaning and disinfecting the root canal system is one of the main objectives in endodontic procedure. Sonic irrigant activation is used to increase the efficacy of irrigant solution to reduce bacteria load, dissolve organic materials and remove smear layer. This method is useful especially because of irregular and complex anatomy of the root canal such as lateral canal. We present an endo-perio case with a lateral canal located on the mesiobuccal root of mandibular first molar and periodontal pocket. The tooth was diagnosed with pulp necrosis; acute apical abscess. Pre-operative radiograph showed a significant bone resorption and periodontium loss along the mesial parts of mesial roots. Root canal therapy and curettage were performed on the same day. Cleaning and shaping of the root canals were followed by irrigation protocol with NaOCl 5,25% and agitation with sonic vibration (EDDY, VDW GmbH). The apical size of mesial roots were 25.06 achieved by VDW Rotate (VDW GmbH). Radiograph, 10 months after treatment, showed an improvement of bone healing. Sonic agitation helps to remove debris, accelerate tissue dissolving capacity, and reach certain areas that are difficult to clean through mechanical preparation only. Sonic agitation is significantly superior to manual irrigation in terms of saving time, cleaning efficacy including lateral canals and create a more predictable outcomes of endodontic treatment.

### Abstract 127

#### The effect of various irrigation protocols during root canal treatment on periapical healing: A systematic review

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**Introduction:** The goal of root canal treatment is to prevent or to treat apical periodontitis; therefore, the microorganisms in both planktonic and biofilm state should be removed from the root canal system. Irrigation procedures could disrupt the biofilm, remove the dentin debris and smear layer from the root canal wall.

**Aim:** The purpose of this systematic review was to determine effect of irrigation protocols on the healing of periapical tissues in patients undergoing root canal therapy. An electronic search was done using Medline database, Cochrane, Open grey and Scopus. Inclusion criteria was human in vivo studies, studies showing radiographic outcome using periapical radiographs or cone beam computed tomography and studies comparing different irrigation techniques. Exclusion criteria included animal or lab studies, studies with microbial or histological outcomes. Risk of bias was measured and tabulated using the Cochrane RoB 2 tool.

**Results:** Based on inclusion and exclusion criteria, 2 articles from a total of 501 articles were identified that met the inclusion criteria. Out of the 2 studies, 1 showed low risk of bias and another study demonstrated high risk of bias overall.

**Conclusion:** Only one study with low risk of bias showed that irrigation using lower concentration NaOCl is adequate for better outcome in teeth with pulpal necrosis and periapical periodontitis. Further studies evaluating microbial analysis along with radiographic outcome of healing may help better understanding of the biology of healing after endodontic treatment.

### Abstract 128

#### Evaluation of color change of the tooth after regenerative endodontic procedure using two different scaffolds: An in-vitro study

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**Aim:** Aim of this study was to evaluate the color change of the tooth after regenerative endodontic procedure using two different scaffolds.

**Materials and Methods:** Mature human maxillary incisor teeth (n=20) were used in this study. To obtain a standardized length, root end was resected with high speed bur and root ends were sealed with composite resin. Access was gained and canals were enlarged and irrigated with 5 mL of 1.5% sodium hypochlorite, 5 mL of 17% EDTA, and a final rinse with 5 mL distilled water. Specimens were randomly divided in to two experimental groups: group 1 (Dentin sealing) and group 2 (without dentin sealing) which was further subdivided in to blood clot group and Platelet rich fibrin group based on the scaffold. Baseline color values were measured before the placement of scaffold and barrier material. Scaffold was then placed below the buccal CEJ and MTA was placed over the Scaffold in both experimental groups. The access cavity was sealed with a temporary restorative material and subsequent color changes ( $\Delta E$ ) were measured using spectrophotometer at different time intervals.

**Results:** There was reduction in tooth discoloration in sealed groups compared to nonsealed groups although there was no statistically significant difference.

**Conclusion:** Sealing the pulp chamber decreased the coronal discoloration compared to unsealed group following regenerative endodontic procedure.

### Abstract 129

#### Effect of biofilm on flexural strength of root canal dentin: A pilot study

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**Aim of the Study:** The aim of this study was to evaluate the effect of multispecies biofilm on flexural strength of root dentin in different age groups.

**Materials and Methods:** 50 single rooted mature, caries free teeth were collected and stored in HBSS solution. Plaque samples from two different donors were used as test organisms. The teeth were cast in a polyester resin foundation to obtain rectangular dentin specimens of dimensions 10 x 1.5 x 05mm. The dentin beams were cut either in buccal-lingual axis using a numerically controlled slicer/grinder. 60 Dentinal beams were prepared as per the protocol from 50 donors. Group 1 (old) number of beams =20, Group 2 (young) number of beams, n=20, Group 3 (Control group n=20). Multispecies biofilm was formed on the dentinal beams by placing them in the Thioglycolate broth mixed with the plaque culture for 3 weeks. These samples were then subjected to 4 point cyclic flexure with simultaneous exposure to the oral biofilm. Independent sample t test was used for the analysis (p value was <0.001).

**Results:** Young dentin showed significantly higher number of cycles to fracture (Nf) when compared to old dentin. The mean Nf in buccal beams of young age group was 3085.19±306.43 which was significantly higher than in old dentin (1981.93134.88).

**Conclusion:** Younger teeth had significantly higher flexural strength than old teeth in buccal- lingual quarters.

### Abstract 130

#### Préservation des dents - ensure to insure!!

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India

“Preservation of life is the only true joy”- Albert Schweitzer  
A tooth in itself is an individual full of life and vibrance. A tooth might fall prey to various traumas and infections, leading to its loss. Eventually, the next step to it is replacement of the extracted tooth with a viable replacement. Dentistry has made a huge leap in the replacement of these diseased teeth. With replacements such as implants, comes along its downside like peri-implantitis, mucositis and generally 99% of them are unsuccessful. Hence, rationalized treatment options of preserving the tooth structure and moving for options such as intentional replantation, autoreplantation, decoronation, orthodontic extrusion where extraction can be avoided and interdisciplinary treatment modalities involving both endodontic and periodontal planning should be considered. Rather than extraction for replacement, the motive should be brought down to preservation for success!!

### Abstract 131

#### A silhouette guide for analyzing and managing tooth loss in post-endodontic treatment: A case series

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Cariou process and endodontic access cavity preparations result in loss of ample tooth structure. The restoration of endodontically treated teeth (ETT) ensures the survival of teeth and the success of the treatment by preventing reinfection. The choice of post-endodontic restoration must depend on the amount of lost tooth structure, type, form, and location of the teeth, the status of the periodontium, and overall maintenance of the patient. An array of options available as post endodontic restorations are direct composite restorations, indirect esthetic restorations like inlays, inlays using composite or ceramic, veneers, FVCs, and endocrowns. This presentation of three cases helps in designing and fabricating a prototype that analyses the loss of tooth structure percentage of tooth structure available on occlusal, facial, and proximal surfaces and guides towards selecting a suitable post endodontic restoration that is minimally invasive and esthetic.

### Abstract 132

#### Anti-microbial efficacy of nanoparticles using photodynamic therapy in endodontics: A systematic review

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**Background:** Photodynamic therapy (PDT) is the process wherein light of a specific wavelength acts upon a suitable photosensitizing agent in the presence of oxygen resulting in the production of free radicals. When applied in living systems, PDT results in targeted cellular and tissue injury with minimal injuries in the surrounding tissues. Nanoparticles have been used along with PDT to obtain maximum therapeutic effect in the target area. In endodontics, PDT is used to improve root canal disinfection without inducing bacterial resistance. The aim of this systematic review is to assess the anti- microbial efficacy of nanoparticles using photodynamic therapy in endodontics.

**Materials and Methods:** An extensive literature search was done in three electronic databases: PubMed, Web of Science and Scopus. The search was carried out using the following key words: photochemotherapy, photosensitizing agents, phototherapy, photo activated disinfection, light activated disinfection, endodontics, biofilms, anti-infective agents, nanoparticles. All articles in English language till June 2021 were considered. Out of the 966 articles obtained, 11 articles were selected which fulfilled the inclusion criteria. Quality assessment of the selected articles was done using Joanna Briggs Institute appraisal tool. Data was extracted and descriptive analysis was performed.

**Results:** Photodynamic therapy was commonly used with silver and chitosan nanoparticles and diode laser at a wavelength of 620- 660 nm. *E. faecalis* was the most commonly studied organism. Based on the evidence available so far, it can be concluded that nanoparticles in conjunction with photodynamic therapy has significant anti-

Abstract

microbial effect, and hence can be used as an adjunct to disinfection procedures in endodontics.

**Abstract 133**

**Efficacy of mouthwashes on SARS-CoV-2 viral load in the oral cavity: A literature review**

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The presence of SARS-CoV-2 in saliva suggests that the oral cavity is a potential reservoir for transmission of COVID-19. This puts dental healthcare professionals at high risk of nosocomial infections with SARS-CoV-2. Center for Disease Control and Prevention(CDC) recommends preprocedural use of mouthwashes due to their ability to reduce microbial count in the oral cavity. Therefore, this study intends to review the literature regarding current recommendations and effect of four different types of mouthwashes [Povidone iodine(PVP), Hydrogen Peroxide(H<sub>2</sub>O<sub>2</sub>), Cetylpyridinium Chloride(CPC) and Chlorhexidine digluconate(CHX)]in reducing SARS-CoV-2 viral load in the oral cavity. Published researches on PubMed and Cochrane databases were reviewed from January 2019 to May 2021. The initial search strategy identified 105 articles on two electronic databases. Clinical trials, Prospective and Observational studies evaluating the virucidal effect of mouth washes in SARS-COV-2 positive cases were included in this review. Only four articles which met the above mentioned inclusion criteria were included. According to the literature reviewed, PVP, CPC was found to be more effective than CHX and H<sub>2</sub>O<sub>2</sub> in reducing the viral load from oral cavity. Suggested concentration of mouth washes are; 1.5 or 3%H<sub>2</sub>O<sub>2</sub>, PVP- 0.5 or 1%, CHX-0.12 or 0.2% and CPC-0.05 or 0.07%. On the basis of the outcomes of this review, it can be postulated that CPC and PVP commercial mouth washes may be effective in reducing the SARS-CoV-2 level in COVID-19 patients. The recommendation of a preprocedural mouth rinse with hydrogen peroxide and chlorhexidine digluconate is questionable. Therefore, further research on in vivo use of mouth wash before dental procedures is required to evaluate the antimicrobial efficacy of mouth washes on SARS-CoV-2.

**Abstract 134**

**Esthetic and functional rehabilitation of post endodontic treatment teeth on four maxillary incisors (a case report)**

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Esthetic and functional restoration of the anterior region is a significant aspect for the patient. Poor restoration and retroclined anterior can affect a patient's appearance and confidence. Esthetic analysis of facial, dentofacial, and dental, is the main key to improve an ideal smile. The gingival contour is also one of the factors that can affect the esthetic. Smile from an uneven gingival contour height or gingival zenith is also considered as an esthetic problem,

it can influence the axial inclination and affect the smile's harmony. This case report presents endodontic treatment and restoration on maxillary incisors with compromised crown height, treated with comprehensive endodontic-periodontal-esthetic approaches using digital smile design for improving the esthetic. The digital smile design is used to help the treatment plan and communicate the expected result to the patient and the dental technician. A 31-years-old female patient presented poor restoration anterior teeth maxilla, gingival disharmony, and complained about tenderness when biting. On clinical examination, there were resin composite restorations on teeth 11, 21, 22, and retroclined on tooth 12. A preoperative periapical radiograph showed a deep proximal secondary carious lesion involving the pulp, apical radiolucency on 12, and poor obturation on 11, 21. The facial harmony, dento-gingival, and teeth dimension were analyzed using digital smile design. The following clinical procedures were performed: endodontic treatment and re-treatment on teeth 12-22, gingivectomy on lateral incisor maxilla (tooth 12) using electrocautery. After three weeks of follow-up, the upper anterior teeth were restored with indirect lithium disilicate crown. The teeth were conditioned with 37% phosphoric acid, followed by washing and rinse. After that, the adhesive was applied to the teeth surface and blasted with air. The intaglio surface of the prosthetic was prepared with 9% hydrofluoric acid, washed with water, continue with the application of silane and adhesive. For the cementation, resin cement was used and photopolymerization was performed. It represents a successful esthetic treatment that improved a harmonious smile.

**Abstract 135**

**Biomimetic post endodontic crown - mimicking white spot (a case report)**

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Enamel decalcification, appearing as white spot lesions (WSLs), is an early lesion that occurs due to the loss of minerals in the enamel tissue. Clinically, it appears as an opaque white and has a softer texture than the surrounding healthy enamel. Oral hygiene is one of the factors that cause these lesions. In some early white spot cases, it can be treated by remineralization alone. However, in other severe white spot cases, lesions will be difficult to remineralization with minimally invasive treatment. A 22-years-old uncooperative female patient presented discomfort on tooth 21 on eating or drinking something cold without a history of trauma. Clinical examination showed tooth 21 had a severe carious lesion close to the pulp from the incisal part, with severe white spots on her surrounding and adjacent teeth. The tooth gave a positive response to the thermal test and was not tender to percussion and palpation. Preoperative periapical radiography showed there is no periapical radiolucency and deep carious lesions close to the pulp. The following clinical procedures: complete caries removal and access cavity preparation, instrumented and cleaning the canal thoroughly in one visit using Mtwo rotary Niti files (VDW) until 50.04. Irrigation was performed using 5.25% sodium hypochlorite at

Abstract

every file change and continued with 17% EDTA for final irrigation. The root canal was obturated with a bioceramic sealer and a fiber post was placed on the canal one week after obturation. The final restoration was using lithium disilicate with white staining on the labial part to mimicking the white spot from surrounding teeth and obtain a natural result. This case report will discuss the manufacture of a ceramic crown that resembles a white spot.

**Abstract 136**

**Endodontic management of endo-perio lesion restored with indirect restoration in mandibular first molar: A case report**

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TAUFIQ ARIWIBOWO**

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The relationship between pulpal disease and periodontal disease occurs because of the close anatomical and vascular relationship between the pulp tissue and the periodontal tissue. Endo-perio lesions can occur because there is a connection between the pulp tissue and the periodontal tissue through three anatomic pathways which is, dentinal tubules, lateral canals, and apical foramen. Primary endodontic lesions with secondary periodontal involvement begin with the presence of necrotic pulp that causes an inflammatory response of the periodontal ligament in the area around the apical foramen or lateral canals or additional root canals. The process of spreading the disease will continue resulting in destruction of the alveolar bone in the periapical and furcation areas. Tooth 36 was diagnosed with pulp necrosis with chronic periodontitis. Pre operative radiograph showed large lesion reaching the bifurcation and there is periodontal pocket on the buccal and lingual areas. Scalling, root planning and endodontic treatment was performed, following with root canal sterilization by applying calcium hydroxide to the entire root canal wall and then covering it with temporary filling. The final restoration planned is a cuspal coverage porcelain fused to metal crown restoration with fiber post. Radiograph after 3 months showed an improvement of the lesions. Most teeth with apical periodontitis are expected to improve after endodontic or nonsurgical treatment.

**Abstract 137**

**Battling COVID-19 as endodontists!!!**

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The spread of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has resulted in millions of confirmed cases and hundreds of thousands of deaths. Despite all efforts to contain the spread of the disease, the number of infections and deaths continue to rise, particularly in some regions. Given its presence in the salivary secretions of affected patients, and the presence of many reported asymptomatic cases that have tested positive for COVID-19, dental professionals, including Endodontists, are at high risk of becoming infected if they do not take appropriate precautions. The COVID-19 pandemic has led to the absolute requirement for strict and effective

infection control protocols beyond those that already exist within the dental setting. The management of endodontic emergencies has been particularly challenging during the COVID-19 outbreak because of the possible generation of airborne particles and aerosols. This review deals on the available endodontic guidelines and the clinical management of endodontic emergencies reported in the literature.

**Abstract 138**

**Multisonics in endodontics - A review**

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The endodontic success depends upon the complete eradication of vital and necrotic remnants of pulp tissues, micro-organisms and microbial toxins, although that might be achieved through chemo-mechanical debridement, it remains paradoxical for removal from the tortuous anatomy of the root canal including canal fins and isthmi. Therefore, irrigation with the irrigants meeting all the ideal requisites is the essential part of achieving the successful endodontic treatment. Those irrigants has to be activated such that it reaches and reacts within the entire complex anatomical root canal. In the extensive chronicles of irrigation in endodontics, efforts have been ceaselessly made to develop more effective machine- assisted irrigation agitation devices. Also the use of conventional treatment requires the removal of excessive radicular dentin which in turns is necessary for long time success. This however, has an adverse effect on integrity of the root and may lead to root perforations and fracture occurrence. There came the evolution of the novel Gentle - Wave system to the dental market to provide better resolution to all the above mentioned drawbacks and improves the treatment outcome while maintaining the integrity of the tooth structure. This system was designed for endodontist's as an alternative to standard root canal treatment. This literature review emphasis on the major advancements presented by the Gentle - Wave system utilizing multisonic technology with broad spectrum of sound waves within the canal anatomy showing more favourable treatment outcome with regards to tissue dissolution ability, negative apical extrusion, minimal invasion, depth of penetration of irrigants, post operative pain management, effectiveness in removal of separated instrument, healing ability and various properties and purposes throughout the entire root canal system and procedure.

**Abstract 139**

**Endodontic irrigation – Fluid dynamics: An update**

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Endodontics is the art and science that deals with prevention and treatment of pulp and periradicular diseases. The success of root canal therapy relies on microbial control achieved by chemo mechanical preparation, irrigation and obturation of the root canals. The intricacy of root canal morphology has curved apical third, apical deltas, narrow isthmi, oval and ribbon shaped canals

## Abstract

that cannot be mechanically cleaned. Bacteria can flourish in these untouched areas and it turned out to be a challenging objective to endodontists and also remains as a real cause for pulpal and periapical diseases. An interdisciplinary approach involving well-established methods from the field of fluid dynamics can provide new insights into the mechanisms involved in cleaning and disinfection of the root canal system. However, there is no one unique irrigant that can meet all the requirements, even with the use of modifying methods such as lowering the pH, increasing the temperature, as well as addition of surfactant to increase the wetting efficacy of the irrigant. More importantly, these irrigants must be brought into direct contact with the entire canal wall surfaces for effective action, particularly for the apical portions of small root canals. Throughout the history of endodontics, endeavors have continuously been made to develop more effective irrigant delivery and agitation method to achieve mechanical, chemical and microbiological functions, which are prerequisites for obtaining a clean root canal system. For effective debridement of the root canal an improved delivery system for root canal irrigation is highly desirable. Such a delivery system must have adequate flow and volume of irrigant to be effective in debriding the canal system without forcing the solution into periradicular tissue. The equipments are developing with an end goal to better address the difficulties of irrigation. The objective of this review is to present and provide cutting edge information on the latest advancement on the irrigant delivery systems and agitation methods available in endodontic practice.

### Abstract 140

#### Evaluation of root dentin microcracks caused by three nickel-titanium rotary file systems in mesial roots of extracted human mandibular molars: A micro-computed tomography study

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**Aim:** To evaluate the incidence of root dentin microcracks post instrumentation with three Nickel-Titanium (NiTi) rotary file systems in moderately curved mesial roots of extracted human mandibular molars using Micro-computed Tomography (micro-CT) analysis.

**Methodology:** Sample size (n=30) was estimated using G\* power 3.1.9.3 software with the power of 0.09. Thirty freshly extracted human mandibular molars with moderately curved roots that met the inclusion and exclusion criteria were selected. The mesial roots were separated, root length standardized, mounted on custom made putty jig and scanned using a micro-CT device at an isotropic resolution of 18µm. Samples were randomly assigned to three experimental groups (n = 10), Group A: TruNatomy (TRN), Group B: DC-Taper 2H (DCT) and Group C: 2Shape (TS) and instrumented. The roots were remounted on custom jig and scanned. The images were analyzed using software CTAn v.1.18 (Bruker, micro-CT). Two previously calibrated examiners analyzed all pre-operative and post-operative slices (n= 19,599), measuring 12mm from root apex

for the presence of root dentin microcracks. The frequency and distribution of microcracks in roots were evaluated.

**Results:** The kappa value of 0.8 was attained indicating good inter-examiner reliability. Shapiro- Wilk's test was done to assess the normality distribution. All inter and intra group analysis was performed using One-way ANOVA and Post-hoc Tukey. Pre-existing microcracks were detected in all groups (P=0.53). All instrumentation systems induced new microcracks with no statistically significant difference between them (p=0.63). The percentage increase in microcracks after instrumentation was 1.04% (TRN), 1.2% (DCT), 1.05% (TS) respectively. 2 shape showed statistically significant increase in the number of post instrumentation microcracks (p=0.01). The frequency of roots exhibiting postoperative microcracks was found to be 60% in TRN and 2S groups and 20% in DCT group. Cracks detected in pre-instrumentation slices were more prevalent in coronal and middle third of the roots (p=0.01) while post-instrumentation cracks showed significantly higher prevalence in middle and apical third (p=0.02).

**Conclusion:** All instrumentation systems induced some root dentin microcracks in moderately curved mesial roots of human mandibular molars. 2shape NiTi rotary file system caused a significant increase in root dentin microcracks post instrumentation.

### Abstract 141

#### Nonendodontic lesions mimicking periapical lesions of endodontic origin: A scoping review

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**Aim:** The aim of this scoping review was to describe the various clinical and radiographic features of non-endodontic lesions (malignant and benign tumors, cysts and infections) mimicking periapical lesions of endodontic origin.

**Materials and Methods:** Literature search was done in five electronic databases- PubMed, Web of Science, Scopus, Embase and ProQuest to include published cases (case reports, case series and cross-sectional studies) of patients with histologic diagnosis of non-endodontic lesions which were clinically and/or radiographically mimicking periapical pathosis of endodontic origin till April 2021. Animal studies, laboratory based studies, reviews and abstracts of conferences were excluded. Specific strategies were developed for different databases using the following keywords: Periapical disease, non-endodontic lesions, malignant lesions, benign lesions, infectious disease, cysts, tumors, diagnostic error, misdiagnosis, mimicking. A total of 121 articles fulfilling the eligibility criteria were included. Further, data extraction was done and descriptive analysis performed.

**Results:** The most common benign and malignant lesions mimicking periapical pathosis were found to be odontogenic keratocyst and metastasis (from lung and breast cancers) respectively.

**Conclusion:** Since a wide variety of non-endodontic periapical lesions mimic that of endodontic pathosis, it becomes imperative for clinicians to be aware of such presentations and consider them in the differential diagnosis of endodontic lesions.

### Abstract 142

#### Efficacy of walking bleach technique for tooth discoloration in mandibular anterior tooth: A case report

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**Background:** Non-vital anterior tooth discoloration is often perceived as an aesthetic problem. It can be defined as being extrinsic or intrinsic factors, and it occurs as a result of surface stains due to actual changes in tooth or because a combination of both factors. The most common causes for intrinsic tooth discoloration are dental trauma, pulp necrosis, intracanal medicament, obturation material and sealers. One of the commonly used techniques used for bleaching endodontically treated teeth is the 'walking bleach' technique, and it is a minimally invasive method that provides a satisfactory result.

**Purpose:** Describes the management walking bleach technique for discolored and infected mandibular central incisor.

**Case and Management:** A 36 years old female patient came with chief complaint of the discolored mandibular central incisor. The periapical radiograph showed that left incisor canal treatment had been done before with non-hermetic obturation and the right incisor with calcified root canal while both had periapical radiolucency. Previous gutta percha filling was removed using hedstroem file and solvent, root canal preparation until size X2 and irrigation with root canal irrigants protocol. For calcified root canal, detection of canal orifice helped by canal detector and C+ file size #6 and #8. The obturation using single cone gutta percha and resin sealer. The next visit removed 2 mm of gutta percha under cemento enamel junction and form mechanical barrier with glass ionomer cement. The tooth bleached using the walking bleach technique with 35 % hydrogen peroxide into the pulp chamber on labial surface for five days. After the second application, the result was achieved, the tooth color was changed for left incisor from B4 to A1 using Vita shade guide and for right incisor from A4 to A1. Then calcium hydroxide applied to neutralize and final restoration with direct composite.

**Conclusion:** Management of non-vital tooth discoloration with walking bleach technique using 35% hydrogen peroxide, effectively with non-invasive procedures.

### Abstract 143

#### Indirect pulp capping using Biodentine™ on reversible pulpitis mandibular left permanent molar: A case report

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Bacteria toxins when reach the pulp will trigger inflammatory response in the pulp, where the severity of pulp inflammation under a carious lesion depends on the degree of depth of bacterial penetration and the formation of sclerosing and/or reparative dentin. In dentistry, vital pulp therapy such as pulp capping has the same goal, using calcium silicate based materials such as MTA

(Mineral Trioxide Aggregate) and Biodentine™. These molecules have the potential to exert direct effects on existing odontoblasts or signal recruitment of undifferentiated pulp cells, with the aim of stimulating regeneration of the lost dentin. MTA and Biodentine™ are biomimetic materials that stimulate the production of BMP and TGF-β1 from pulp cells. MTA and Biodentine™ are said to influence the early differentiation of odontoblasts and the initiation of mineralization and synthesis of reparative dentine. This case report discusses the results of indirect pulp capping treatment in a mandibular left permanent molar (37) using Biodentine™. A 37-year-old patient complained of pain in the left mandibular permanent molar when drinking cold and chewing food. Vitality examination positive, sensitive to percussion, no respons to palpation. Radiographic examination showed a radiolucency under the old composite resin filling in the occlusal area, there was widening of the periodontal ligament in the apical 1/3. Biodentine™ material was chosen because it has advantages in terms of material handling, setting time, color and material hardness compared to MTA. Biodentine™ also shows a higher ability to produce apatite crystals and induce mineralization with reparative dentine formation compared to other pulp capping materials such as calcium hydroxide and GIC. Control after 5 months application of Biodentine™ found improvement in apical area, positive pulp vitality and no subjective complaints.

### Abstract 144

#### Root canal treatment of mandibular first molar with vertucci Type II configuration: A case series

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Root canal is a complex system that varies in anatomy. Based on its orifices and apical root canals, Vertucci classified eight types of root canal configurations. Vertucci type II configuration (two orifices in the pulp chamber that fuse at the apex), is often found in the mesial root canals of mandibular molars (37%). This configuration is commonly caused iatrogenically during root canal treatment, resulting in a non-hermetic obturation and may lead to failure of root canal treatment. Thus, performing optimal root canal treatment is essential yet challenging for the dentists. This case series will discuss the management of root canal treatment of mandibular first molars with Vertucci type II configuration with the use of ProTaper Gold® and warm vertical compaction obturation technique.

### Abstract 145

#### Treatment of primary endodontic lesion with periodontal involvement in mandibular molar: A case report

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Infection from root canal can extend to periodontal tissue and vice versa. A cross infection may occur through the apical foramen,

Abstract

accessory canals, or even through exposed dentinal tubules and form endodontic-periodontal lesion. To overcome this, a combination of endodontic treatment and periodontal treatment is needed. For most cases, root canal treatment is performed first followed by periodontal therapy. Chemo-mechanical preparation is performed to create aseptic conditions in root canal and stimulate healing of the periapical tissue. This followed with periodontal therapy that can increase the prognosis of the tooth by healing of the periodontal structure. This case report will discuss the management of primary endodontic lesions with periodontal involvement in mandibular molar. Endodontic treatment was performed first and followed with periodontal treatment. After two months evaluation, the result revealed no clinical symptoms and no mobility of the tooth supported by the normal pocket depth. Radiographically, there was an increased bone density, extending to the bifurcation area. Six months follow up is still needed to conduct for final healing process.

**Abstract 146**

**Dentin microstructure and its correlation to the direction of fracture line in mandibular molars of elderly individuals: *In vitro* study**

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**Aim:** The objective of this study is to evaluate the direction of the fracture line in mesial roots of mandibular first molars in elderly individuals.

**Materials and Methods:** Twenty extracted mandibular first molars from aged individuals (above 45 years) were included in the study. The mesial roots of the mandibular molars were decoronated and embedded in acrylic blocks and subjected to vertical force under a universal testing machine. Then the fractured roots were examined under a stereomicroscope at 10X magnification to determine the location and direction of the fracture line. To evaluate the correlation between the dentin microstructure and the direction of the fracture line, teeth were sectioned and observed under a stereomicroscope at 20X and 40X magnification. Statistical analysis was done using Fisher exact test.

**Results:** Sclerotic dentin distribution was more in the apical area and less in the coronal third of the root. The correlation between the direction of sclerotic dentin and the direction of the fracture line was statistically significant with harder sclerotic dentin impeding the propagation of fracture in the root.

**Conclusion:** Among the older individuals there was a gradual increase in the prevalence of sclerotic dentin from coronal to the apical direction and the presence of harder sclerotic dentin impeded the propagation of fracture line.

**Abstract 147**

**No cry- with cryotherapy: Adding a new dimension to endodontic practice!**

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Cryotherapy is originated from the Greek word 'CRYOS' meaning COLD. Do you remember how your pain gradually vanished after you applied an ice pack posts your wisdom tooth extraction? And how your hands got numb on a cold winter morning Cryotherapy, seemingly a complex idea, is actually the simplest in its application, bringing about magnificent effects. This makes it a hot topic in the research and treatment arenas. In Physiotherapy, it means lowering or decreasing the temperature of tissues but in reality, cryotherapy does not implement cold but rather extracts heat. It is effective in reducing edema, pain, inflammation, and recovery time by its inherent nature of vasoconstriction, alteration in nerve conduction, blood flow, and cellular metabolic activity. Though a known technique in medicine, the rapidly growing field of endodontics invited this concept only a few years back. With the introduction of bioceramic materials and the ever-increasing popularity of Regeneration, the concept of Cryotherapy holds the promise of combining the two, in its unique way and giving birth to an innovation called 'BIOACTIVE ENDODONTICS'. Cryotherapy brings conservation and comfort together for both, the patients and the clinicians. Its application in Endodontics is not just limited to Vital Pulp Therapy but also in Post-Endodontic Pain (PEP) Management. Metallurgical Advancements use Deep Cryotherapy to increase the strength, microhardness, and corrosion resistance of metals, and the same concept can be applied clinically on NiTi rotary files by increasing their cyclic fatigue resistance and cutting efficiency. Cryoablation and Cryosurgery are already in practice in the field of Oral Medicine, Oral Surgery, and Periodontics, it won't be long before we start applying the same in Endodontic Surgeries too. The applications of Cryotherapy thus can bring about a paradigm shift in the conventional endodontic practice. Further studies and research is bound to unleash its hidden potentials.

**Abstract 148**

**Cleaning effectiveness of ultrasonics with and without endodontic solvents on root canal dentin: An *in vitro* study**

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**Aim:** To compare the ultrasonic effectiveness with and without solvent on the cleanliness of endodontic obturation material in middle third and apical third of the root canal.

**Materials and Methods:** Eighteen freshly extracted single rooted mandibular first premolars were selected. Teeth were decoronated until they reached a length of  $16 \pm 0.5$  mm. All teeth were prepared and obturated using bioceramic sealer and gutta-percha in single cone technique. Pre-instrumentation Cone Beam Computed Tomography (CBCT) imaging of all teeth were done to get initial volume of the obturation material at middle and apical third levels. After 30 days in incubator, the teeth divided into three groups (n=6). Group 1 was cleaned by ultrasonic with xylene, group 2 was cleaned by ultrasonic with orange oil and group 3 was cleaned by ultrasonic only. Post-instrumentation CBCT were done in a similar method

Abstract

as pre-instrumentation scan. The amount of obturation material removed were calculated using CT Analyser. Two-way ANOVA was used to determine the solvent and location interaction.

**Results:** There was no significant interaction was found between solvent and location ( $P > 0.05$ ).

**Conclusion:** Using ultrasonic with solvent as effective as without solvent in order to clean the obturation material in the middle and apical third.

#### Abstract 149

##### Management of separated instrument in a curved disto-buccal canal of maxillary first molar – A case report

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During root canal therapy, there will always be potential for iatrogenic errors such as an intracanal separation of endodontic instruments hindering cleaning and shaping procedures within the root canal system, which may have an impact on the treatment outcome. This problem can be treated conservatively or surgically, where conservative approaches are considered favorable and preferred whenever possible. Conservative methods include procedures such as leaving the fragment in situ, bypassing the separated fragment or complete removal of the instrument. In addition to experience in handling such cases, it is important for a clinician to know the indications, advantages and disadvantages of each treatment option and technique in order to decide what method will be used to achieve the desired results. This presentation discusses the management of an accidentally separated file in a curved disto-buccal canal of the maxillary first molar through complete removal of the instrument using ultrasonic technique with predictable results.

#### Abstract 150

##### Ice on endo

**R SARANYA**

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Cryotherapy is derived from greek word “cryos” denoting “cold” and “therapy” denoting “cure. As early as 3000 BC, the ancient Egyptians were the first to apply cold to treat injuries and reduce inflammation. A british physician Arnott reported cryotherapy as early as 1851. In the field of endodontics, cryotherapy is employed in peri-radicular surgeries, root canal treatment, vital pulp therapy, to minimize pain and inflammation and to enhance few physical properties of nickel-titanium endodontic files. In endodontics commonly used cryogens include ice pack, gel pack, ice chips, melted ice water, ice massage, pre-packaged chemical ice pack, liquid nitrogen. The principle of cryotherapy is a rapid cooling and repetition of the freezing process to maximize the tissue destruction for therapeutic purposes. Swelling and or pain to the peri-radicular tissues are caused by various factors such as

chemical, mechanical or microbial injury. Though other strategies are employed to reduce the endodontic pain, cryotherapy is also an alternative method. Cryotherapy decreases metabolic activity, blood flow and neural signals by reducing the release of the chemical mediators that are responsible for pain conduction, thereby reducing the conduction velocity. It makes the dental treatment more comfortable for the patient and the dentist. Cryotherapy is used in the various fields of dentistry and it is a new emerging treatment modality in the field of endodontics. Cryotherapy can be considered as a simple, cost-effective and non-toxic therapeutic procedure preoperatively, during the treatment and postoperatively in endodontic pain management. This review paper describes the various advantages of cryotherapy in endodontics.

#### Abstract 151

##### Effect of gutta percha with different sealers on the expression of *Enterococcus faecalis* virulence factor: A polymerase chain reaction study

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**Objective:** To compare and evaluate the effects of Gutta percha with AH plus sealer, Gutta percha with Sealapex and Gutta percha with CeraSeal on *E. faecalis* virulence factor - *E. faecalis* endocarditis antigen (efaA) using real time Polymerase chain reaction.

**Aim:** To evaluate the effect of Gutta percha with different sealers on the expression of *Enterococcus faecalis* virulence factor (efaA)- using real time polymerase chain reaction.

**Materials and Methods:** Forty single rooted premolars were taken and decoronated to standardize the root length as 14 mm. The canals were instrumented up to F3 Protaper Gold and teeth were autoclaved at 121°C for 20 minutes at 15 psi. 1 mL *E. faecalis* suspension was injected into the root canals, and the samples were incubated at 37°C and 100% humidity for 21 days. The samples were randomly divided into four groups. Group A- control group, Group B -Gutta percha with AH plus sealer, Group C -Gutta percha with Sealapex, Group D -Gutta percha with CeraSeal. After the obturation procedure, teeth will be sectioned and root filling material will be removed gently with spatula under aseptic condition. Dentin powder will be obtained from the middle third of the root canal from which the DNA sample will be extracted to detect the presence of *enterococcus faecalis* virulence factor (efaA) using real time polymerase chain reaction.

**Results:** Gutta percha with Sealapex showed highest antibacterial efficacy against expression of *E. faecalis* virulence factor(efaA). Gutta percha with AH plus showed the second most effective antibacterial efficacy followed by Guttapercha with CeraSeal. The least antibacterial efficacy efficacy was expressed by the control group

**Conclusion:** Based on this study it could be concluded that the antibacterial efficacy against the expression of *E. faecalis* virulence factor (efaA) was highest for the calcium hydroxide based sealer (Sealapex) followed by resin based sealer (AH plus). It was least for calcium silicate based bioceramic sealer (CeraSeal).

### Abstract 152

#### Comparison of fracture resistance of endodontically treated teeth restored with three different restorative materials: An *in vitro* study

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**Aim:** To compare the fracture resistance of three different restorative materials in endodontically treated teeth.

**Objective:** To compare the fracture resistance of badly mutilated, endodontically treated teeth restored with three different restorative materials- Conventional nano hybrid resin composite (Ivoclar Tetric N-ceram), Nano ceramic composite (ceram.x sphereTEC One, Dentsply) and hybrid glass ionomer cement (GC gold label HYBRID) in MOD cavity.

**Materials and Methods:** Forty extracted human maxillary premolars were selected.

(GROUP 1): Ten intact teeth served as positive controls.

MOD cavities were prepared for the remaining 30 specimens and access gained using Endo access bur. Instrumentation was done upto F2 (size 25, 8%) ProTaper Gold files. Irrigation was done using 3% NaOCl solution. Root canal obturation was done with gutta percha and bioceramic sealer (Angelus Bio-C sealer). The specimens were then randomly divided into 3 groups of 10 teeth each. The cavities were restored with

GROUP 2: Conventional nano hybrid resin composite (Ivoclar Tetric N-ceram),

GROUP 3: Nano ceramic composite (ceram.x sphereTEC One, Dentsply) and

GROUP 4: Hybrid glass ionomer cement (GC gold label HYBRID).

The restorative procedures were carried out using Tofflemire matrix system for creating the proximal contours. Thermocycling was done for all the specimens (500 cycles). Fracture resistance was measured using Universal testing machine and the force needed to fracture each tooth was measured in Newtons(N).

**Results:** Fracture resistance was highest with intact teeth (positive control). Nanoceramic composite (ceram. X sphereTEC one, Dentsply) showed the highest fracture resistance among the experimental groups followed by nanohybrid composite (Tetric N-ceram, Ivoclar). The least fracture resistance was showed by hybrid glass ionomer cement (GC gold label hybrid).

**Conclusion:** Based on this study it could be concluded that, among the experimental groups, the fracture resistance was highest in nanoceramic composite followed by nanohybrid composite and it was least in hybrid glass ionomer cement.

### Abstract 153

#### Anti *Enterococcus faecalis* efficacy of astaxanthin as root canal irrigant: An *in silico* and *in vitro* study

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**Objective:** To assess the anti bacterial efficacy of 20% Astaxanthin (ASX) solution as a root canal irrigant against *E. faecalis* by disc diffusion assay. To assess the potential target sites of ASX against *E. faecalis* using molecular docking method.

**Materials and Methodology:** Molecular docking: Mechanism of anti *E. faecalis* action of astaxanthin was assessed using PyRx software version 0.8 with Auto Vina. Agar Disc diffusion assay: 20% ASX irrigating solution was prepared by dissolving 20 mg of powder in distilled water. 30 Kirby Bauer discs were taken and soaked in the following irrigation solutions till they were completely soaked: Group 1: 1000  $\mu$ l of 3% NaOCl, Group 2: 1000  $\mu$ l of 2% chlorhexidine, Group 3: 1000  $\mu$ l of 20% ASX (n=10 in each group). The discs were dried and placed in 6 MHI agar plates containing 10 $\mu$ l suspension of *E. faecalis* (MTCC 439). The agar plates are kept at room temperature for 2 hours for prediffusion of materials and then incubated at 37°C for 24 hours and observed for zones of inhibition.

**Statistical Analysis:** The results obtained from *in vitro* study were tabulated on excel sheet and was statistically analyzed for normality using Kolmogorov Smirnov test. Inter group analysis was quantitatively done using Kruskal Wallis ANOVA followed by post hoc test with Mann Whitney analysis. P value of less than 0.05 was considered statistically significant.

**Results:** Molecular docking revealed ASX targeted four potential sites against *E. faecalis* namely Nicotinamide adenine dinucleotide hydrogen(NADH), Alanine racemase (AR), Dihydrofolate reductase (DHFR) and Acyl carrier protein (ACP) with affinity values of -9.1, -8.4, -7.3, -4.6 kcal/mol respectively. Disc diffusion assay: NaOCl produced the maximum mean bacterial inhibition zone of (22 mm), followed by chlorhexidine (17 mm) and ASX (15.5 mm) which was statistically significant (NaOCl<CHX<ASX)(p-value<0.05). Post hoc test revealed that NaOCl produced significantly more bacterial inhibition zone in comparison with Chlorhexidine and Astaxanthin (p-value <0.001 & 0.05 respectively). However there was no significant different between Chlorhexidine and Astaxanthin as a root canal irrigant. (p-value=0.222).

**Conclusion:** *In vitro* and *in silico* analysis revealed that ASX could be a potential root canal irrigant against *E. faecalis* comparable to Chlorhexidine.

### Abstract 154

#### Warm vertical compaction obturation technique of maxillary second premolar with vertucci Type I configuration: Case report

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Root canal treatment needs an adequate process of cleaning, shaping, and obturation. However, the root canal configuration is a complex system. They can be separated or merge into one canal in the apex. This configuration was explained by Vertucci, who has identified the root canal space into eight configurations system. The Vertucci type I has a 48 percent on maxillary second premolar. The purposes of the obturation process are to seal all the communication from periapical tissue and prevent the bacteria grow in the root canal. Several previous

## Abstract

studies have also stated that the single-cone technique cannot provide adequate obturation in oval root canals. For obturation in wide root canals, like the Vertucci type I morphology, the operator should use the warm vertical compaction technique followed by thermoplastic injection. This case report will discuss the right maxillary second premolar with a diagnosis of symptomatic apical periodontitis of a 35th-year-old female patient who had vital root canal treatment. Root canal filling used the warm vertical compaction technique because the tooth has Vertucci type I anatomy. The post-treatment radiograph shows successful obturation. The warm vertical compaction technique resulted in more homogeneous obturation and had a significantly smaller number of voids when compared to the single-cone and lateral condensation techniques. This treatment is successful and shows a healing reaction since the patient has no other complaints. Moreover, there are no periodontal tissue abnormalities clinically and radiographically.

### Abstract 155

#### Variety of surface engineering techniques of NiTi instruments: A narrative review

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**Aim:** The aim and objective of this review is to present and discuss the characteristics of NiTi alloys and to present an overview on the variety of surface engineering techniques which may improve cyclic fatigue resistance, hardness and wear resistance while maintaining the torsional resistance and mechanical properties.

**Methodology:** A literature search for this narrative review was conducted in Google Scholar, PubMed and Web of Science using the keywords NiTi rotary instruments, cyclic fatigue, surface engineering techniques, surface treatment. Over 98 articles were found.

**Results:** identification of over 98 studies for preliminary analysis. Articles unrelated to the surface treatment of NiTi instruments were excluded. The included articles were checked to identify further relevant literature. Overall, 25 articles were included up to 2018.

**Conclusion:** This review summarizes that there appears to be a risk of corrosion for NiTi instruments without surface treatments and also the cyclic fatigue resistance of NiTi files is influenced by the surface treatment. Thus by performing various surface engineering techniques, a smooth surface, from which machining defects were removed can be achieved. Hence, improved cyclic fatigue resistance, hardness and wear resistance while maintaining the life of the instruments can be achieved.

### Abstract 156

#### Techniques for successful management of C-shaped canals: A case report

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India

The key for successful endodontics usually revolves around adequate knowledge of root canal anatomy and the ability to meticulously

perform cleaning and shaping procedures. The variations of canal configuration always present a challenge to endodontic management. A C-shaped canal is one of the variant canal configurations that require special attention and customization of the treatment process. A C-shaped canal presents as a thin fin connecting the canals and is commonly observed in single rooted mandibular second molars. Due to the presence of a high incidence of transverse anastomoses, lateral canals, and apical deltas, cleaning and sealing the root canal system in these teeth becomes difficult. The inaccessible areas and unique canal patterns make the provision of optimum treatment quality a highly challenging proposition. Successful endodontic therapy of this type of canal configuration can be achieved with a combination of rotary and hand instrumentation assisted with ultrasonics. Three-dimensional obturation of the canal system can be achieved by appropriate modifications to conventional obturation techniques. Early recognition of the C-shape becomes imperative for its successful management. This case report presents successful management of a C-shaped canal configuration encountered in a single-rooted mandibular second molar. A thorough Cone Beam Computed Tomographic evaluation was done before access opening to assess the root canal configuration. After access opening adequate cleaning and shaping of the canal was done accompanied with proper irrigation technique. Obturation was done with warm vertical compaction technique and entrance filling was given with composite.

### Abstract 157

#### Endodontic treatment of maxillary first premolar with Weine's Type IV root canal configuration: A case report

**STEVAN UNTONO, ADE PRIJANTI DWISAPTARINI,  
ARYADI SUBRATA**

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Jakarta, Indonesia

**Introduction:** understanding of the internal anatomy of teeth is important for clinician before approach to any endodontic procedure. Proper interpretation of radiograph, proper access cavity preparation, detailed exploration with higher magnification and illumination can be useful to recognize and locate root canals. The complexities of root canal should be effectively assessed and efficiently approached for successful endodontic therapy. This case present maxillary first premolar with Weine's type IV root canal configuration.

**Case Report:** a 59 years old male patient came to Department of Conservative Dentistry and Endodontics, University of Trisakti with chief complaint of uncomfortable dull pain on his upper left side teeth. Clinical examination showed the presence of decay with loss of palatal aspect. The tooth gave negative response to vitality test and was positive to percussion. Radiograph examination confirmed decay has reached the pulp chamber with periapical radiolucency. Crown lengthening was done followed by pre-endodontic build up before endodontic approach. The treatment was done under magnification.

**Conclusion:** Thorough knowledge of the root canal anatomy, proper radiograph image and interpretation, access cavity preparation and

Abstract

exploration of root canals with help of magnification can identify various internal anatomy of root canals.

**Abstract 158**

**Management of separated file on mandibular right first molar by bypass technique: A case report**

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ANASTASIA ELSA PRAHASTI**

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**Background:** File separation is an iatrogenic procedure that can occur during cleaning and shaping of the root canal system. Separated file arises primarily as a result of the metal fatigue (cyclic and torsional fatigue) and canal curvature. Correction of this mishap is challenging. Management of fractured files can be either non-surgical or surgical. Non-surgical approach includes the following treatment: bypass, removal, or instrumentation and coronal obturation of the fragment. **Objective:** To report the management of separated file on the mandibular right first molar by bypass technique. Case: A male patient, 16 years old, came to the University of Trisakti's dental hospital with a subjective complaint of a cavity on his lower right back tooth. He realized the presence of the cavity for a year. Two weeks ago, he began to experience a sharp pain in the offended tooth. On clinical examination, large caries were found on tooth 46. Percussion, palpation test, and gum boil showed positive. Cold thermal and mobility showed negative. The preoperative radiograph showed a radiolucent area with a diffuse outline on the mesial, distal root, and furcation. Broken file was seen at the middle to the apical third one of the mesial canal. Based on the clinical examination and radiographs findings, pulp necrosis with chronic apical abscess was diagnosed. Bypass procedure was done considering micro-biological and biomechanical aspects. Bypass procedure was initiated with file #06 (Switzerland, Dentsply Maillefer) to cross over the fragment into the apical region. A watch-winding combined with light in and out movement along with multiple root canal irrigation was performed. File #08, #10, and #15 (Switzerland, Dentsply Maillefer) were used for scouting until the full working length and create a smooth apical glide path. Each root canal was prepared by using crown down technique. Post-endodontic treatment restoration was cast-metal onlay. Four weeks follow-up revealed that healing was found to be satisfactory, while percussion and palpation were absent.

**Conclusion:** Bypass procedure considered to be a conservative technique, with low risk of clinical mishap and acceptable clinical success rates.

**Abstract 159**

**Deep margin elevation technique to achieve success in post endodontic restoration: A case report**

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ELLINE ELLINE**

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Trisakti University, Jakarta, Indonesia

Restoring cavities with subgingival margins may be challenging during rubber dam isolation, dental impression, and delivery of the

restoration. These procedures are time-consuming and can cause inappropriate placement of the restoration. The purpose of deep margin elevation technique is to coronally displace proximal margin using a base of composite resin following the placement of a matrix, under rubber dam isolation. The adhesive composite resin base is also used to seal the dentin, reinforce the undermined cusps, fill undercuts, and provide the necessary geometry for inlay or onlay restorations. This case report describes a coronal margin elevation, followed by placement of indirect partial adhesive restoration. A 39-year-old female patient came to the office with a chief complain of a cavity on tooth 35. Clinical examination revealed a class II caries at the distal site of tooth 35 reaching the gingival sulcus. There was no response to cold test, no tooth mobility, and probing depths of 2 mm. Radiographic examination showed the presence of deep distal caries approaching the pulp cavity and an apical radiolucency. The diagnosis of 35 was pulp necrosis, asymptomatic apical periodontitis. Root canal treatment was performed after isolation of the operative field and pre-endodontic build-up. Negotiation of the canal was performed using size 8 and 10 K-file, followed by rotary instrumentation, copious irrigation, and obturation with warm vertical compaction technique. The pre-endodontic build-up was removed, then a basis for restoration was created by elevating the margin of the cavity with composite using sectional matrix, wedge, and ring under absolute isolation. Afterward, bulk-fill flowable composite was used to create a barrier followed by application of packable composite. Vonyl restoration was performed to avoid fracture and correct the slight misalignment. Deep margin elevation is a non-invasive alternative to the surgical procedure in treatment of subgingivally damaged tooth structures.

**Abstract 160**

**Apicoectomy- A review**

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Apicoectomy also known as root resection is defined as surgical removal of the apex of the root and is a part of surgical endodontics. It includes surgical treatment of area surrounding root and is done when conventional root canal treatment has failed to remove the infection. This procedure includes three important steps to eliminate persistent endodontic pathogens: surgical debridement of pathological periradicular tissue, rootend resection (apicoectomy), and retrograde root canal obturation (root-end filling). There is abundance of literature on the clinical studies and case reports on apicoectomy procedures. Thus, the main aim of this review is to discuss the theoretical and clinical aspects of this procedure.

**Abstract 161**

**Mandibular first molar with middle distal canal: A case report and review**

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Tamil Nadu, India

Abstract

Achieving consistently high levels of success in endodontic treatment requires a thorough understanding of anatomy of root canal and. Associated structures. The root canal system must be effectively debrided, disinfected, obturated and restored post-endodontically. Morphology of permanent mandibular molars are generally described as a group of teeth with two roots and three or four canals. Variations in normal anatomy of permanent mandibular first molar have been extensively reported in literature. The incidence of middle distal canal in the mandibular first molar has been reported as rare with a incidence of between 0.2 to 3 %. This case report describes the pre-operative assessment, diagnosis and techniques for successful management of a case of mandibular first molar with this unusual canal configuration of three distal canals. Morphological variations in pulpal anatomy must always be looked and assessed preoperatively as one of the most common reasons for failure is a missed canal. It is necessary for the clinician to have knowledge of not only the normal anatomy but also its variations. Though frequency of incidence of this condition is low, each case should be evaluated carefully preoperatively and suitable treatment methodologies should be considered when such anatomical variations are found.

**Abstract 162**

**Successful multidisciplinary management of an endodontic-periodontal lesion in first mandibular molar with radix entomolaris: A case report**

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Endodontic-periodontal lesions have a varied pathogenesis ranging from simple to relatively complex one related to the presence of anatomical and vascular relationship between the pulp and periodontium that could facilitate bacterial transportation between the two structures. Diagnosis and management of endodontic-periodontal lesions are often challenging to clinician caused by the similar characteristic of the clinical condition between the primary and secondary lesion and the treatment outcome is not as predictable as lesion of single origin. Accurate identification of the primary etiological factor through a thorough clinical and radiograph examination is important to determine the correct diagnosis and prognosis in endodontic-periodontal lesions. Moreover, the presence of anatomical variation in pulpal and periodontal poses a challenge to the comprehensive management of endodontic-periodontal lesions. This case report presents the successful multidisciplinary management treatment outcome of endodontic-periodontal lesion in first mandibular molar with Radix Entomolaris. A 25 years old female patient was referred to Departement of Conservative Dentistry Clinic at RSKGM Faculty of Dentistry, Universitas Indonesia with recurrent throbbing symptoms of her lower right molar. The endodontic-periodontal lesion was initially conducted with non-surgical endodontic therapy followed by periodontal treatment using open flap debridement with bone graft application technique. After three-month follow up, patient was completely asymptomatic

with an increase of the gingival attachment level, no furcation involvement, and reduction of the lesion size on the radiograph. At six-month follow up, the tooth remained asymptomatic and significant healing of bone defect was presented radiographically.

**Abstract 163**

**The dislocation resistance of prefabricated aesthetic fibre posts bonded with self-adhesive resin cement following air abrasion: A systematic review and meta-analysis**

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**Background:** This systematic review aimed to determine the presence of any in-vitro proof to validate the utilization of air abrasion to advance the bond strength of fibre posts to intra-radicular dentin with self-adhesive resin cement.

**Materials and Methods:** Laboratory studies that assessed the push-out or pull-out bond strength of prefabricated aesthetic posts whose surface was treated with air abrasion and bonded using self-adhesive resin cement within the root canal model were included for this systematic review. Study reporting was performed following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Relevant articles were identified using a literature database search in Web of Science, Scopus, PubMed, and EBSCO. Besides this hand search was also done to ensure complete capture of the articles.

**Results:** Six articles were then selected and included in this study out of which one was excluded for meta-analysis due to usage of the artificial substrate. It was shown that an additional step of air abrasion of the aesthetic fibre post did not result in significant improvement in dislocation resistance. Assessment of risk of bias categorized the available research into high risk and medium risk. The results showed heterogeneity.

**Conclusion:** The use of additional steps such as mechanical post surface treatment does not have any added benefit. However, the results must be interpreted with caution due to methodological shortcomings.

**Abstract 164**

**Disinfecting efficacy of pomegranate peel extract, garlic, tulsi leaf and clove leaf with autoclaving on dental round burs tested against *Enterococcus faecalis***

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**Objectives:** To compare the disinfecting efficacy of Pomegranate Peel Extract oil, Garlic oil, Tulsi leaf oil and Clove leaf oil with standard autoclaving on dental round burs infected with *Enterococcus faecalis*.

**Materials and Methods:** Round dental burs were exposed to *Enterococcus faecalis* and the disinfecting capability of four different test chemicals against autoclave were evaluated using two different methods- Blood agar streaking method to check for colony forming

Abstract

units and peptone water test was used to check for turbidity which proposed the growth of bacteria. After overnight incubation, gram stain was performed from the colonies grown on Blood agar plate and from the overnight turbid peptone water. The presence of catalase negative gram positive cocci in pairs confirmed the presence of *Enterococcus Faecalis* and helped to rule out any contamination during the entire experiment.

**Results:** Clove leaf oil showed the best disinfection efficacy, followed by Tulsi leaf oil comparable to autoclaving, whereas Garlic oil and Pomegranate peel extract oil were significantly less effective against *Enterococcus faecalis*.

**Conclusion:** Clove leaf oil and Tulsi leaf oil can be used to disinfect dental burs, as alternatives to autoclaving against the tested organism.

### Abstract 165

#### Comparative evaluation of volume and homogeneity of obturation with four different obturation systems using microcomputed tomography: An *in vitro* study

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**Aim:** To evaluate and compare the volume and homogeneity between Single cone gutta-percha, Beefill 2 in 1, Guttacore and Guttaflow bioseal obturation systems.

**Materials and Methods:** Twenty four single rooted premolar teeth were selected and decoronated. The roots were instrumented with protaper next upto X3 and divided into 4 groups with 6 samples each (n=6), namely: Group I (Single cone gutta-percha obturation) Group II (Beefill 2 in 1 obturation), Group III (Guttacore obturation), Group IV (Guttaflow bioseal obturation) and subjected to preoperative MicroCT imaging to evaluate the volume of the prepared root canal space, then the root samples were obturated. The post-obturation MicroCT imaging was taken to evaluate the volume of obturation material in the prepared root canal space and the area of voids in the apical, middle, coronal third sections.

**Results:** Guttacore obturation showed least mean difference in the volume of obturation and showed least mean area of voids in the apical, middle and coronal thirds with statistically significant difference in the apical and middle thirds ( $p < 0.05$ ).

**Conclusion:** All the four groups had difference in volume and showed voids in the obturation at different levels. Within limitations of this study it is concluded that the Guttacore obturation occupied the maximum volume of the prepared root canal space with minimum of voids.

### Abstract 166

#### Unmasking through digital evidence - endodontic imaging in forensics

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Dental identification of a deceased individual is a core task in Forensic Odontology and plays a vital role in identifying remains when there is a lack of a fingerprint record. The accurate recording of clinical dental procedures has become more critical because of the increasing trend of lawsuits worldwide. Teeth and the facial bones of the human body are considered to endure destruction or decomposition even under temperature variations and may remain intact for many years after a person's death. The classic comparative dental identification uses post-mortem and ante-mortem dental records to determine similarities and exclude discrepancies that are considered essential for both humanitarian and judicial reasons. Dentofacial radiography has become one of the routine procedures in dental and medical hospitals in this digital era as a part of primary investigations. In forensic dentistry, written dental records that comprise documents that attempt to convey in written language, features observed during dental examination are more prone to errors because these records would be written by an individual different from the operator. Such errors may lead to failure to identify individuals correctly. However, radiographic images such as (Periapical radiographs and Three Dimensional Images) display details of the physical features of the item recorded and form accurate records of a person derived directly from that person; they are not surrogate records in the way that written records are. Therefore, dental radiographs play a valuable role as legal tools supporting the criminal demands on the daily forensic practice by providing all necessary information so that legal authorities may recognize malpractice, negligence, fraud or abuse, and identify unknown humans. Nevertheless, these dental radiographs are easily duplicated, stored, or distributed in digital format, making it difficult to guarantee the authenticity of digital images; hence they have to be protected against manipulation. This review explores and highlights the versatile nature of the imaging modality by reviewing its application in the field of forensic dentistry.

### Abstract 167

#### Effect of intracanal medicaments on radicular dentine: A FTIR spectroscopy analysis

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India

**Objective:** This study aims to evaluate the effect of calcium hydroxide, calcium hydroxide combined with silver nanoparticles and graphene oxide combined with silver nanoparticles medicaments on the chemical arrangement of radicular dentine by Fourier-transform infrared (FTIR) spectroscopy.

**Materials and Methods:** Eighteen mandibular premolars were sectioned to obtain 54 radicular dentine discs and Pre-FTIR analysis was performed for all the samples which served as a control. Calcium hydroxide (CH) paste (Group I), calcium hydroxide combined with silver nanoparticles paste (Group II), graphene oxide combined with silver nanoparticles paste (Group III) medicaments were applied on the pulpal surface of the dentine & placed in a small eppendorf tube and stored at 37 °C for 1 week. After a given time interval, stored samples were taken out and washed thoroughly with deionized

Abstract

water for 15 min to washout treatment paste completely. Using FTIR spectroscopy, Post- FTIR analysis was performed and the Amide/ Phosphate ratios were determined.

**Results:** Statistical analysis of the collected data was performed using SPSS version 23.0. Normality test for the collected data was performed using Shapiro-wilk numerical test & normal curve graphical test. The data was found to be normally distributed. Hence, parametric analysis was performed. Inter-group comparison of mean Amide/phosphate ratio was done using one-way ANOVA with Tukey's pairwise comparison. Intra-group comparison of mean Amide/phosphate was done using paired t test. p value <0.05 was set as statistically significant. There was no significant difference between the groups was seen, though the mean Amide/phosphate ratio was found to be low in group II & III as compared to group I. However, there was a significant difference between Pre-FTIR and Post-FTIR in group I with no significant difference in Pre- FTIR & Post-FTIR of group II & III.

**Conclusion:** All medicaments caused demineralization of radicular dentine depending on the duration of time. Calcium hydroxide (CH) caused maximum demineralization of radicular dentine as compared to the calcium hydroxide combined with silver nanoparticles and graphene oxide combined with silver nanoparticles.

#### Abstract 168

##### Comparative evaluation of various irrigant activation systems following different tapers of rotary instruments using radiopaque dye: An *in vitro* study

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**Aim:** The aim of this study is to comparatively evaluate the various irrigant activation systems following different tapers of rotary instruments using radiopaque dye in single rooted teeth.

**Materials and Methods:** A sample of twenty single rooted teeth were standardised at the level of CEJ, access cavity preparation was done followed by cleaning and shaping using 4% and 6% taper rotary instruments under irrigation with 3% NaOCl. Radiopaque solution was utilised to measure the depth of irrigant penetration from the apex. The irrigation techniques performed during this study were: (i) sonic activation and (ii) ultrasonic activation. Radiographs were taken after dye injection to measure the length of irrigant penetration in each technique. Results were statistically analysed using SPSS software. One way ANOVA and post hoc Tukey tests were performed.

**Results:** The depth of penetration from the apex was calculated and the mean values were obtained as: Group 1: Sonic(4% taper)- 2.4+/-0.3; Group 2: Sonic(6% taper)- (1.4+/-0.3); Group 3: Ultrasonic (4% taper)- 1.8+/-0.3 and Group 4: Ultrasonic (6% taper)- 0.8+/-0.3. The study reveals that ultrasonic activation after 6% taper instrumentation was proved to be effective followed by ultrasonic activation after 4% taper instrumentation. The results revealed a highly significant difference between the irrigation techniques.

**Conclusion:** This study has indicated that ultrasonic irrigant activation proved to be better and an effective technique for cleaning of the root canal.

#### Abstract 169

##### A survey on challenges encountered during rubber dam isolation among Indian dental practitioners

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**Aim:** To assess the challenges and problems encountered during rubber dam isolation among Indian dental practitioners.

**Materials and Methods:** A self-administered web-based questionnaire was designed and used for data collection. The participants comprised of total 214 Dental Health Care Professionals including General Dental practitioners, Post Graduates and Endodontists. Information sought included various problems they encounter during rubber dam isolation and description of challenges they face during the same. The data was analyzed using Statistical package for social sciences (SPSS v 26.0, IBM).

**Results:** 70.1% of respondents encountered problems in selection and adaptation of rubber dam clamp. 82.7% found rubber dam application time consuming whereas 65.4% lack experience/ knowledge in placement of rubber dam. 82.2% encountered rubber dam sheet tearing as the main problem while using rubber dam sheet. 69.6% faced impingement of gingival tissue whereas 65.9% faced accidental dislodgement of clamp as main problem(s) with rubber dam clamps. 82.7% encountered difficulty in taking radiographs due to rubber dam frame. 79.4% were aware of modifications in rubber dam frames of which 78.7% are more aware about Nygaard Ostby frame. 71.5% are more aware about Optra-dam as an alternative to conventional rubber dam.

**Conclusions:** Rubber dam isolation is considered as gold standard for isolation in dental practices and more so in endodontic practices. The Covid pandemic has further stressed its importance and may act as an additional shield to protect the clinician from aerosol generating procedures. It is challenging for most practitioners as it needs skilled expertise for quick and efficient placement. This survey revealed that there is an urgent need to introduce Rubber Dam Isolation at early stages in Dental Education and make it as a mandatory practice. Also research needs to be directed at better, convenient and eco-friendly alternatives to Rubber Dam Isolation.

#### Abstract 170

##### Broken file removal - solve problems as they arise

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Once root canal treatment is considered, clinician must be aware of the real possibility that complications and unforeseen accidents can occur. Procedural errors of which instrument fracture is probably the most challenging to manage, can occur during any stage of root canal cleaning and shaping. It compromise and reduces the prognosis of tooth by preventing 3D sealing of canal. The best antidote for a broken file is prevention. Yet, when this procedural accident occur,

Abstract

it is reassuring to know that removal procedures can generally be executed to solve this problem, in times when bypass is not possible. This poster will emphasize the importance of coronal and radicular access, with special focus on the retrieval methods and commercially available retrieval systems that improve safety, efficiency and simplicity when removing intracanal obstructions.

### Abstract 171

#### Intentional re-implantation: An asset for a hopeless tooth

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Re-implantation means re-insertion of tooth in its socket, after its complete avulsion due to trauma or some other etiologies. Intentional re-implantation is a purposeful extraction of a tooth and its re-insertion into the socket almost immediately after sealing the apical foramen. It is a one stage treatment that maintains the natural tooth aesthetics. The success rate varies between 52-95%. Key points to be considered are, the surgical procedures have to be rigorous, minimum extra-oral time and splint adapted properly. This case was done in the Department of Conservative Dentistry and Endodontics, UDMRI, Dehradun, Uttarakhand. A male patient aged 28 years reported to the department with the chief complaint of pain, swelling, protrusion, mobility in maxillary left central incisor. Clinical examination revealed pathologically migrated tooth 21, with palatal inflammation and grade III mobility. Radiographic examination revealed moderate to severe bone loss and a periapical radiolucency of the affected tooth. The resulting clinical situation had guarded prognosis. The line of treatment was Intentional Re-implantation. Firstly, tooth was extracted atraumatically. The extracted tooth was held with gauze moistened with isotonic saline and root planing was done for removal of necrotic debris adhering to root cementum and granulation tissue. RCT was carried out in the extracted tooth. The socket was then subjected to curettage to remove inflammatory tissue. The root surfaces were treated with tetracycline solution and re-implanted in the alveolar socket with the help of bone graft and splinting. Post-operative radiographs were taken and the patient was recalled for follow up at regular intervals.

### Abstract 172

#### Comparative evaluation of apical microleakage in immediate and delayed post space preparation using four different root canal sealers by using stereomicroscope: An *in-vitro* study

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**Objective:** The aim of the study was to compare and evaluate the apical microleakage in immediate and delayed post space preparation using four different root canal sealers such as zinc oxide Eugenol, Meta ADseal, Endomethasone N, Bioroot RCS by using a stereomicroscope.

**Materials and Methodology:** A sample of ninety extracted mandibular first premolar teeth were taken and decoronated at

cemento-enamel junction. Root canals were prepared and divided into 4 groups. Forty teeth each in group A and B; and 5 teeth each in group C and D.

Group A and B were further divided into 4 subgroups (A1, A2, A3, A4, B1, B2, B3, B4). Obturation was done using gutta percha and respective sealers using single cone technique.

Subgroup A1 and Subgroup B1 – Zinc oxide Eugenol

Subgroup A2 and Subgroup B2 – Meta ADseal

Subgroup A3 and Subgroup B3 – Endomethasone N

Subgroup A4 and Subgroup B4 – BioRoot RCS

Group C – positive control group

Group D – negative control group

Next post space preparation were done immediately for group A and delayed post space preparation were done after a week for group B. All the samples were then placed in 2% methylene blue dye for 3min. The teeth were removed and sectioned vertically and evaluated under stereomicroscope for apical microleakage. Data were analyzed using Mann-Whitney test and Kruskal-Wallis tests.

**Results:** The post space preparation done immediately using BioRoot RCS sealer showed the least apical microleakage and delayed post space preparation using Zinc oxide eugenol sealer showed the maximum amount of apical microleakage.

**Conclusion:** Apical microleakage was seen among all the groups. Among the sealers, BioRoot RCS showed the least amount of microleakage, followed by Meta ADseal, Endomethasone N and the highest apical microleakage was exhibited by Zinc oxide eugenol.

### Abstract 173

#### Comparative evaluation of cutting efficiency, cyclic fatigue, corrosion resistance, autoclave cycle effects of three different file systems: An *in-vitro* metallurgy analysis

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**Aim:** To compare the cutting efficiency, cyclic fatigue, corrosion resistance and autoclave cycle effects of Protaper Gold, TruNatomy and Wave One Gold file systems *in-vitro*.

**Materials and Methods:** For evaluating cutting efficiency, mesiobuccal roots of maxillary first molars having similar weights was used. The roots were randomly divided into three groups (n=10 for each); Group A, B, C; Protaper Gold, TruNatomy-Prime and WaveOne Gold- Primary preparations respectively. Hyposol – 3% hypochlorite sodium was used for irrigation. The specimens were weighed using the AUW220D scale (Shimadzu, Kyoto, Japan) before and after instrumentation. Weight of the material removed by each instrument in 240 seconds gives cutting efficiency. For evaluation of cyclic fatigue, corrosion resistance and autoclave cycle effects, files were randomly divided into three groups, Group A, B, C; Protaper Gold-F2, TruNatomy-Prime and WaveOne Gold-Primary (n=10) respectively. For cyclic fatigue testing (3-point bend test) the instruments were firmly held with clamping mechanism with passive adjustment and without pressure in a stainless-steel block containing an artificial

Abstract

canal (Gambarini *et al.* and Champa *et al.*). The time was calculated in seconds (s) until fracture. The number of cycles to fracture (NCF) was calculated by the following formula: (Resistance (s) x Speed)/60. For evaluation of corrosion resistance, surface topographical analysis was carried out using High resolution SEM in response to three irrigants (5.25% NaOCl, 2% CHX, 17% EDTA). For evaluation of autoclave cycle effects, High resolution SEM surface topographical analysis was carried out for 1, 5 and 10 autoclave cycles. Data was analysed using one-way ANOVA followed by multiple comparisons with Bonferroni test ( $\alpha=0.05$ ). The level of statistical significance were determined at  $p<0.05$ . **Results:** TruNatomy was the most resistant to cyclic fatigue and Protaper Gold the least. WaveOne Gold removed significantly more dentin and had least corrosion resistance and highest autoclave cycle effects compared to TruNatomy and Protaper Gold. **Conclusion:** TruNatomy can be considered as a better file system compared to Wave One Gold and has comparable efficiency with Protaper Gold.

#### Abstract 174

### Comparison of stress distribution and failure probability of endodontically treated teeth with different computer-aided design/computer-aided manufacturing materials: A finite element analysis

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**Aim:** To compare the stress distribution and failure probability of endodontically treated mandibular first molars with different CAD/CAM materials using 3D finite element analysis.

**Materials and Methods:** Three 3 dimensional models of mandibular first molars were modeled with a CAD software (SpaceClaim 2021 R1). The first model comprised of tooth restored with lithium disilicate crown, the second model comprised of tooth restored with lithium disilicate endocrown and the third model comprised of tooth restored with polymer infiltrated ceramic network (PICN) endocrown. The designed models were imported to Ansys (Workbench 2021 R1) testing software. The mechanical properties including elastic modulus, Poisson's ratio and density of dental structures and materials were assigned. The three models were obtained from the same mesh design to avoid variations in stress levels among the models. An angular and vertical load of 600N was applied at the occlusal surface. Results were determined by colorimetric graphs of maximum principal stress (MPS). Von Mises stress were evaluated and the Weibull function were incorporated with finite element analysis to calculate the long-term failure probability.

**Results:** Endocrown restorations presented a lower mV stress level than the conventional crowns. Stress distribution in endocrown restored with polymer infiltrated ceramics (PICN) was lower when compared to endocrown restored with lithium disilicate glass ceramics. Weibull analysis revealed that the failure probability diminished in endocrown when compared to conventional crowns. **Conclusion:** Endocrowns can be considered as a conservative,

aesthetic and clinically feasible restorative approach for endodontically treated mandibular first molars.

#### Abstract 175

### Development of novel bioactive glass-tideglusib nanoparticles as a dentine regenerative material

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Kattankulathur, Tamil Nadu, India

**Aim:** Primary objective, of this study was to synthesize tideglusib coated nanoparticles incorporated in an experimental calcium silicate-based cement. Secondary objective was to evaluate the physical, mechanical and Cytocompatibility of the newly synthesized experimental cement.

**Materials and Methods:** Bioactive glass nanoparticle was synthesized by sol-gel method, to these nanoparticles tideglusib (GSK-3 inhibitor) was loaded. Experimental Calcium silicate cement was manufactured by sol-gel method, drug loaded nanoparticles were added to the cement at 5, 10 and 15 weight percentage. Commercial Biodentine (BD), bioactive glass nanoparticles mixed with experimental cement (BgC) and drug loaded bioactive glass nanoparticles mixed with experimental cement (D-BgC) were the three different groups evaluated in this study. Physicochemical properties including initial setting time, compressive strength and alkalinity were evaluated for different weight percentages. Drug encapsulation efficiency and drug release from 2\*2mm set D-BgC was analysed. Cytocompatibility was assessed with scratch wound healing assay, transwell migration assay and proliferation assay. Statistical analysis was performed by using one-way analysis of variance (ANOVA) and Tukey's test ( $p<0.05$ ).

**Results:** Addition of nanoparticles did not affect the initial setting time, which was comparable to Biodentine ( $P> 0.05$ ). After 1day, Compressive strength and alkalinity of 15wgt% group of D-BgC was comparable to that of BD ( $P<0.05$ ). Encapsulation efficiency of the drug was 62.332% and there was an immediate drug release in the initial 6-12hrs followed by a sustained release with tapering percentages up to 48hrs( $p>0.05$ ). D-BgC exhibited better wound healing, faster proliferation and better migration of human dental pulp stem cells (hDPCs) than compared to that of BD ( $p<0.05$ ).

**Conclusion:** In this study, dentine regenerative potential of drug-loaded nanoparticles incorporated in an experimental calcium silicate-based cement was evaluated, it was found to have comparable physical properties and better regenerative properties than the commercial alternatives, indicating a new direction for regenerative endodontics.

#### Abstract 176

### Recent advances in repair material for bony defects subsequent to periapical surgery

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According to American Association of Endodontists 2018 the primary objective of endodontic treatment is to prevent and

Abstract

intercept pulpal/periradicular pathosis and to preserve the natural dentition when affected by pathosis. Despite the recent advances in endodontic materials, instruments, and techniques, the complete resolution of periapical pathology is not achieved in some cases. Under such circumstances, the only line of treatment is often surgical intervention. The ultimate goal of endodontic surgery is the predictable regeneration of periapical tissues, including the complete repair of the osseous defects which has an important bearing on tooth retention. The ideal bone replacement material should be clinically and biologically inert, noncarcinogenic, facilitate revascularization, osteogenesis and osteo-induction, provide adequate stability and support and should slowly resorb to permit replacement by new bone. Different types of materials are available for grafting of osseous defects. These include autografts, allografts, xenografts and alloplasts. Calcium hydroxyapatite (HA) and tricalcium phosphate (TCP) have gained much attention and popularity which constitute the ceramic/synthetic grafts. Recently bioactive glass was introduced in the putty form, (NovaBone®) which is a next-generation calcium phospho-silicate bone graft material built from a bioactive glass platform with additives that improve handling characteristics and performance. Some bioactive proteins like Bone Morphogenic Protein, Platelet Rich Fibrin or Platelet Rich Plasma can be used as an adjunct to the bone graft materials. The present review will highlight the recent advances in materials to repair bone defects post endodontic surgery.

#### Abstract 177

### Comparative evaluation on neutralizing effect of reactive oxygen species of limonene and cytotoxic analysis of citrus sinensis as root canal irrigant on fibroblast cells

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**Introduction:** Resistant microbes always represent a challenge in the treatments of various well-known infections and urges the need for substances with potent antimicrobial properties. Citrus sinensis is known for its medicinal value. ROS are oxygen-containing, chemically reactive molecules which kill microbes but also destroy the adjacent infected host tissues. This study aims to evaluate the cytotoxicity of citrus sinensis against fibroblasts and the neutralizing effect of limonene (orange peel extract) on reactive oxygen species generated by the mixture when used as an intracanal medicament. **Methodology:** Citrus sinensis extracts were screened for in vitro cytotoxic activity against L9292 cells using MTT cell viability assay. The microplates filled with 100  $\mu$ l of L929 Cells and growth medium using micropipette, read on an ELISA reader at 570 nm. Each experiment was carried out in triplicate and the IC50 of the test samples as the percentage survival of the cells was calculated. Group A: 2% CHX gluconate (control group) Group B: A mixture of 125 mg of Ca(OH)<sub>2</sub> with 2% CHX gluconate solution. Group C: was a mixture of 125 mg of Ca(OH)<sub>2</sub> with 1 mL of 2% CHX gluconate solution and dichloromethane (orange peel extract). The groups were analyzed for ROS formation using the mass spectrometer (JEOL GC MATE II) immediately after preparation.

**Results:** CSE did not adversely affect the fibroblasts even up to 50%

concentration showing a nontoxic effect even till 200  $\mu$ g/ml dose in comparison with CHX on these cells. The peak value of 3345.6 m/z denotes ROS formation. Limonene reduces the ROS significantly, shows more antioxidant properties when compared with other groups. Addition of natural antioxidants to the Ca(OH)<sub>2</sub>-CHX mixture increases the antibacterial efficacy and also decreases damage to the host tissue by lowering ROS formation.

**Conclusion:** Citrus sinensis peels extract demonstrated less cytotoxic activity. The peak value obtained probably originated from the production of reactive compounds. Thus decreased ROS formation was noted in orange peel aqueous extract warranting further in vivo clinical studies to determine the exact dosages and its effectiveness in practical situations.

#### Abstract 178

### Evaluation of inter-canal distance in mandibular first permanent molar with middle mesial canal amongst Indian sub-population: Cross-sectional cone beam computed tomographic analysis

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Karnataka, India

**Aim:** Analysis of the inter-canal distance between mesio-buccal (MB) and mesio-lingual (ML) canals in the presence of middle mesial canal (MMC). Categorical assessment of the prevalence of MMC variants in Mandibular First Permanent Molar (MFPM) in an Indian sub-population considering factors of age and gender.

**Methodology:** Analysis of pre-operative CBCT images was performed on 256 MFPM. MMC when detected, was classified as fin, confluent or independent as per classification given by Pomeranz et al (1981). Orthogonal slices from pulpal floor up to 2mm below root furcation were used to measure mean inter-canal distance from buccal wall of MB to lingual wall of ML canal using CBCT software tool.

**Statistical Analysis:** Data recorded was subjected to descriptive statistics, Chi-square test and Independent t-test using SPSS software version 23 (p-value  $\leq$  0.05).

**Results:** Occurrence of independent MMC was 4.7% (n=12), confluence 14.6% (n=37) and fin 8.7% (n=22). Mean inter-canal distance measured for the fin variant was  $3.12 \pm 0.512$ mm,  $3.31 \pm 0.402$ mm for confluence variant,  $3.72 \pm 0.493$ mm for independent MMC and  $3.36$ mm  $\pm$  0.579 for two-canal variant. Significant association (p=0.001) was observed between age and gender, and overall detection of MMC, where in presence of fin (8.6%) and confluent (12.9%) configurations was higher (p=0.003) in individuals  $\leq$  40 years. There was increased inter-canal distance observed in females (17.9%) than in males (10.3%), for confluent, independent and two-canal configuration (p=0.04; =0.01, =0.001). Decrease in inter-canal distance was observed in individuals aged >40 years for two-canal configurations which was statistically significant (p=0.05).

**Conclusion:** Pre-operative CBCT assessment of MFPM aids in detection of MMC. According to the results of this study, individuals aged 40 years or less, have shown higher prevalence of fin and confluent variants. Increased inter-canal distance was seen in females for confluent, independent and

Abstract

two-canal configurations. Decreased inter-canal distance was seen in individuals aged more than 40 years having two-canal configuration. Thus, root canal complexities vary with age and gender, and should be taken into consideration prior to endodontic treatment.

### Abstract 179

#### Clinical presentation of mucormycosis and endodontic diagnosis

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**Objective:** Clinical presentation of mucormycosis and endodontic diagnosis.

**Description:** Mucormycosis, also called zygomycosis or phycomycosis is an uncommon, opportunistic, acute infection with high morbidity rate. It is caused by a certain number of fungi species. Due to Covid 19 pandemic, Mucormycosis has recently come in picture as a serious post covid complication with cases increasing rapidly. Often case of Mucormycosis may manifest with dental pain and apical radiolucency at the initial stage. Lack of proper knowledge and understanding about the condition will turn the situation critical. Due to initial resemblance to an Endodontic lesion, it becomes highly essential for an Endodontist to properly understand the signs and tests to diagnose the condition. The review attempts to express importance of oral signs of condition and alert clinicians to include Mucormycosis in the differential diagnosis for the early management of this life-threatening fungal infection.

**Result and Conclusion:** Awareness by healthcare professionals is critical for the prompt diagnosis of this rapidly developing and lifethreatening infection.

### Abstract 180

#### Stereomicroscopic evaluation of pre and post instrumentation surface defects of nickel-titanium instruments in moderately curved root canals: An *in vivo* pilot study

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**Objective:** To evaluate pre and post instrumentation surface defects of Nickel-Titanium Endodontic Instruments under the stereomicroscope.

**Materials and Methods:** 40 individuals requiring endodontic treatment and satisfying the inclusion criteria for the study were included. For root canal instrumentation, NiTi endodontic instruments used were Fkg XP Endo Shaper ((FKG Dentaire, La Chaux-de-Fonds, Switzerland) ) and Micro Mega One Curve (Micro Mega, Besancon, France). Pre instrumentation Examination of all the files was done under stereomicroscope to observe for surface defects. 40 subjects were randomly divided into 4 groups having 10 individuals each. Grp 1: Instrumentation of root canal in 10 individuals was done using FKG Endo Shaper for 15 seconds. Grp 2: Instrumentation of root canal in 10 individuals using FKG Endo Shaper for 30 seconds Grp 3: Instrumentation of root canal 10 individuals using Micromega One Curve for 15 seconds. Grp 4: Instrumentation of root canal using in 10 individuals Micromega One Curve for 30seconds. After instrumentation all the files were cleared off the debris using a gauze piece, stabilized using an endo

block. Examination was done by a single observer at the apical and middle third of the file under the Stereomicroscope in 40X magnification at 90-360 degrees for the presence of any surface defect or deformity. The observations were recorded and maintained. Scoring of defects was assigned to each file according to the degree of damage.

**Statistical Analysis Used:** Kruskal Wallis test and Mann Whitney Post hoc test were used to compare the median microscopic scores between different groups at Apical and Middle third region.

**Results:** Defects were observed on examination under the stereomicroscope than naked eye observation. Apical region showed more defects compared to middle third region. Micromega One Curve file showed less surface defects when compared to FKG XP Endo shaper. None of the files fractured during root canal instrumentation

**Conclusion:** Niti instruments can be safely used within root canals for duration upto 30 seconds. However, studies with more number of samples are required to confirm.

### Abstract 181

#### Evaluation of the inhibitory potential of blackseed and brown seaweed against the *Enterococcus faecalis* biofilm: An *in vitro* and *in silico* study

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**Objectives:** To evaluate the inhibitory activity of black seed extract and brown seaweed extract against *Enterococcus faecalis* biofilm. To investigate the binding interaction between the active components of blackseed and brown seaweed against the Enterococcal surface protein of *Enterococcus faecalis* through molecular docking.

**Materials and Methods:** The ethanolic extracts of blackseed and brown seaweed were prepared using the soxhlet apparatus. They were categorised as Group I: Blackseed and Group II: Brown seaweed. The antibiofilm activity was assessed using the crystal violet biofilm assay. *Enterococcus faecalis* biofilm was sub-cultured on BHI broth. Cell suspension were inoculated with the test compounds in 96 well micro-titre plate. Planktonic cells were removed by washing with PBS. The wells were stained with 125µl of 1% crystal violet and the percentage of inhibition was evaluated. The molecular docking process was performed using the SWISSDOCK suite. PyMOL version 4.5.0 was used as visualization software. The Enterococcal surface protein (Esp) was selected as the target protein of *Enterococcus faecalis* due to its primary role biofilm formation. Thymoquinone of Group I and Ledene oxide of Group II selected as ligands based on their chromatographic studies.

**Results:** The percentage of inhibition of *Enterococcus faecalis* biofilm analysed through crystal violet assay showed Group I - 52.13 % and Group II 38.31% of antibiofilm activity. The binding energy of thymoquinone (Group I) and ledene oxide (Group II) analysed through molecular docking against the Enterococcal surface protein

Abstract

(Esp) of *Enterococcus faecalis* showed the delta G value of Group I as -6.90 K cal/mol and Group II as -6.44 K cal/mol.

**Conclusion:** The blackseed has the higher antibacterial activity against the *Enterococcus faecalis* biofilm both in microbial inhibition and in molecular interaction when compared to brown seaweed.

### Abstract 182

#### The mysterious middle mesial canal: An *in-vivo* analysis

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**Aim:** Missed canals are one of the imperative reasons for failure of endodontic treatment of molars. This study aimed to determine prevalence of middle mesial canal (MMC) in mandibular molars (1st and 2nd) in the population of Greater Noida and also to find relationship of intracanal distance between mesiobuccal (MB) and mesiolingual (ML) canals with presence or absence of MMC.

**Materials and Methods:** Five hundred Cone-beam computed tomography (CBCT) scans of mandibular molars from patients were included. Following data was collected: identification of MMC, the distance between MB and ML orifices, whether MMC was more prevalent in mandibular 1st or 2nd molar, whether MMC was prevalent in mandibular molars of right or left side. The results were analysed using Chi-square test and independent student's t-test.

**Results:** The overall prevalence of MMC was 21.8% ( $P < 0.05$ ). MMC was more prevalent in mandibular first molar (29.7%) than mandibular second molar (16%) and overall prevalence of MMC was higher on left side (24.3%) than on right side (18.8%). The mean distance between MB and ML orifices was 2.9 mm and 3.4 mm with and without MMC respectively, ( $P < 0.05$ ) i.e. the MB-ML orifice distance was inversely related with the presence of MMC.

**Conclusion:** MMC is a common finding in the population of Greater Noida, and should be negotiated. Along with the use of CBCT, careful exploration of the pulpal floor between canal orifices is crucial to prevent missing the MMC, as this could lead to undesirable clinical outcomes.

### Abstract 183

#### Silver nanoparticles and its applications in dentistry: A review

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Nano particles are small particles that ranges between 1 to 100 nm in size, and it exhibits significantly different physical and chemical properties as compared to their larger counterparts. Silver has been used as an antimicrobial and disinfectant, without any side effects. Silver nanoparticles have antimicrobial, antifungal and, antiviral properties. It has the ability to penetrate bacterial cell walls and, can change the structure of cell membrane which results in cell death. Silver nanoparticles can be incorporated into acrylic resins for fabrication of removable dentures, composite resins, irrigating solutions and obturating material in endodontic treatment, adhesive materials in

orthodontic treatment, membrane of guided tissue regeneration for periodontal treatment and, titanium coating in dental implants. Silver nanoparticles are promising with important features as, antimicrobial, anti-inflammatory and antitumor activity and, a potential carrier in sustained drug delivery. The aim of this review paper is to highlight the benefits of application of silver nanoparticles in dentistry, especially in field of endodontics and its safety in clinical aspect.

### Abstract 184

#### Morphological characteristics of canal convolution in mesial root of mandibular second molars: A three-dimensional analysis using cone-beam computed tomography in Indian population

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**Aim:** To evaluate the anatomical characteristics of mesio-lingual and mesio-buccal canal through and beyond the confluence in terms of its exit direction, distance and the angle of confluence.

**Materials and Methods:** The CBCT images of two-rooted fifty mandibular second molars were analysed whereas C-shaped canal configuration and root canal treated teeth were excluded in this study. The course of mesio-lingual and mesio-buccal canals were evaluated in terms of its direction and exit point, angle of confluence and the distance of the confluence from the minor constriction.

**Results:** The results of the study showed that the mesio-lingual canal was straighter in terms of having a mild curvature and the mesio-buccal canal had an aggressive curvature with the course of the canal beyond the confluence towards the buccal side of the root. The angle of confluence had a median value of 35.64. The distance of the confluence from the minor constriction had a median value of 2.43mm.

**Conclusion:** The morphological variance noted in mandibular second molars highlights that the mesio-lingual canal continued through and beyond the confluence as a mild curvature when compared to the mesio-buccal canal which exhibited a tortuous course through the confluence.

### Abstract 185

#### Ideal color match - recent advancement of color science in dentistry

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A thing that is not understood often becomes the focus of mystery, fear, indifferent of abject, rejection. Color although a part of nearly every human activity is one of those things is poorly understood and shrouded by misconceptions. Shade selection is one of the important aspect of esthetic dentistry. In the present scenario patient seeks dental treatment under two situations: pain and esthetics. For esthetics every dentist should know the shade matching procedures.

Abstract

Patient are currently demanding esthetic replacement that must match their existing dentition, and are more concerned about the shade match of their restoration rather than the quality of the restoration. To achieve esthetics, four basic determinants are required in sequence; viz, position, contour, texture and color. Shade matching includes knowledge of Color (hue, value, and chroma), Translucency and opacity gloss, Surface toughness, opalescence, iridescence, fluorescence and Luminescence Phosphorescence and Metamerism. Just as disharmony is created by a discordant note in a symphony, the wrong shades can destroy the result and thus, this necessitates the thorough knowledge and understanding of the concept of shade selection.

### Abstract 186

#### Comparative evaluation of fracture resistance of roots after application of three different root canal sealers-AH plus, mineral trioxide aggregate fillapex and BioRoot RCS: An *in vitro* study

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**Aim:** To compare and evaluate the fracture resistance of root dentin following the application of AH-Plus sealer, MTA Fillapex sealer and BioRoot RCS sealer.

**Materials and Methodology:** Seventy extracted single rooted premolars decoronated at the cemento-enamel junction. The samples were divided into 3 experimental and 2 control groups. 14 samples served as negative control (Group 4) which were left unprepared. The remaining 56 samples were prepared using Protaper rotary files up to F3. Roots were obturated using cold lateral compaction using gutta percha and AH Plus sealer (Group 1), gutta percha and MTA Fillapex (Group 2), gutta percha and BioRoot RCS (Group 3). Group 5 was left unobturated that served as the positive control group. The roots were then mounted in acrylic resin molds to test for fracture resistance and then subjected to compressive load using Universal Testing Machine until fracture occurred. Data was analyzed using one-way ANOVA with post hoc Tukey test.

**Results:** The highest resistance to fracture was shown by Group 4 (negative control) followed by Group 1 (AH Plus), Group 3 (BioRoot RCS), Group 2 (MTA Fillapex) and the least by Group 5 (positive control). There was a statistically significant difference between all the groups ( $p=0.00$ ) except between AH Plus and BioRoot RCS ( $p>0.05$ ).

**Conclusion:** Samples in all the groups fractured when vertical force was applied. The maximum resistance to fracture was shown by the roots which were neither instrumented nor obturated. Among the experimental groups, AH plus showed the maximum fracture resistance followed by BioRoot RCS and MTA Fillapex.

### Abstract 187

#### Comparative evaluation of apically extruded debris with hyflex EDM, Mtwo and self adjusting file systems: An *in vitro* study

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**Objective:** To compare and evaluate the amount of apically extruded debris with Hyflex EDM, Mtwo and the Self-Adjusting File systems.

**Materials and Methods:** Sixty single rooted extracted mandibular teeth with straight canals were selected and access cavities were prepared. All the teeth were mounted in the Eppendorf tubes after obtaining initial weight of the empty tubes. Samples were then divided into three groups ( $n=20$ ) according to the rotary system used, and instrumented with Hyflex EDM, Mtwo and SAF respectively. The entire stopper assembly was detached from the Eppendorf tube after complete instrumentation. The root surfaces were washed with 1 ml of distilled water to collect the adhered debris, and incubated at 70°C for the next 5 days to evaporate the distilled water. Then, the dry weight of the debris was calculated. Results were analyzed using ANOVA and post hoc Tukey's test.

**Results:** SAF showed least amount of apical debris extrusion of all, while Mtwo showed maximum apical debris extrusion. The difference between amount of apically extruded debris among all the groups were statistically significant.

**Conclusion:** The SAF showed least amount of apical debris extrusion when compared to other file systems and Mtwo showed the highest amount of apical debris extrusion.

### Abstract 188

#### Effect of various root canal disinfection procedures on expression of *Enterococcus faecalis* virulence factor: A polymerase chain reaction study

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**Objective:** To compare and evaluate antimicrobial effects of 2% Chlorhexidine (CHX) versus 0.1% Octenidine Dihydrochloride (OCT) as root canal irrigant with and without Laser activation against *Enterococcus faecalis* virulence factor- *E.faecalis* endocarditis antigen (efaA) using real time polymerase chain reaction.

**Aim:** To evaluate the effect of various root canal disinfection procedures on expression of *Enterococcus faecalis* virulence factor (efaA) using real time PCR.

**Materials and Methods:** Forty single rooted premolars were taken and decoronated to standardize the root length as 14mm. The canals were instrumented up to F3 Protaper Gold and teeth were autoclaved at 121°C for 20 minutes at 15 psi. 1 mL of the bacterial suspension was injected into the root canals, and the samples were incubated at 37°C and 100% humidity for 21 days. The samples were randomly divided into four groups: Group I –2% Chlorhexidine, Group - II 2% Chlorhexidine with Laser, Group III –0.1% Octenidine dihydrochloride, Group IV- 0.1% Octenidine dihydrochloride with Laser. After the irrigation protocol, Paper points were used to transfer the contents of the canal. PCR was performed to detect the presence of *Enterococcus faecalis* virulence factor (efaA).

**Results:** Octenidine dihydrochloride (0.1%) was more effective than 2% chlorhexidine against *E.faecalis*. Group II and IV showed significant difference compared to group I and III. Laser activation

Abstract

enhanced the antimicrobial action of the irrigants.

**Conclusion:** Octenidine dihydrochloride (0.1%) was more effective than 2% chlorhexidine against *E.faecalis*. Laser activated irrigation proved to enhance the antimicrobial action of the irrigants.

### Abstract 189

#### Evaluation of apical fit of standardized gutta percha after root canal preparation using four different files: An *in vitro* study

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SARATHY SARATH, SHEKAR SHOBANA, KUMAR SARATH**

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**Aim:** To compare the apical fit of standardized gutta-percha after root canal preparation using four different file systems.

**Materials and Methods:** Forty single-rooted lower premolar teeth were selected. Standard access cavity preparations were made and patency confirmed. Working length (WL) was determined using a 10 size k file. The teeth were then randomly divided into 4 groups with 10 teeth in each group. Instrumentation was done as follows using X-smart plus Endomotor for the first 3 groups:

Group 1- Protaper gold files system up to size F2

Group 2- Hero shaper files system up to size #25/6%.

Group 3 – Wave One Primary file.

Group 4 – Teeth were prepared manually with Hand NiTi files up to a file size #25/2% and “step back” up to size #40/2%.

Irrigation was done using saline. Apical gauging was done. WL was transferred to the corresponding ISO tapered Gutta-percha (GP) using the ruler and pen marker. GP cone was passively inserted as far as it can reach. GP Fitting at the WL or short of the WL or beyond the WL was tabulated and statistically analyzed using the Kruskal-Wallis test followed by Mann-Whitney u test.

**Results:** Among 4 groups, root canals prepared using waveOne file group showed the maximum number of GP's at the working length and least number of GP's beyond the WL, followed by Heroshaper files > Protapergold files > Hand NiTi files. Root canals prepared using protapergold files group showed a maximum number of GP's short of the WL, followed by Heroshaper files > Hand NiTi files > WaveOne file. Data suggested that WaveOne primary file was the best and Hand NiTi files were the least among the four files in maintaining the apical constriction with statistically significant results ( $P < 0.05$ ).

**Conclusion:** This “*in vitro*” study highlights that WaveOne primary file system was the best in maintaining the apical constriction and Hand NiTi files were the least among the 4 groups evaluated.

### Abstract 190

#### Antimicrobial, antioxidant, anti-inflammatory and cytotoxic activity of silver nanoparticles synthesized using fruit extract of solanum xanthocarpum: An *in vitro* study

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**Aim:** The aim of this study was to evaluate antimicrobial, antioxidant, anti-inflammatory and Cytotoxic Activity of Silver Nanoparticles

Synthesized using fruit extract of Solanum Xanthocarpum.

**Materials and Methods:** For this study about 25 grams of dried fruit powder of solanum xanthocarpum was mixed with 250 ml of water. The solution was placed in a rotating shaker at room temperature for 48 hours. After incubation, the extract was filtered in Whatman No: 1 filter paper and the filtrate was allowed to air dry in room temperature and dried powder was stored at 4 degree C. 25 ml of plant filtrate was added into 225 ml of aqueous solution of 1mM silver nitrate for reduction of silver nitrate into Ag<sup>+</sup> ions and kept at room temperature for 24 hours in a rotating shaker at 28degree C. After preparation of the silver nanoparticles using Solanum Xanthocarpum fruit extract antimicrobial,antiflammatory activity, antioxidant activity and cytotoxicity was assesed.

**Results:** Solanum xanthocarpum induced with silver nanoparticles showed good antibacterial activity against oral pathogens and good anti inflammatory activity. The values for antioxidant property of nanoparticles was found to be comparable to the standard values at all concentrations except at 10 and 20  $\mu$ L and highest at 50  $\mu$ L. Percentage of inhibition was 49.5% at 10  $\mu$ L concentration, 57.4% at 20  $\mu$ L, 75% at 30  $\mu$ L, 76% at 40  $\mu$ L and 79.6% at 50  $\mu$ L. Cytotoxicity study was done against brine shrimp artemia. As the concentration increased the cytotoxicity of the nanoparticles increased.

**Conclusion:** The use of fruits for the synthesis of silver nanoparticles has many advantages such as, ease with which the process can be scaled up, economic viability and to obtain smaller particle size. According to the results of this study, silver nanoparticles synthesized using the fruit extract Solanum Xanthocarpum showed excellent anti-inflammatory activity, antimicrobial activity, antioxidant activity and the concentration increased the cytotoxicity activity increased.

### Abstract 191

#### Antibacterial, antioxidant and cytotoxic property of an indegenious herbal extract (Gymnema sylvestre): Can they be a potential alternative in endodontic treatment?

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**Aim:** The aim of this study was to analyse the antibacterial, cytotoxic and antioxidant potential of ethanolic extract of Gymnema sylvestre.

**Materials and Methods:** The ethanolic extract of Gymnema sylvestre was prepared at different concentrations (10, 25, 50, 100, 200  $\mu$ g/ml). The antibacterial activity against *E. faecalis* and *S. mutans* was studied by disk diffusion method and compared with 2.5% NaOCl. The antioxidant property was tested using DPPH assay and ABTS radical scavenging activity and reducing power were designated by their IC50 (concentration required to attain 50% radical-scavenging effect) and compared with that of the standards (Ascorbic acid). The cytotoxic potential of the extract was tested on L929 Mice Fibroblast Cell using MTT assay and compared with that of the standards 2.5% NaOCl. The statistical analysis was done using ANOVA and post hoc analysis.

**Results:** The herbal extract showed concentration dependent antibacterial efficacy against *E. faecalis* and *S. mutans*, with maximum zone of inhibition being  $12.1 \pm 1.1$  mm and  $13.1 \pm 1.1$  mm respectively at 50  $\mu$ g/ml ( $p < 0.001$ ). The antioxidant activity with IC50 was found to be 74.8  $\mu$ g/ml and 83.8  $\mu$ g/ml by ABTS and DPPH assay

Abstract

respectively with  $p < 0.001$ . The cytotoxicity analysis of the ethanolic extract showed it did not adversely affect the fibroblasts even up to 50% concentration showing a nontoxic effect even till 200  $\mu\text{g/ml}$  dose in comparison with NaOCl on the fibroblast cells with  $p < 0.001$ . **Conclusion:** Within the limitations of the study, the ethanolic extract of *Gymnema sylvestre* showed maximum antibacterial efficacy against *E. faecalis* and *S. mutans* at 50  $\mu\text{g/ml}$  and antioxidant activity with IC50 found to be at 74.8  $\mu\text{g/ml}$  and 83.8  $\mu\text{g/ml}$  by ABTS and DPPH assay respectively and the extract showed a non toxic effect even till 200  $\mu\text{g/ml}$  dose in comparison with NaOCl on the fibroblast cells.

### Abstract 192

**Evaluation of antifungal activity of triple antibiotic paste with epigallocatechin gallate against candida albicans: An *in vitro* study**

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**Aim:** To evaluate the antifungal activity of Triple antibiotic paste with epigallocatechin gallate against *Candida albicans*.

**Materials and Methods:** Disc Diffusion Test: 30 Kirby Bauer discs were soaked in the following intracanal medicaments: Group 1 – Fluconazole: Group 2: + Epigallo catechin gallate (EGCG): Group 3: Fluconazole + EGCG; Group 4: EGCG + TAP (Ciprofloxacin 500mg, Minocycline 100mg, Metronidazole 400mg in 1: 1:1: ratio) using Dimethylsulfoxide carrier. The dried discs were placed in agar plates with 10  $\mu\text{l}$  suspension of *C. albicans* and incubated at 37 °C for 24 hours and observed for zone of inhibition.

**Simulated Dentine Model Study:** Forty extracted single rooted teeth were decoronated to obtain uniform samples of 12 mm in length. Biomechanical preparation was done using Nickel-Titanium rotary ProTaper Universal files (Dentsply, Maillefer, Switzerland) up to size F2. Saline was used for root canal irrigation. All teeth were then autoclaved at 121°C. 10  $\mu\text{L}$  culture suspensions of *C. albicans* was placed into the prepared root canal space of all the teeth. After 2 days of incubation following which intracanal medicament was placed inside the canal using lentulospiral and the samples were incubated for 3 days. After incubation all the samples were irrigated using saline. Sterile absorbent points were inserted in to the root canal of each sample, which were then transferred immediately in to Sabouraud dextrose agar plates and incubated for 48 hours at 37 °C. The Colony forming units (CFUs) were counted using the digital colony counter. **Results:** Intergroup analysis was done using Kruskal Wallis test and intragroup analysis with Mann Whitney test. There was a statistically significant difference in the zones of inhibition produced by the medicaments: Group 1 (30mm) > Group 3 (25mm) > Group 2 (17mm) > Group 4 (16mm) ( $p < 0.001$ ). Group 1 and 3 produced significantly greater zones of inhibition when compared to groups 2 and 4 ( $p = 0.001$  and 0.014 respectively). None of the groups showed fungal growth in the dentin simulation study.

**Conclusion:** *C. albicans* is susceptible to EGCG. TAP does not interfere with the antifungal property of EGCG and may be used in combination for broader antimicrobial activity.

### Abstract 193

**Comparative evaluation of efficacy of endoactivator and laser assisted irrigation on dentinal tubule penetration of newer irrigants: A confocal laser scanning microscopy study**

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**Aim:** To evaluate and compare the efficacy of Endoactivator and Laser assisted irrigation on dentinal tubule penetration of newer irrigants like Fumaric acid, Ozonated water and Curcumin using confocal laser scanning microscope.

**Materials and Methods:** Forty Eight freshly extracted single rooted mandibular premolars were selected and divided into two groups ( $n = 24$ ) based on the irrigation method used. Each group was further subdivided into three subgroups ( $n = 8$ ) based on irrigants used. Group IA: Fumaric acid with endoactivator assisted irrigation, Group IB: Ozonated water with endoactivator assisted irrigation, Group IC: Curcumin with endoactivator assisted irrigation, Group IIA: Fumaric acid with LASER assisted irrigation, Group IIB: Ozonated water with LASER assisted irrigation, Group IIC: Curcumin with LASER assisted irrigation. To ensure standardization, the length of the teeth was standardized to 14 mm from the apex under water cooling. Root canal of each tooth was shaped using ProTaper rotary system up to size F3. 2 mL of Normal saline was used to irrigate root canals between each instrument. The root canals were irrigated with 5 mL of 17% EDTA solution after root canal preparation for smear layer removal. Two coats of nail polish were applied around the root surface, and flowable composite was used to seal the apex. All experimental irrigants to be used as final irrigation were mixed with 0.01% fluorescent rhodamine B isothiocyanate to provide visualization within dentinal tubules under confocal laser scanning microscopy. Then root canals were dried using size F3 ProTaper paper points. Roots were mounted vertically in acrylic blocks and sectioned horizontally at 2 mm (apical) and 5 mm (middle) from the apical foramen, removing 1 mm of thickness. The sections were examined using a confocal laser scanning microscope to evaluate dentinal tubule penetration of each irrigant.

**Results:** The overall results showed that Laser assisted irrigation with Fumaric acid exhibited significantly higher penetration percentage than other groups. Statistically significant differences were also determined between middle and apical section with Tukey's post hoc test ( $P < 0.05$ ).

**Conclusion:** Within Limitations of this study it was concluded the Laser assisted irrigation with Fumaric acid showed higher dentinal penetration.

### Abstract 194

**Comparative evaluation of the efficacy of four different irrigation devices in the debridement of root canal isthmus: An *in vitro* study**

**ANILA VINOY**

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## Abstract

**Objective:** To compare the efficacy of Diode Laser, Endo Activator, Passive Ultrasonic Irrigant and Manual Irrigation Activation in the debridement of root canal isthmus using a stereomicroscope.

**Materials and Methods:** A total of sixty five (65) extracted mandibular first molars were selected for the study. The access cavity preparation was done and the working length was determined. All teeth were prepared using Pro Taper rotary system up to F2 size and irrigation was done using 5.25% sodium hypochlorite and 17% Ethylene diaminetetraacetic acid. The samples were randomly divided into five groups (n=13) used in the study

Group 1: Diode Laser (n=13): Samples were irrigated using Diode Laser having a wavelength of 980nm.

Group 2: Endo Activator (n=13): Samples were irrigated using Endo Activator sonic device.

Group 3: Passive Ultrasonic Irrigation (n=13): Samples were irrigated using an Ultrasonic device.

Group 4: Manual Irrigation Activation (n=13): Samples were irrigated manually by placing a master gutta percha cone of F2 size.

Group 5: Control (n=13): No activation of irrigant.

Following irrigant activation, the mesial roots were sectioned 4mm from the apex and the isthmus cleanliness was observed under a stereomicroscope at 20x magnification. Statistical analysis was done using ANOVA and post hoc Tukey's test.

**Results:** Endo Activator showed least amount of debris when compared to Diode laser, Passive Ultrasonic Irrigant and Manual Irrigation Activation at the isthmus level. There was no significant difference between Diode Laser and Passive Ultrasonic Irrigant.

**Conclusion:** Endo Activator showed the least amount of debris at the isthmus level when compared to diode laser, Passive Ultrasonic Irrigant and Manual Irrigation Activation.

### Abstract 195

**Comparative evaluation of microleakage of biodentine and geristore root end filling materials in dry, saliva and blood contaminated environments: A fluorescent microscope study**

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**Aim:** Is to compare and evaluate the microleakage of Biodentine and Geristore root end filling materials in dry, saliva and blood contaminated environments using fluorescent microscope.

**Materials and Methods:** A sample of 90 extracted human maxillary central incisors were taken and decoronated. Their root canals were instrumented and obturated. The apical 3 mm of each root was resected and a standardized root end cavity was prepared using a #8 round bur and restored 45 samples with Biodentine and 45 samples with Geristore. Groups of roots were divided into three equal subgroups for each material and were placed in different environments namely dry, saliva and blood. All samples were immersed in 0.2% Rhodamine B dye for 48 hrs. Roots were sectioned longitudinally and examined under a fluorescent microscope to measure the linear dye penetration. Data was analyzed using ANOVA and post hoc Bonferroni.

**Results:** Geristore showed higher microleakage compared to

Biodentine in dry ( $0.47 \pm 0.516$ ), saliva ( $1 \pm 0.65$ ) and blood ( $1.27 \pm 0.59$ ) sub-groups. Statistical significant difference was seen between dry and blood subgroup in Geristore group, whereas there was no significant difference between any subgroups in Biodentine group.

**Conclusion:** Microleakage was observed in both the tested groups. Biodentine exhibited the least apical leakage value, while Geristore exhibited the maximum apical leakage value.

### Abstract 196

**Cold plasma as an endodontic disinfectant**

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The ultimate goal of endodontic treatment is to eliminate bacterial infection in the root canal system and prevent reinfection. However, traditional treatments such as mechanical instrumentation techniques, chemical irrigation, laser irradiation, and ultrasonics cannot achieve a complete elimination of biofilm from endodontic sites because of the complex root canal system and the innate resistance capacity of biofilm. In this situation, more effective disinfection methods are needed to eradicate biofilm from the root canal. In recent years, Cold Atmospheric pressure plasma jets (CAPPJs) have received significant attention because they widen the plasma application range for biomedical purpose. Plasma, the fourth state of matter, is a quasineutral collection, consisting of neutral species and charged particles. CAPPJs have been used in various biological and biomedical applications such as sterilization, gene transfer to cells, promotion of blood clotting, cell detachment, and inducing tumor cells apoptosis. They have also gained interest in dental applications such as root canal disinfection, tooth bleaching and dental material modification. Portable plasma jet devices like jet needle and plasma pencil have been constructed that can enter the root canal of teeth that have been drilled and mechanically prepared and remove the microorganisms associated with infected root canals. The interaction of plasma jet with wet surfaces generates reactive oxygen (hydroperoxyl, superoxide anion radical, hydroxyl, and ozone) and nitrogen (nitrates and nitrites) species. The reactive oxygen and nitrogen species can easily penetrate into the bacterial cell wall and inactivates the bacteria efficiently by destroying the intracellular components. This review paper describes the components, mechanism and efficiency of cold plasma as a root canal disinfectant in endodontics.

### Abstract 197

**A new method of restoring subgingival fracture with a polished collar of custom made post and core**

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Traumatic injuries which can occur during falls or accidents are one of the main causes of crown-root fractures. Crown-root fractures most commonly occur in mature permanent teeth with closed

Abstract

apices. Dental trauma in esthetic region especially subgingival fractures pose a great challenge to the dentist. Due to the poor esthetics and functional prognosis such teeth are often indicated for extraction. It not only causes an esthetic and functional breakdown but also psychological breakdown. Various factors influencing treatment depends upon the level of fracture line, root development, type of dentition, periapical status. Numerous treatment modalities like orthodontic extrusion, periodontal crown lengthening are practiced for such cases. In this paper a case report describing a new method of restoring subgingival fracture with a polished collar of custom made post and core will be discussed.

**Abstract 198**

**Comparative evaluation of sealing ability of mineral trioxide aggregate, biodentine, and new light-cure mineral trioxide aggregate used for furcal perforation repair using scanning electron microscope: An *in-vitro* study**

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SHUBHAM GODGE, SNEHAL SHINDE, SAYALI KAMAT**

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**Aim:** To evaluate and compare the sealing ability of Mineral trioxide aggregate (MTA), Biodentine, and new light-cure MTA used for repair of furcal perforations using scanning electron microscopy.

**Materials and Methods:** The study sample comprised 45 extracted mandibular molars. Carious, restored, hypoplastic teeth, fractured teeth, and teeth with root resorption where the furcal area could not be involved were excluded. The teeth were embedded in modeling wax. Standard access cavities were prepared in each tooth using a round bur and non-end cutting bur with a high-speed handpiece with water spray. Furcal perforations were made on the center of the pulpal floor of each tooth using a 0.5mm round bur. The teeth were then randomly divided into 3 experimental groups of 15 specimens each based on the materials used to seal the perforations; Group A: MTA; Group B: Biodentine; Group C: Light cure MTA. All the sealed perforations were compacted with a moist cotton pellet, and the samples were stored in a closed container for 24 hours to allow the repair materials to set completely. After 24 hours, the samples were sectioned longitudinally and the extent of marginal adaptation was measured using the scanning electron microscope. The sealing ability was evaluated by measuring the gap (in microns) between the pulpal floor and the material used for perforation repair. The intramolecular space within each repair material was also examined using the scanning electron microscope.

**Results:** The overall results showed that the marginal adaptation of light-cure MTA was better than both MTA as well as Biodentine. The mean space between the pulpal floor and the repair material was the least for group C (2.29). Tukey's post hoc test showed that a significant difference ( $p < 0.05$ ) existed between group C & A and group C & B.

**Conclusion:** Within the limitations of the study, it can be concluded that light-cure MTA exhibits a better sealing ability when compared to conventionally used Biodentine and Mineral Trioxide Aggregate.

**Abstract 199**

**Comparative evaluation of fluid uptake, solubility and porosity of mineral trioxide aggregate, biodentine and glass-ionomer cement using micro computed tomography: An *in vitro* study**

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India

**Aim:** The aim of this study was to evaluate the solubility and fluid uptake and quantify changes in volume, density, and porosity of Glass Ionomer cement, MTA, and Biodentine in distilled water and butyric acid.

**Methodology:** According to the three groups i.e Group 1 – GIC, Group 2 – MTA, Group 3 – Biodentine; 4 cylindrical discs were prepared for each group (i.e 24 cylindrical discs in total, including two subgroups) using stainless steel mold. All the cements were manipulated according to the manufacturers instruction. The cylindrical discs had a diameter of 5mm and thickness. After final set the discs were retrieved and then immediately analyzed for volume and porosity using Micro CT. All specimens were scanned and three dimensional micro CT images were constructed using an ex vivo micro CT scanner immediately after initial setting of GIC, MTA, Biodentine. After which the samples from each group were divided into 2 subgroups which included subgroup 1 – Distilled water and subgroup 2 – Butyric acid. The assigned samples were then immersed in respective mediums. The discs were analyzed under Micro CT on 7th, 14th and 28th day for volume loss, porosity, dissolution and fluid uptake. The region of interest was particularized as the surface, density, volume of the discs that were prepared.

**Results:** The results showed that the final porosity values i.e after 28 days (in comparison to initial porosity values) in distilled water are highest for GIC (27.86) followed by biodentine (26.27) followed by MTA (22.5) and in case of butyric acid the final porosity values are highest for MTA (24.11) followed by GIC (23.07) followed by Biodentine (22.93).

**Conclusion:** Biodentine showed the least porosity followed by GIC followed by MTA. Solubility, porosity, fluid uptake are related to each other and degrade the quality of restoration. All the cements used in Conservative Dentistry and Endodontics are constantly in contact to variety of fluids of varying nature and pH and it is necessary to know their potential to withstand such environment.

**Abstract 200**

**Static versus dynamic navigation for endodontic microsurgery: A comparative analysis review**

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Digitalization realization of operative procedures through 3D navigation is a remarkable advancement in the field of dentistry which allows precision and accuracy, both, in treating patients. It is as an emerging technology with its wide variety of applications

Abstract

in the dental field. These computer aided 3D systems are being used in the field of endodontics; employed for accessing canals and localizing calcified teeth; for the removal of fiberglass posts; and in apical surgeries. Preservation of important anatomical structures is necessary in case of root end resection or periapical surgeries. However, it is clinically difficult to achieve accurate root–end resection due to limited field of view, the inconvenient perspective, and interferential bleeding, among other factors. 3D guided endodontic plays its role here, Static and Dynamic navigation are the two ways of guided endodontic. There is need to review new evidence comparing the effectiveness of both techniques of 3D guided endodontic navigation system. This review paper describes the comparative evaluation of effectiveness of static as well as dynamic navigation in the field of endodontic microsurgery.

### Abstract 201

#### Graphene oxide-our next “go” to disinfectant?

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The primary goal of successful endodontic therapy is the complete elimination of the endodontic biofilm from the root canal system. Extensive research are underway on the search for an ideal material for the eradication of the micro-organisms. In 2004, graphene was isolated for the first time as a single sheet of carbon atoms with a hexagonal honeycomb lattice. Since then, graphene has quickly emerged as a promising material with unique electrical, optical, and catalytic capabilities that has been used for a variety of applications in energy, environment, and biomedical systems. Among the graphene based materials, graphene oxide (GO) is a 2D carbon based material which is a water-soluble graphene derivative with carboxylic groups on the edges and phenol, hydroxyl, and epoxide groups on the basal plane. It has gained popularity in biomedical applications because of its high surface area, high functional groups and cost-effective synthesis in a large scale. When compared to pristine graphene, the hydrophilic groups give GO polarity and improve its dispersity and stability in aqueous conditions, thereby assist it in developing a steady colloid dispersal and makes it cytocompatible. Hence, these products have piqued the interest of biological researchers. In endodontics, graphene-oxide based solutions have demonstrated outstanding antimicrobial and antibiofilm potential with the reduction of total biovolumes and high biocompatibility when used to disinfect the canals. These properties could be improved due to its inherent ability of functionalization with various other materials. Literature reports reveal that the intracellular densities of *S. mutans*, *F. nucleatum* and *P. gingivalis* decreased in the presence of GO nanosheets indicating the loss of intracellular substance. Further, it has proven to decrease the extracellular polymeric substances (EPS) synthesis and increases the susceptibility of *E. faecalis* biofilms. Thus, the aim of this review is to comprehensively summarise and predict the future scope of this interesting material.

### Abstract 202

#### Managing large periapical lesions - conservative or surgical approach?: A case report

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Trauma to a tooth can damage the pulpal tissues even if the crown and root are intact. The pulp may survive or undergo necrosis, depending on a number of factors mainly the severity of trauma and the type of inflammatory reaction. This reaction may lead to extensive destruction tissues of the periapical region over a period of time if left untreated. On the basis of histological findings, chronic periapical lesions of the pulpal origin are diagnosed as either periapical granulomas or cysts. In situation like this, most often a surgical approach for therapy of large periapical lesion is advocated when involvement of multiple teeth happens. A conservative approach with an attempt to maximally preserve local tissues, without weakening those fragile teeth can also be done. Basic rationale behind this conservative management is, the body will heal on its own when bacterial load is reduced below critical colonization. So, the current concept and rationale of endodontic treatment of periapical lesion are centered on stopping the bacterial stimulation of the host response at the apical foramen that would allow healing of the lesions. Now, because of improvements in conventional endodontic therapy and a better understanding of the healing potential of periapical tissues, fewer patients need periapical surgery. If a conservative approach fails a surgical management can be done. This case report discusses a large periapical lesions involving 11-14 with destruction of the nasal floor. After treatment with conservative approach the long term 15 month review shows nasal floor reformation and promising healing with asymptomatic teeth.

### Abstract 203

#### Echoes in endodontics

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Ultrasound (US) is defined by the American National Standards Institute as “sound at frequencies greater than 20 kHz.” Ultrasound imaging is a radiation-free, minimally intrusive imaging method in which an ultrasonic beam travels through internal tissues and is reflected, absorbed, or transmitted to create an image. It has recently gained traction in the field of dentistry, with applications including the detection of carious lesions, tooth fractures, soft tissue lesions, periodontal bone abnormalities, maxillofacial fractures, salivary gland diseases, and temporomandibular disorders. It does not emit hazardous ionising radiation, unlike X-rays. Both hard and soft tissue can be detected with ultrasound. USG allows echoes to be processed at a fast enough pace to allow motion perception; this is known as real-time imaging. Ultrasound imaging has a promising future as a hard-and soft-tissue diagnostic tool in all dental specialties since it has a lot of progress from two-dimensional to three-dimensional visualization in the evaluation

and diagnosis of disorders. The aim of this review is to provide an insight into the applications of Ultrasonography into the field of Endodontics in particular.

#### Abstract 204

##### Guided tissue regeneration and grafts in endodontics

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Periradicular surgery has become an established treatment option in endodontic surgery. The major objective of this surgery is to obtain periradicular tissue regeneration, including the formation of a new attachment apparatus, by exclusion of any potentially noxious agent within the physical confines of the affected root. However, in a substantial number of cases, the endodontic lesion has a concomitant marginal periodontal lesion that may complicate the healing success. Performing endodontic surgery has the principal goal of not only maximizing the procedural outcome from an endodontic standpoint but also periodontally, by returning the site to its preoperative periodontal state despite bone removal to access the root end. Because endodontic microsurgery involves a process to stabilize the endodontic status of the tooth while accessing through the periodontal structures that affect the overall status of the tooth, guided tissue regenerative techniques have a place in the wholetooth management of an endodontic surgical case. Guided tissue regeneration is a valuable technique available to the endodontist because the quality, quantity, or extent of bone loss cannot be visualized by the surgeon until the tissue is reflected and the surgical site is exposed. It involves the use of Membrane barriers and/or bone grafts which are often used to enhance periapical new bone formation. This review paper describes the molecular and cellular biologic concepts when using membrane barriers and/or bone grafts in periapical surgery, along with predictable healing and suggested treatment plan for combined endo-perio lesions with specific reference to guided tissue regeneration in periodontal regenerative therapy.

#### Abstract 205

##### Dental pain - causes and management: A review

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Pain as an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage. It is a subjective perception. Diagnosis and management of pain is an everyday occurrence in dentistry. It is a perception that dental treatment and pain go hand in hand. So its effective control is essential to ensure the wellbeing of patients. Most tooth-associated pain originates from the dental pulp, a highly vascularized and innervated tissue. Causes of dental pain contains a broad spectrum which needs to be analyzed properly before arriving at a diagnosis. Current approaches in the management of dental pulp pain has

mostly been the combination of pharmacological management and restorative part. Arrival of new approaches which include modulation of thermo-sensitive transient receptor potential cation channels (TRP), use of novel biomaterials, stem cells, exosomes and physical stimulation to obtain pulp regeneration in regenerative medicine which appears promising. The aim of this review is to assess the causes of underlying dental pain, diagnostic methods and current and newer methods for effective management of pain.

#### Abstract 206

##### A remarkable method toward salvaging a tooth employing intentional replantation

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Intentional replantation is a method involving the deliberate extraction of a tooth, and after evaluation of root surfaces, endodontic manipulation and repair, placement of the tooth back into its original socket. It is one of the oldest known methods for the treatment of disease of endodontic origin, dating as far back as the 11th century. It is a preferred treatment option when more conventional forms of treatment either fail or are impossible. Recent studies have shown a high success rate of intentional replantation of upto 88% to 95%. Post treatment endodontic disease is one of the most common reasons for intentional replantation. The primary cause has been attributed to the presence of microorganisms in the root canal system and periapical tissue, although additional etiologies, including the presence of cysts, cholesterol crystals and foreign bodies have also been implicated. Because of the difficulty of surgical access and the anatomical limitations, intentional replantation is preferred over apical surgery. The present paper describes a series of cases pertaining to intentional replantation and its success rates.

#### Abstract 207

##### Internal resorption an endodontic challenge: A case series

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Internal root resorption (IRR) is a particular category of pulp disease characterized by the loss of dentine as a result of the action of clastic cells stimulated by pulpal inflammation. This case series present the etiology, the clinical and radiographic features, points helpful for diagnosis, the clinical decision, and the therapeutic management of IRR. Root canal treatment remains the treatment of choice of internal root resorption as it removes the granulation tissue and blood supply of the clastic cells. This case series describe with different clinical cases, ultrasonic improvement of chemical debridement, and the use of alternative materials such as calcium silicate based cements. In these conditions, the prognosis of the conservative treatment of internal resorptions, even if root walls are perforated, is good.

### Abstract 208

#### Comparative evaluation of the decalcification effect of chitosan, ethylenediaminetetraacetic acid, maleic acid as a root canal irrigant: An energy dispersive X-ray analysis

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**Objective:** To evaluate and compare the decalcification effect of 3 different irrigant -0.5% Chitosan, 17% EDTA and 7% Maleic acid on the root canal dentin using Energy Dispersive X Ray Analysis.

**Methodology:** Single rooted premolar (n=96) were selected and decoronated at a standard length of 15mm. Patency and working length were established. Canals were prepared to a size F2 using rotary Protaper file employing the accepted protocol. The canals were irrigated with 3% sodium hypochlorite at each change of instrument followed by distilled water. The samples were divided into four groups (each n=24). Group 1: 0.5% Chitosan Group 2: 17% EDTA Group 3: 7% Maleic acid Group 4: Control group (Samples without any treatment). Each group were irrigated with respective chelating solution for 1 minute. The root canals were flushed with distilled water and dried with paper points. The roots were sectioned in two halves and one half was used for Energy dispersive X ray analysis to obtain the calcium phosphate ratio. Intergroup results were statistically analyzed using one way ANOVA.

**Results:** 7% Maleic acid on the root dentin showed significantly higher alteration of calcium phosphate ratio. 0.5% Chitosan showed the least alteration of calcium phosphate ratio of the root dentin.

**Conclusion:** Within the limitation of the study all the irrigant solutions used altered the calcium phosphate ratio of the root dentin. 7% Maleic acid showed the highest decalcification effect and 0.5% Chitosan showed the least decalcification effect on root dentin.

### Abstract 209

#### Comparative evaluation of sealing ability of calcium phosphate, mineral trioxide aggregate and biodentine as perforation repair material: An *in vitro* scanning electron microscope study

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**Objective:** To comparatively evaluate the sealing ability of three different perforation repair material- Calcium phosphate, Mineral Trioxide Aggregate and Biodentine when used to seal a furcal perforation using SEM analysis.

**Methodology:** Multirooted teeth (n=90) were collected and perforations were made on the centre of pulpal floor using a round bur (0.8 mm). The samples were grouped into three (each n= 30) according to the material used. Group 1 repaired with calcium phosphate, group 2 repaired with MTA and group 3 repaired with biodentine. The perforation repair material was manipulated and mixed using manufacturers instructions and perforation sealed. Specimens were stored in distilled water. Specimens were cut into two equal halves mesio-distally. Two points of the semi circle

point A and point B were taken as reference points respectively. The selected points were viewed under SEM (HITACHI -SU6600) at 1000x magnification. Marginal adaptation was assessed by measuring the gap between the tooth and repair material. The results were obtained and statistical analysis was performed using ONE WAY ANOVA.

**Results:** The highest duncan grading was found to be in calcium phosphate and lowest in mineral trioxide aggregate. The SEM analysis of the specimens showed gap between repair materials and tooth interphase in all the three groups. Mean width of the gap was found to be least in group 1 (0.52518) followed by group 3 (0.87548). Group 2 (MTA) exhibited the largest value (2.17189). The values were compared and found to be significant with  $p < 0.05$ . The intergroup comparison by pairwise multiple comparison procedures was done using Post hoc tests Bonferroni corrections, and has revealed significant differences between all the three groups.

**Conclusion:** Within the limitation of the study Calcium phosphate cement performed well as a perforation repair material in terms of sealing ability followed by biodentine. MTA showed the maximum gap between the perforation and repair material among the three material tested.

### Abstract 210

#### Comparative evaluation of the bond strength of reattached fractured segment of maxillary central incisor using three different methods and materials: An *in vitro* study

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**Aim:** To comparatively evaluate the bond strength of re-attached fractured segment of maxillary central incisor using three different methods and materials.

**Methods:** 90 extracted human maxillary permanent central incisors were collected. Each specimen was sectioned 3 mm from the incisal edge using a diamond disc. Sectioned specimen were equally distributed into three groups (n=30) based on the technique used for re-attachment. Group I-Simple reattachment, Group II-Over contouring, and Group III-Internal dentinal groove. Each group was further divided into two subgroups on the basis of the intermediate restorative material used for reattachment (Hybrid composite, Nano composite). Bond strength of each specimen was determined using universal testing machine and the data collected was analyzed using two-way ANOVA.

**Results:** The mean value of fracture strength obtained in 3 different groups were Group I: 120.8133N, Group II: 250.6730 N, Group III: 319.6397N, and among the sub-groups Hybrid composite showed fracture strength of 193.5762 N and Nano composite had a fracture strength 267.1744 N.

**Conclusion:** Within the limitation of the present study the highest fracture strength was obtained when the fragments were reattached using internal dentinal groove technique, which was statistically significant than reattachment by over contouring technique. The least fracture strength was exhibited by simple reattachment

Abstract

technique which was significantly lower than other two techniques. Nano composite was found to have higher fracture resistance compared to hybrid composite but was not statistically significant.

### Abstract 211

#### Artificial intelligence in endodontics

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The concept of “artificial intelligence” (AI) refers to machines that are capable of doing human jobs. It defines the process of using technology to create software or a machine that can readily mimic human intelligence and execute specified tasks. The utilization of neural networks in dentistry has advanced dramatically as science and technology have progressed. AI has mostly been utilized in dentistry to improve the accuracy and efficiency of diagnosis, which is critical in attaining the most precise diagnosis and enhanced patient care. Artificial intelligence has various applications in dentistry, from taking a patient’s history to data processing and then extracting information from the data for diagnosis. Though artificial intelligence will never be able to fully replace the function of a dental surgeon, it is crucial to be aware of the possibilities for incorporating this progress in technology into dental practice in the future. The aim of this review is to track the development of AI applications used in endodontics, as well as to assess their performance in terms of diagnostic, clinical decision-making, and treatment prognosis prediction.

### Abstract 212

#### Oral health-related quality of life in patients with traumatic dental injury of permanent teeth: A systematic review and meta-analysis

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**Objective:** The objective was to assess the impact of traumatic dental injuries on permanent teeth in children and adolescents on oral health-related quality of life.

**Methods:** The protocol was registered in PROSPERO. PRISMA guidelines were followed. A focused on structured question using Population(P), Exposition(E), Comparisons(C), Outcomes(O), (PECO) was: “Does traumatic dental injury impact OHRQoL of children and adolescents with trauma of permanent teeth?” A broad search according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was conducted and literature was screened via PubMed/MEDLINE, Cochrane, Proquest databases from January 2000 to February 2021. A total of 2677 articles were retrieved from databases, from which only 50 articles were selected on the basis of the title and abstract. The full text of these 50 articles were downloaded and finally 25 studies that fulfilled all the requirements of inclusion criteria were selected for data extraction and review. Evaluation criteria of methodological quality and risk of bias control were applied to selected articles. A fixed effect model was used for the meta-analysis and quality of the evidence was performed using

Quality Assessment Checklist for Survey Studies in Psychology (Q-SSP) tool.

**Results:** 21 studies were of acceptable quality, and 2 studies were considered for meta-analysis. A negative impact on OHRQoL was detected for children mostly in the domain of emotional well-being, oral symptoms, and functional limitations.

**Conclusion:** Traumatic injuries to the permanent dentition affects not only child but their caregivers or parents too. Timely management of TDI not only improves the child eating and speaking but overall improvement in aesthetics boosts up their self-esteem. Since the majority of studies used a well validated questionnaire tool and were of high-quality it can be concluded that there is a significant association between TDI and OHRQoL.

### Abstract 213

#### Vital pulp therapy: Restoring the tooth’s own heartbeat!!! – A case report

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Vital pulp therapy (VPT) in mature permanent teeth with carious pulp exposure has been a matter of debate, with root canal therapy being the conventional standard of care. Previously reported negative outcomes for VPT in these teeth were based on data from studies that have used calcium hydroxide in direct pulp capping and partial and full pulpotomy. The introduction of hydraulic calcium silicate-based materials with sealing and bioactive potentials have opened a new era in VPT with more favorable results. Understanding the histopathology and histobacteriology of the cariously exposed pulp and the healing potential of the inflamed pulp could guide the decision-making process toward an ultraconservative management of these teeth. However, proper case selection, strict aseptic condition, capping material, and good coronal seal are crucial for long-term success. The present case report highlights the conservative management of a mandibular molar with deep caries and irreversible pulpitis.

### Abstract 214

#### Apical end resection followed by root end ultrasonication and sealing with various retrograde filling materials: A case series

**ARSHPREET KAUR, PREETIKA KAUR, SUNANDAN MITTAL, TARUN KUMAR, VANITA KESHAV**

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Injury to anterior teeth is a common event. It requires a treatment approach that assures the complete biologic healing and functional restoration of the tooth or teeth involved. A cystic lesion, which is unable to heal nonsurgically, heals well with surgical intervention. Apical surgery is considered a standard oral surgical procedure. It is often the last resort to surgically maintain a tooth with a periapical lesion that cannot be managed with conventional endodontic retreatment. The main goal of root end surgery is

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to prevent bacterial leakage from the root-canal system into the periradicular tissues by placing a tight root-end filling following root-end resection. The modern surgical approach instills the application of microsurgical techniques in apical surgery, i.e., gentle incision and flap elevation, production of a small osteotomy and the use of ultrasonic driven microtips, which results in less trauma to the patient and faster postsurgical healing. A major step in apical surgery is to identify possible leakage areas at the resected root face and subsequently ensure adequate root-end filling. Only a tight and persistent apical obturation will allow periapical healing with a good long-term prognosis. The present paper describes a case series pertaining to endodontic surgery followed by sealing the apex with various retrograde filling materials.

#### Abstract 215

### Role of biomaterials as a coronal plug in pulp revascularization of necrotic immature permanent teeth: A systematic review and meta-analysis

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**Background:** Revascularization technique involves placement of biomaterial after inducing a blood clot within the canal. Its role is to maintain a microorganism free environment, also proliferation and differentiation of stem cells. Various biomaterials which have been put-to use in the revascularization technique are not sufficiently studied. Hence, the aim of this systematic review was to analyze and summarize the clinical and radiographic results after using different coronal plug materials during pulpal revascularization.

**Methods:** Literature search was conducted on the following databases: PubMed and Cochrane yielded a total of 2836 whereas ProQuest, Science direct and Wiley yielded 954 studies. Among these 1 RCT, 1 NRCT, 2 cohort studies, 2 case series and 6 case reports comparing different outcomes of various biomaterials as coronal plug were selected. Extraction of information and assessment of methodological quality of the included studies was done using Risk of Bias. Meta-analysis using random-effects model was conducted for the outcomes. All studies published till 30th September 2020, conducted among population below 35 years were included. Studies conducted on animals, reviews and systematic reviews, studies with participants above 35 years, studies that did not mention follow up and proper results were excluded.

**Results:** Total 12 articles were selected for qualitative synthesis of which 6 were analyzed for various parameters using meta-analysis and the results were shown using Forest plot. It was observed that overall, MTA alone or with Collaplug showed better results, that is higher increase in root width and decrease in apical diameter along with resolution of periapical radiolucency than Biodentine which showed least discoloration.  $I^2$  value was found to be zero for the parameters of clinical outcome, resolution of periapical radiolucency and root length indicating that variation between the studies was negligible. Meta-analysis of decrease in apical diameter showed a high  $I^2$  value indicating a considerable heterogeneity.

**Conclusion:** There was a good overall clinical outcome (absence of pain, tenderness to percussion and swelling) with MTA alone or

with Collaplug. In addition, radiographic findings like increase in root width, root length and decrease in apical diameter too were far better with MTA followed by Biodentine.

#### Abstract 216

### Survival analysis of endodontically treated tooth with or without full coverage crowns: A systematic review

**ROJA BASTIA**

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**Aim:** The objective is to assess the effects of restoration of endodontically treated permanent teeth by crowns versus conventional filling materials.

**Materials and Methods:** The protocol was registered in PROSPERO. PRISMA guidelines were followed. A focused structured question using Population(P), Intervention(I), Comparison (C), Outcome(O) was designed: "Which type of restoration (direct or indirect) provides a better clinical outcome for endodontically treated permanent teeth?" According to Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA), a broad search was conducted and literature was screened via the following databases: the Cochrane Oral Health Group's Trials Register, Pubmed, Web of Science, and SCOPUS and Google scholar until May 2021.

**Results:** A total of 306 articles were retrieved from the databases, from which only 70 articles were selected based on title and abstract. The full text was downloaded for these 70 articles and finally, 6 studies that fulfilled all the requirements of inclusion criteria were selected for data extraction and review. Two review authors independently assessed the extracted data and the risk of bias was assessed.

**Conclusion:** Indirect restorations consisting mostly of crowns have a higher survival rate than direct restorations using composite or amalgam, but no significant difference was found in short-term ( $\leq$  5-year) restorative success. However, high-quality clinical trials, especially well-designed RCTs with larger sample sizes and longer follow-up duration are needed for a better quality of evidence.

#### Abstract 217

### Effectiveness of antioxidant dentifrices on cariogenic bacteria: A systematic review

**SWETA MISHRA**

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**Aim:** This study assesses the effect of antioxidants present in dentifrices on cariogenic bacteria and hence preventing the formation of oral microbial biofilm that leads to dental caries.

**Materials and Methods:** The protocol was registered in PROSPERO, PRISMA guidelines were followed. A focused structured question using Population (P), Intervention (I), Comparison (C), and Outcomes (O) model, PICO was designed: "What is the effect of antioxidants present in dentifrices on cariogenic bacteria?" A broad search according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was conducted and literature was screened via PubMed/MEDLINE, Cochrane and TRIP database till 30th May 2021.

**Results:** A total of 57 articles were retrieved from which, 10 articles

Abstract

were selected on the basis of the title and abstract that met all the inclusion criteria, were incorporated in this review and selected for data extraction and review. Evaluation criteria of methodological quality and risk of bias control were applied to selected studies.

**Conclusion:** Antioxidants terminate the chain reaction caused by free radicals of oxidation reaction, thereby preventing cell damage or death of the cells. Antioxidants are widely available in various dentifrices and safety and efficacy of these antioxidants has been proven by clinical research. However, lack of randomised controlled trials in dental research limits their usage. This review highlights the effectiveness of antioxidant therapy to curb oral microbial biofilm formation when used as dentifrices.

### Abstract 218

#### Revascularization: A boon over apexification

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For decades, the apexification technique with calcium hydroxide has proven its effectiveness in open apices. It is the most studied to induce a calcific apical barrier with a success rate of 74% to 100%. However, this technique, which is considered a long-term procedure (6 to 24 months to obtain the apical barrier), does not increase the thickness or length of the root wall and make the tooth fragile and susceptible to future fractures. Recently, scientific research had led to the development of a new concept called revascularization to treat necrotic immature permanent teeth. This technique allows the continuation of root edification while the periapical lesion is healing. However, this protocol is not sufficiently studied and required a certain clinical dexterity. The origin and the nature of the tissue formed in the canal are still controversial. Several authors performed a histological study in relation to this topic on both human and animals. Recently, revascularization has been proposed as an improved alternative treatment for irreversibly damaged pulp of immature teeth as it has been shown to preserve the potential for continued root growth in treated teeth. The root canal is cleaned and disinfected by irrigation with sodium hypochlorite and/or chlorhexidine. The second step included the placement of disinfectant paste [Ca (OH)<sub>2</sub> or triple antibiotic paste (TAP)], followed by coronal seal and an intermediate restoration of the tooth. In the follow-up appointment, the tooth is reopened and canal over-instrumentation with a k-file is carried out to provoke bleeding from the periapical region. This causes blood cells to be trapped in clot, followed by the induction of angiogenesis and new pulp-like tissue formation over a period of time. MTA is placed over the clot and the tooth is permanently restored. Institution name not given.

### Abstract 219

#### Irrigation protocols in clinical scenario of separated instruments

**AISHWARYA WATTAMWAR**

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Complete chemo-mechanical preparation and three-dimensional obturation of root canals are sine qua non (essential) for successful

endodontic treatment. Nickel–titanium (NiTi) files are widely preferable to stainless steel files during chemo-mechanical preparation. Although NiTi files have several advantages such as ability to create well-centered and minimally transported root canals with minimal procedural errors, they might be unintentionally separated during different stages of the root canal treatment. This fractured file segment might prevent microbial control beyond the obstruction, especially if it is separated at the onset of treatment without further intervention.

An irrigation solution should reach the apical third by passing the blockage, to improve dentinal tubule penetration and antimicrobial control in the root canal, in the presence of the separated instrument. The combination of sodium hypochlorite (NaOCl) and ethylenediaminetetraacetic acid (EDTA) is widely used during chemo-mechanical preparation with NiTi files to improve antimicrobial activity. NaOCl is preferred mostly because of its antimicrobial effect, tissue dissolution capacity, and acceptable biologic compatibility when confined to the root canal.

Various devices such as EndoVac, EndoActivator, RinsEndo, etc are manufactured to increase the penetration depth of irrigants into the dentinal tubules and to improve their smear layer removal capacity. Previous studies reported that ultrasonic activation, EndoVac, and RinsEndo have the potential to ensure better microbial control compared to manual needle irrigation. It has been reported that EndoVac prevents apical extrusion of NaOCl. It applies negative pressure, while RinsEndo applies positive pressure and causes apical extrusion in vitro during root canal irrigation. Acoustic energy is delivered to intracanal irrigation solution via a file or special tip to generate acoustic streaming and cavitation in PUI method. Vibringe and EndoActivator sonic irrigation systems are used for sonically activate intracanal irrigants. However, to the best of our knowledge, efficiency of irrigation techniques with regard to removing the smear layer by reaching the apical region of the fragment in the presence of intracanal fractured instruments has not yet been investigated. Thus, this poster emphasizes on efficiency of different irrigation methods in presence of a separated instrument for effective endodontic treatment.

### Abstract 220

#### Clinical outcome of young immature necrotic permanent teeth treated with regenerative endodontic therapy versus apexification procedure: A systematic review with meta-analysis

**PRATIMA PANDA**

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**Objective:** To evaluate the effectiveness of regeneration compared to traditional apexification for managing young immature necrotic permanent teeth.

**Methods:** The protocol was registered in PROSPERO. PRISMA guidelines were followed. A focused structured question using Population (P), Intervention (I), Comparison(C), Outcome(O) was: “Which procedure between the two that is regenerative and apexification has more successful outcome in young permanent non-vital tooth?” The literature was screened via PubMed/MEDLINE,

## Abstract

Embase, ProQuest and Cochrane databases from January 2000 to February 2021 to select randomized clinical trials and observational studies that compared pulp revascularization and apexification treatments assessing clinical, radiographic outcomes. Two reviewers independently performed screening and evaluation of articles. A total of 814 articles were retrieved from databases, in which only 46 articles were selected for full-text analyses. After exclusion criteria, six studies were evaluated quantitatively and qualitatively.

**Results:** The outcomes at postoperative follow-up, such as dentinal wall thickness (DWT), increase in root length (RL), calcific barrier formation (CB), apical closure (AC), vitality response (VR), survival rate (SvR) and success rate (SR) were subjected to both qualitative synthesis and quantitative meta-analysis. The meta-analysis showed that the regeneration procedure showed significantly improved in the increase in RL, DWT, AC, VR than Apexification whereas no significant effect was observed on the survival rate and success rate of necrotic immature permanent teeth treated with both the groups.

**Conclusion:** Both regeneration and apexification procedure are equally comparable interventions and have over all similar outcomes. Clinicians should consider employing Regeneration treatment in cases when the root development is severely deficient, with insufficient dentin and where tooth prognosis is hopeless even with apexification procedure.

### Abstract 221

#### Surgical management of a persistent periapical cystic lesion: A case report

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A thorough debridement and mechanical preparation of the root canal followed by filling is required to eliminate infection in conventional endodontic treatment. Though a predictable procedure with a high degree of success, failures can still occur after conventional treatment. The primary mode of management in cases of previous endodontic failures is usually non-surgical revision of root canal treatment. However success of non-surgical retreatment maybe impeded by factors such as a complex root canal system or previous procedural accidents. Periradicular surgery though less often the first choice of treatment in such cases, could be the last hope to save an endodontically treated tooth with non-healing periradicular pathosis. It may be undertaken after unsuccessful retreatment or when retreatment is impossible. This presentation discusses a case of persistent periapical cystic lesion treated with enucleation of the lesion and apicoectomy on a lower right first molar.

### Abstract 222

#### Comparative evaluation of partial caries excavation and complete excavation in the management of deep carious lesions using different pulp capping materials: A randomized clinical trial

**S SHARMILA**

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**Aim:** The aim of this study was to compare management of caries removal and pulp capping in a single session that preserves pulp vitality in cases of deep carious lesions.

**Materials and Methods:** One hundred and ninety eight patients of age group 15-60 years with mature permanent molars having deep carious lesions were divided into two groups: partial caries removal (PCR) and CCR. Each group was further divided into subgroups A and B depending on the pulp capping material. A layer of soft, wet carious dentin was left adjacent to pulpal wall in PCR group, whereas in CCR group, complete infected caries was removed with bur. Teeth were restored with composite resin (Tetric N-Ceram; Ivoclar Vivadent), with base of resin-modified glass ionomer cement (RMGIC) and patients were recalled at 1, 3, 6, 12, and 18. Success was defined as absence of signs and symptoms of irreversible pulpitis (spontaneous pain, fistula, and swelling) and absence of periapical alterations (radiolucency at furcal or periapical region).

**Results:** Pulp exposure occurred in 15(7.57%) cases of CCR group. Statistical significant difference ( $P < 0.05$ ) in terms of pulp exposure was found between two groups. After 18 months, 176 teeth were evaluated (CCR = 82 and PCR = 94) and the success rate in CCR group (92.21%) and the PCR group (88.53%) did not differ significantly.

**Conclusion:** PCR could be as an elective treatment option for the mature permanent teeth with deep carious lesions.

### Abstract 223

#### Comparative evaluation of the colour stability of preheated and conventional composite after immersing in two different potential discolourant solutions: A digital spectrophotometer *in vitro* study

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**Objective:** To evaluate and compare the colour stability between preheated composite and conventional composite after immersion in two different potential discolourants.

**Methodology:** The sample size consisted of 42 composite discs of standard dimension. The samples were divided into 2 groups of 21 discs each. Group 1 was prepared using conventional composite at room temperature and group 2 was prepared by heating composite to 68°C. The composite discs were then light cured and stored in distilled water for 24 hours. The samples in each group were divided into 3 subgroups and immersed for 6 days in 3 different solutions including 2 potential discolourants (coffee solution and tea solution) and one control. The final colours of the discs were measured using Digital spectrophotometer. The difference between the measured colours (CIE-L\*a\*b\* system) were calculated and statistically analyzed using Paired t-test, ANOVA and Tukey's test.

**Results:** The preheated composites showed significantly lower staining in the coffee solution than the room temperature composites ( $p < 0.05$ ). In contrast, no statistically significant difference was observed for the tea solution ( $p = .065$ ). The staining

Abstract

of the preheated composites in distilled water was higher than composite made at room temperature, however, the difference was not significant ( $p=0.770$ ).

**Conclusion:** Within the limitation of this study, preheating of composite was found to be effective to improve the color stability of composite resin up on immersion in coffee solution.

#### Abstract 224

##### Prevalence of C-shaped canal in mandibular first premolars in the Indian sub-population: A cone-beam computed tomography cross sectional study

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Aim of this study was to analyse the prevalence of C-shaped canal and radicular groove (RG) in mandibular first premolars of Indian sub-population using Cone Beam Computed Tomography (CBCT) in vivo. The primary objective of the study was to assess the prevalence of C-shaped canal and radicular groove and secondary objective was to analyse the association between (RG) and C-shaped canal.

**Methods:** CBCT scans of 220 subjects were retrospectively collected, compiled and analyzed using volume rendering software. Parameters assessed were presence of C-shaped canal, RG, and classification of the C-shaped canal in coronal 3rd, middle 3rd, and apical 3rd. Any correlation between gender, age, and the parameters analyzed were evaluated. Pearson Chi-square test was used to compare the qualitative variables ( $p < .05$  was considered significant).

**Results:** Prevalence of C-shaped canal configuration in the Indian sub-population was 16.8% with the predominance of C3 configuration in the middle 3rd and C4 configuration in the apical 3rd ( $p < 0.5$ ). There is a significant association between C-shaped canal and RG. Gender and age did not show any association with RG and C-shaped canal.

**Conclusions:** Mandibular first premolars in the Indian sub-population showed a prevalence of C-shaped canals to be 16.8% and a strong association between RG and C-shaped canals.

#### Abstract 225

##### Comparative evaluation of compressive strength of biodentine and biodentine combined with graphene nanoparticles: An *in vitro* study

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**Aim:** To evaluate the compressive strength of biodentine incorporated with graphene nanoparticles.

**Materials and Methods:** A total of 36 samples were analyzed. The following experimental groups were established according to the materials to be tested: Group 1: Biodentine mixed with graphene nanoparticles. Group 2: Biodentine To test the compression strength, specimens measuring 12 mm in height by 6 mm in diameter were fabricated. The material was mixed according to the manufacturers guidelines; and placed in the molds. Both the experimental groups

included 6 samples each, which were maintained at 37°C under 100% relative humidity until the tests were performed. Each experimental group was subjected to testing at 1 hour and at 24 hours after-manipulation of the cements. The compression strength of each specimen was evaluated using a universal testing machine at a crosshead speed of 1 mm/min. The load was applied along the long axis. All measurements were recorded in megapascal (MPa). Results so obtained were statistically analysed.

**Results:** The study showed that an increase in compressive strength of biodentine mixed with graphene than biodentine.

**Conclusion:** Within the limitations of the study, it was concluded that the compressive strength was maximum in biodentine with graphene. In the present study, the materials were tested after their setting, which is not the real clinical scenario, where the tooth is immediately subjected to masticatory stresses. Thus, there is a need to conduct more elaborated studies, considering all the relevant limitations.

#### Abstract 226

##### Comparative evaluation of the effect of carbonic acid as solvent on the dissolution of mineral trioxide aggregate and biodentin and effect of carbonic acid on root dentin

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PRASANTH DHANAPAL**

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**Objective:** To compare and evaluate the effect of carbonic acid on the dissolution of MTA and Biodentin and the effect of carbonic acid on root dentin.

**Methodology:** Uniform discs of MTA and Biodentin were prepared under standardized condition following manufacturer's instructions. Dentin disc of standard dimensions were prepared. Preliminary microhardness of all the samples were tested after the initial set. All samples were soaked in carbonic acid for 5 minutes and the microhardness of all samples were tested again. The results were statistically analyzed using paired sample 't' test and the results compared.

**Results:** Biodentin showed no statistically significant difference in microhardness before and after the exposure to carbonic acid. MTA showed a statistically significant difference in microhardness before and after the exposure to carbonic acid. Root dentin showed significant reduction in the microhardness on exposure to carbonic acid.

**Conclusion:** Within the limitation of this study, it can be concluded that carbonic acid can be effectively used as an adjunct to dissolve set MTA. The effect of carbonic acid to dissolve Biodentin was minimal. Carbonic acid in contact with root dentin has been found to be detrimental to the microhardness of root dentin.

#### Abstract 227

##### Physics behind disinfecting canals - role of fluid dynamics in endodontics

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## Abstract

Endodontic research is focused on finding the clinical procedures and irrigants which can increase the success rate of endodontic treatment by reaching the apical anatomy. The infected root canal contains bacteria, necrotic tissue, organic and inorganic debris. Root canal irrigation along with instrumentation is important for its removal. Apical pressure, shear wall stress, and turbulence are the factors that play a role in deciding the safety and effectiveness of irrigation. In-vivo measurement in a root canal is difficult due to its microscopic size. So Computational fluid dynamics (CFD) allows for numeric simulation of irrigation in root canals in real physical conditions. It is a very powerful tool that can investigate flow patterns of irrigants, with the help of mathematical modeling and computer simulation. It deals with the pattern of irrigant flow, forces, and exchange within the root canal space. Wall shear stress depends on irrigant flow. The geometry of the irrigation needle and the increased flow rates cause the wall shear stress to increase gradually. It has an influence on the debris detachment by mechanical means, removal of tissue remnants, microbes as well as a biofilm. The force that is applied perpendicular to the surface of the apical wall is apical pressure. CFD analysis demonstrated that lowest apical pressure was for side vented closed-ended needle while the highest was for the open-ended needle. To prevent the irrigating solution from reaching the periapical tissues and cause an accident, it is necessary to maintain adequate apical pressure in the root canal. Fluid dynamics play an important role in endodontics and helps in deciding the amount of apical pressure and wall shear stress needed for proper cleaning of the canals and to prevent extrusion of irrigants. This review paper discusses the role of different needle designs in the proper disinfection of root canal with the help of computational fluid dynamics.

### Abstract 228

#### Influence of disinfecting procedures on the surface characteristics of gutta-percha and resilon points: A systematic review of lab studies

**GATHANI DASH**

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**Objective:** Aim of this study is to discuss about the influence of disinfecting procedures on the surface characteristics of both Gutta-percha (GP) and Resilon (R) cones.

**Methods:** The protocol was registered in PROSPERO, PRISMA guidelines were followed. To identify studies for this review, a detailed search strategies were developed by using the following electronic databases: Embase, Scopus, MEDLINE (PubMed), Web of Science, Google Scholar, non-indexed citations, reference lists of eligible studies. A broad search strategy was used to include the relevant terms, synonyms and alternatives obtained from MeSH browser related to disinfection of GP/R points. Data extraction was carried from the search results obtained from various databases. It was then exported to EndNote (details), following which, duplicates were removed. The titles and abstracts of the resulting studies was screened by a reviewer to remove papers that are out of scope of the topic in review. Full text of the remaining papers was obtained for further analysis. Two reviewers independently assessed these studies for possible inclusion in this review.

**Results:** The electronic search according to Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) identified 145 articles from which after removal of duplicated articles, the total number of articles were found to be 141. However, after screening of articles based on abstracts and titles, a total of 101 full text eligible articles were downloaded and finally only 24 articles were included in this review. After disinfection, presence of surface deposits with some alterations in physical properties of GP/R cones were detected. But these deposits were seen to be removed when rinsed with distilled water, 96% ethyl alcohol, 70% isopropyl alcohol. Presence of these deposits were seen to hamper the apical seal at the time of obturation and increase in concentration of disinfectant leads to changes in structural integrity of GP/R cones.

**Conclusion:** As there are few number of quality invitro studies, so there is a scope for further evaluation and analysis for changes in structural integrity of GP/R both macroscopically and microscopically.

### Abstract 229

#### Immunomodulation and regeneration properties of dental pulp stem cells: A potential therapy to treat coronavirus disease 2019

**PRATHAMESH GALKAR**

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The coronavirus disease 2019 (COVID-19) is known to cause severe acute respiratory symptoms. The occurrence of a cytokine storm in the lungs is a critical step in the disease pathogenesis, as it causes pathological lesions, pulmonary edema, and acute respiratory distress syndrome, potentially resulting in death. Currently, there is no effective treatment that targets the cytokine storm and helps to regenerate the damaged tissue. Mesenchymal stem cells (MSCs) are known to act as anti-inflammatory/immunomodulatory candidates and activate endogenous regeneration. As a result, MSC therapy is a potential treatment approach for COVID-19. Intravenous injection of clinical-grade MSCs into COVID-19 patients can induce an immunomodulatory response along with improved lung function. Dental pulp stem cells (DPSCs) are considered a potential source of MSCs for immunomodulation, tissue regeneration, and clinical application. Although some current clinical trials have treated COVID-19 patients with DPSCs, this therapy has not been approved. Here, we review the potential use of DPSCs and their significance in the development of a therapy for COVID-19.

### Abstract 230

#### The effect of different intracanal medicaments on fracture resistance of simulated immature teeth managed by apexification with mineral trioxide aggregate: An *in vitro* study

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**Aim:** The aim of the study is to evaluate the effect of different intracanal medicaments, Calcium hydroxide (Ca(OH)<sub>2</sub>), combination of Ca(OH)<sub>2</sub> with 2% Chlorhexidine solution, modified triple antibiotic

Abstract

paste (mTAP with Cefaclor ) on fracture resistance of simulated immature teeth managed by apexification with MTA.

**Materials and Methods:** Forty single rooted human mandibular premolars with single root canal were selected. Teeth were sectioned to obtain a standard root length of 14mm followed by working length determination and root canal preparation using Protaper universal rotary file system up to size F3. The prepared canals were then instrumented with peeso reamers number 1 to 4. Number 4 peeso reamer was used 1mm beyond apex to create blunderbuss canal to simulate immature teeth. The specimens were then randomly allotted into 4 groups based on intracanal medicament used: Group I- control group (no intracanal medicament), Group II - Ca(OH)<sub>2</sub>, Group III - combination of Ca(OH)<sub>2</sub> with 2% Chlorhexidine solution, Group IV - mTAP (Cefaclor 100mg + Ciprofloxacin 200mg + Metronidazole 400mg). After one week intracanal medicaments were removed using Ultrasonics and a 4mm MTA plug was placed in apical third of root canal. After 24 hours obturation was done using thermoplastic gutta-percha using Calamus (Dentsply/Tulsa; Tulsa,Okla). Specimens were then embedded in an acrylic cylinder and loaded till fracture using universal testing machine. Data was analyzed using One-way analysis of variance and Tukey's Post Hoc test.

**Results:** Vertical fracture resistance was highest for control group (Group I) followed by group IV (mTAP). There was no significant difference between group II and group III (Ca(OH)<sub>2</sub>, Ca(OH)<sub>2</sub> + 2% Chlorhexidine solution).

**Conclusion:** Within limitations of the present study, use of Ca(OH)<sub>2</sub>, Ca(OH)<sub>2</sub> with 2% Chlorhexidine solution significantly reduced fracture resistance as compared to mTAP when used as intracanal medicaments in simulated immature teeth managed by apexification with MTA.

### Abstract 231

#### Nanoparticles as endodontic disinfectants: An emerging trend

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The role of microorganisms as the primary cause of apical periodontitis has been well established, and thereby efforts have been directed toward eliminating them for higher success in endodontics. The disinfection process is challenging because of the complexity of the root canal system and the presence of isthmuses, accessory canals, and dentinal tubules, all of which can harbor bacteria and biofilms. Several studies have shown the presence of biofilm inside the root canal with bacterial penetration into dentinal tubules at varying depths. Mechanical preparation can physically remove tissue remnants, biofilms, and infected dentin. However, large portions of the root canal system after mechanical preparation may remain uninstrumented. Although current chemical irrigants, such as chlorhexidine (CHX) and sodium hypochlorite (NaOCl), are effective antimicrobials, they are still incapable of eradicating bacterial infection with limited efficacy to completely disinfect dentinal tubules. To overcome the drawbacks of the

conventional antibacterial agents and to achieve promising results in endodontics, antimicrobial nanoparticles offering numerous advantages like large surface-area-to-volume ratio, ultra-small sizes, and excellent chemical and physical properties have been introduced. Nanoparticles (NPs) provide a new advancement for the prevention and treatment of dental infections. The positive charge and increased surface area of NPs allow them to react with the negatively-charged bacterial cells causing increased antibacterial activity. Furthermore, NPs can be combined polymers or can be coated onto biomaterial surfaces. This was also found to exhibit enhanced antimicrobial property. Nanomaterials (NMs) have recently gained importance in technological advancements due to their superior physical, mechanical, chemical and biological properties. These properties have resulted in better performance as compared to that of their conventional counterparts. Nanomaterials have shown great promise to reduce biofilm formation, enhance remineralization of the tooth structure by inhibiting its demineralization process, and to counteract the caries-related and endodontic microorganisms. These results have been inspiring enough to open the doors for further clinical studies that will allow the therapeutic value of nanotechnology-based materials to be authenticated. This poster highlights the various nanoparticles used in disinfection of root canal.

### Abstract 232

#### Morphological and canal variations encountered in permanent mandibular first molars: An overview

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Adequate knowledge of canal anatomy and morphology plays a vital role in achieving successful outcomes of Endodontic therapy. The incidence of anatomical complexities and variations in canal configuration in the mandibular first permanent molar tooth makes endodontic treatment challenging. One of the main reasons for failures of root canal therapy is inadequate cleansing and a missed canal. It is therefore of utmost importance that the clinician should have thorough knowledge of variations likely to be encountered in the tooth to be treated. The mandibular first molar is one of the earliest tooth to erupt in the oral cavity and is one which is most frequently treated endodontically. This review discusses the variations in morphology and canal configuration commonly encountered in mandibular permanent first molars and also the need for a preoperative knowledge and assessment of the same prior to initiation of therapy.

### Abstract 233

#### Comparative evaluation of dentinal crack propagation during removal of gutta percha using two rotary instruments: An *in vitro* study

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## Abstract

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**Aim:** 1.To evaluate and compare the occurrence of dentinal defects caused by two different rotary file systems and hand files during the retreatment procedure and the efficacy and cleaning ability of rotary file systems and hand file using Scanning Electron microscopy and Stereomicroscope.

2.To evaluate and compare the time elapsed from entering the root canal with the hand file and the nickel-titanium file to the completion of the re-instrumentation.

**Materials and Methods:** 60 extracted human maxillary first molars with curved roots were mounted on addition silicone set in an aluminium hollow block and instrumented using step-back preparation with 35 #K files and obturated using gutta-percha with AH plus sealer. After the storage period of 14 days, samples were divided into 3 groups- Mani GPR, Endostar Re Endo and H file and subjected to retreatment procedures. Retreatments were considered complete when no filling material was observed on the instrument and canal wall was smooth and free of visible debris. The root was sectioned horizontally into coronal, middle and apical thirds and the sample was examined under a stereomicroscope and Scanning electron microscope and photographs were taken. The number of cracks and percentage of root canal filling material was calculated and time taken recorded in seconds. The data obtained were analyzed using descriptive statistics, ANOVA (Analysis of Variance), chi-square test and Scheffe's post hoc test through SPSS software (version 22.0).

**Results:** All instrumentation techniques showed similar amount of crack propagation ( $P > .05$ ) with no statistical difference between the groups. Retreatments done using H Files required more time and removed less material ( $P < .05$ ). The coronal third showed less amount of gutta-percha remnants than the apical third in all groups ( $P > .05$ ).

**Conclusion:** All the groups showed similar amount of crack propagation. Less and more number of cracks were observed in the coronal one third and apical third respectively. Endostar RE Endo rotary instrument proved to be most effective and least time-consuming. H Files required more time and removed less material.

### Abstract 234

#### Artificial intelligence: The panacea to endodontic dilemmas

**PARVATHI SUDEEP, PARAS MULL GEHLOT**

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In today's world, patients desire to retain their natural dentition, which can be technically demanding in specific challenging scenarios. In this era of advancements in science and technology, it is this increase in awareness among individuals which has revolutionised the field of dentistry. Every branch of clinical dentistry, especially the branch of endodontics, has seen a breakthrough in diagnosis, treatment planning and prediction of prognosis in recent years. Endodontics is an excellent coalescence of art and science, though challenging, which requires a lot of skill and precision for long term success. With the help of picture archiving systems (PACS), advances in artificial

intelligence (AI) and computer-aided diagnostic (CAD) systems, dentists have been able to augment the quality of treatment and ensure a favourable outcome by improving and facilitating the delivery of appropriate dental care. Artificial intelligence (AI), consisting of a sequence of algorithms, work on the concept of a neural network architecture pattern similar to the human brain and mimics human thinking. It encompasses a broad spectrum of emerging technologies; starting from booking a patient's appointment in the clinic, taking proper medical and dental history, managing insurance to assisting procedures, diagnosis (radiographs/CBCT), guided access (use of dynamic navigation tools), working length determination (apex locators, determining the apical constriction), irrigation (Gentle wave - irrigation mechanism), and treatment and retreatment procedures (Endomotors/Torque control motors); with which AI accomplishes a remarkable role in simplifying endodontic treatment. It has also been used widely in locating apical foramina, predicting periapical pathologies, detecting and diagnosing vertical root fractures, evaluating the outcome of regenerative procedures and retreatments, assessing root morphologies and difficulties associated with canal preparations. Being a potential game-changer and beginning something called a 'fourth industrial revolution, AI has what it takes to revolutionise endodontics with time. This review paper describes the principles of AI, concepts and development, relevance and how it is currently being used, emphasising the future of inter-professional coordination by bridging the gap between technology and dental medicine for comprehensive and successful endodontic treatment modalities.

### Abstract 235

#### Bio-printing: Modern era of regenerative endodontics and tissue engineering

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Bioprinting is an emerging field in regenerative medicine, it is a subcategory of additive manufacturing (AM), also known as three-dimensional (3D) printing. It is the stacking of structures using viable cells, biomaterials and biological molecules using the printing principle. The main technologies used for 3D bioprinting of living and biological materials are inkjet, laser-assisted printing, and micro-extrusion. Presently, bioprinting has been applied to the regeneration and reconstruction of multilayered skin, bone, vascular grafts, tracheal splints, heart tissue, cartilaginous structures, and the retina, among other structures offering great potential to fabricate microstructures that have specific alignment and interactions in different layers of the microstructures. With the development of additive manufacturing and bioprinting techniques, dental tissue research has transitioned from inert synthetic materials to biological and bioactive hydrogels, which can better mimic the 3D dental pulp microenvironment. The fabrication of scaffolds via 3D printing is already being performed extensively at the laboratory bench and in clinical trials; however, printing living cells and matrix

Abstract

materials together to produce tissue constructs by 3D bioprinting remains limited to the regeneration of dental pulp and the tooth germ. Although it remains in its early stages to print living cells and matrix materials together to produce dental tissue constructs, 3D bio-fabrication utilizing photo cross-linkable polymers, such as gelatin methacryloyl (GelMA) hydrogels, has been proven to be promising for the dental pulp and whole-tooth regeneration due to their good biocompatibility and efficient revascularization. In this short review, recent progress and challenges on the emerging strategies to fabricate the dental pulp vascular microenvironment are addressed from a biomaterial and microengineering standpoint.

**Abstract 236**  
**Endodontic management of permanent maxillary second molar with two palatal roots: A report of two cases**

**ASMAT FATIMA**

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The maxillary molars are one of the most complex types of teeth by virtue of their multifaceted internal and external anatomy. Their root canal anatomy has been traditionally described as three roots with three canals, with the commonest variation being a second mesiobuccal canal (MB2). The incidence of MB2 has been reported to be between 18% and 96.1%. In vivo studies show that 1.4% of maxillary second molars can present with two palatal roots and two palatal canals. Slowey was the first author to report the endodontic treatment in a maxillary second molar with two independent palatal roots. Complexity of root canal system and variations in internal anatomy of teeth require careful analysis and the clinician must be aware of anatomical variations of the root canal system for the success of endodontic therapy. This presentation of two cases discusses the successful endodontic management of maxillary second molar with two palatal roots.

**Abstract 237**  
**Effect of gutta percha disinfection against *Enterococcus faecalis*: A systematic review**

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**Objective:** To discuss the effect of gutta percha (GP) disinfection against *E faecalis*.

**Methods:** The topic was registered in PROSPERO, PRISMA guidelines were followed. A focused structured question using Population (P), Intervention (I), Comparison (C), Outcome (O) (PICO) was designed: "Does gutta percha disinfection reduces the microbial count of *E faecalis*?". To identify studies for this review, a detailed search strategy were developed by using the following electronic databases: Embase, Scopus, MEDLINE (PubMed), Web of Science, Google Scholar. A broad search strategy was conducted to include the relevant terms, synonyms and alternatives obtained from MeSH browser related to the topic. Data extraction was done from the

search results obtained from various databases. The titles and abstracts of the resulting studies was screened by a reviewer to remove papers that are out of scope of the topic in review. Full text of the remaining papers was obtained for further analysis. Two reviewers independently assessed the studies for possible inclusion in the review.

**Results:** The electronic search according to Preferred Reporting Items for systematic Reviews and Meta-Analysis (PRISMA) identified 145 articles. However, after screening of articles based on abstracts and titles, a total of 101 articles were eligible. 17 full-text articles were found to be eligible that fulfilled all the inclusion criteria could be assessed for the study.

**Conclusion:** Most of in vitro studies had moderate risk of bias, however the disinfection protocol of gutta-percha is an effective procedure against *E. faecalis*.

**Abstract 238**  
**Triumphant fragment reattachment techniques and bonding material**

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Dental trauma is a public health issue due to its high prevalence and because it directly influences the individual's quality of life. It requires a multidisciplinary approach, accurate treatment with simple and suitable techniques to prevent complications. Making a clinical decision to preserve the natural dentition has many treatment options to restore uncomplicated traumatized teeth, including the direct and indirect restorative procedure. This review focuses on attempts being made to overcome complexities in the traumatized tooth. Many techniques have been reported, there is no consensus as to which promotes the better result in increasing the bond strength and fragment reattachment. The tooth fragment bonding technique, frequently used to restore traumatized teeth, may be affected by dehydration/rehydration periods. Rehydrating a tooth fragment before bonding with an adhesive appears to maintain sufficient moisture to increase reattachment strength. Bonding depends on tooth vitality and adaptation of fragments to the remaining tooth structure that will affect the prognosis of teeth. Rehydrating a tooth fragment before bonding with adhesive appears to maintain sufficient moisture to increase reattachment strength. This review will choose tooth fragment reattachment techniques and bonding material for the crown of a fractured anterior tooth.

**Abstract 239**  
**Dental pulp auto-transplantation: A novel approach to regenerative endodontics**

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The advancement of science and technology has huge positive

Abstract

impacts on the present day world. It has contributed immensely to every aspect of our lives, including the medical and dental care. The treatment concepts that were once perceived to be imaginative are today considered achievable. One of such achievement is regenerative therapy. Regenerative therapy promises numerous clinical dental benefits, including biological strategies to repair teeth. Caries is the most common cause of pulp-periapical disease. When the pulp tissue involved in caries becomes irreversibly inflamed and progresses to necrosis, the treatment option is root canal therapy because the infected or non-infected necrotic pulp tissue in the root canal system is not accessible to the host's innate and adaptive immune defense mechanisms and antimicrobial agents. Therefore, the infected or non-infected necrotic pulp tissue must be removed from the canal space by pulpectomy. As our knowledge in pulp biology advances, the concept of treatment of pulpal and periapical disease also changes. Endodontists have been looking for biologically based treatment procedures, which could promote regeneration or repair of the dentin-pulp complex destroyed by infection or trauma for several decades. One such approach to regeneration of dentin-pulp complex is pulp auto-transplantation, which is highly specialised and technique sensitive process. With the help of this review, we want to highlight the potential for clinical application of pulp regeneration using this new modality of endodontic therapy.

**Abstract 240**

**The effect of different activation techniques on dissolution capacity of pulp tissue in simulated internal resorption cavities**

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**Objective:** Internal root resorption (IRR) in permanent teeth is a pathological progressive destruction with hard tissue lost in dental hard tissue that occurs because of clastic activation. Although there are advanced endodontic instruments and treatment techniques, bacteria and debris cannot be removed completely due to the complexity of the root canal anatomy. Moreover, there are difficulties in removing the pulp tissue remnants perfectly from the internal resorption cavities (IRC). The aim of this study was to evaluate the effect of different irrigation activation techniques on dissolution capacity of pulp in IRC.

**Material and Methods:** Ninety freshly extracted human teeth were selected. After decoronation procedure, the roots were split longitudinally, and IRC were prepared in the canals on each half of the roots. Bovine pulp tissue samples were weighed and placed into the resorption cavities. The root fragments were reassembled and cemented to create a circular simulated resorption cavity within the canal. Teeth were divided into six groups (n=15) according to the irrigation protocols: Group 1: sodium chlorur (NaCl) and sonic irrigation (SI), Group 2: sodium hypochlorite (NaOCl) and SI, Group 3: NaCl and passive ultrasonic irrigation (PUI), Group 4: NaOCl and PUI, Group 5: NaCl and laser activated irrigation, Group 6: NaOCl

and LAI. After irrigation protocol, teeth were decemented and the tissue samples inside the resorption cavities were weighed. The difference between initial and last measurement was calculated. The obtained data was analyzed statistically using One-way ANOVA test with a significance level of 0.05.

**Results:** SI has significantly more successful results than PUI and LAI in groups which the irrigation solution was NaCl. There was also a significant difference between LAI and PUI in groups which the irrigation solution was NaOCl (Group 6 > Group 4, p=.003). There was no significant difference between LAI and SI with NaOCl. **Conclusion:** LAI with NaOCl was more effective than other irrigation activation system in dissolution capacity of bovine pulp tissue from simulated IRC. However, there is no significant difference between LAI and SI with NaOCl.

**Abstract 241**

**Effect of glide path files with different metallurgy on intracanal bacterial extrusion by HyFlex EDM files: An *in-vitro* study**

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**Aim:** To comparatively evaluate the effect of glide path files with different metallurgy on apical extrusion of intracanal bacteria after instrumentation with HyFlex EDM file.

**Materials and Methods:** Forty human mandibular premolar teeth were selected, decoronated and autoclaved. The specimen were placed in a test apparatus of sterilized glass vials and inoculated with Enterococcus faecalis. The specimens were randomly divided into four major groups depending upon the glide path file used. Group I with Proglider, Group II with Edge GlidePath Files and Group III with Neoniti GPS and Group IV without glide path instruments using HyFlex EDM. After Glide path preparation, final canal preparation was done with HyFlex EDM. 0.1 mL NaCl solution was taken from the experimental vials. The suspension was plated on brain heart infusion agar and bacterial colonies were counted. The results were given as number of colony-forming units (CFU). Statistical analysis was done using SPSS Version 20.0 (SPSS Inc., Chicago, IL, USA).

**Results:** The group without glidepath preparation showed maximum number of extruded bacteria compared to the other 3 groups (p < 0.05). The groups I and II using glide-path instruments extruded similar amounts of bacteria. The group III showed significantly higher bacterial extrusion than group I and II.

**Conclusion:** All the instrument systems tested caused a measurable apical extrusion of intracanal bacteria. The group without glide-path preparation showed the highest number of bacteria extruded compared to the other NiTi glide-path establishing instruments.

**Abstract 242**

**The foot soldiers of the dental pulp: Natural antimicrobials**

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The Dental Pulp is a specialized dental connective tissue which is equipped with its own innate and adaptive immune responses,

Abstract

designed to defend against infections & limit its spread. The innate immune response provides an effective and broad, non-specific first line of defense by combining the phagocytic activity of inflammatory cells like neutrophils & macrophages with the release of certain factors such as antimicrobial peptides that have potent chemotactic, antimicrobial & immune modulatory actions with lower cytotoxic effects on the host cells. These naturally occurring antimicrobial peptides have a broad spectrum of activity against bacteria, viruses & fungi. Within the pulp, these antimicrobial peptides have their origins traced to various resident or recruited components of the dental pulp such as the odontoblasts, neutrophils, fibroblasts, nerves & stem cells. Lately, there is a resurgence of interest in the biological activities of these antimicrobial peptides, largely driven by the need to develop & obtain alternatives to antibiotics & also aiming at the possibility of maintaining the vitality of the dentin-pulp complex. This review would provide an overview of the sources and actions of antimicrobial peptides within the dental pulp & how these factors could avoid antibiotic use, thereby reducing the possibility of antibiotic resistance.

### Abstract 243

#### Comparative evaluation of antibacterial property of chlorhexidine alone and its combination with calcium hydroxide, chitosan and bioactive glass against *Enterococcus faecalis*: An *in vitro* study

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**Aim:** The aim of the study is to compare the antibacterial property of Chlorhexidine and other medicaments namely Calcium hydroxide, Chitosan and Bioactive glass and each of its combination with 2% Chlorhexidine gel against *Enterococcus faecalis*.

**Materials and Methods:** Eighty permanent maxillary non-carious single-rooted teeth were randomly divided into eight groups of ten teeth each. After debris and smear layer removal, prepared blocks were inoculated with *E. faecalis* and incubated for seven days for biofilm formation. Medications including 2% Chlorhexidine gluconate gel, Calcium hydroxide, Chitosan, Bioactive glass alone and the combination of CHX with other three medications were placed into the dentin blocks and incubated at 37°C for seventy-two hours. Dentinal shavings were taken and the mean bacterial count was recorded. Statistical analysis was done using One-way Analysis of Variance (One way ANOVA), Tukey's post hoc test and Unpaired t-test for pairwise comparison. Result The highest reduction in the bacterial count was obtained for Group 1 ( 2% CHX). Compared to Group 2A ( Ca(OH)<sub>2</sub>), Group 2B( Ca(OH)<sub>2</sub> + CHX) exhibited more reduction in bacterial count. The effect of Group 2B( Ca(OH)<sub>2</sub> + CHX) was almost similar to Group 1 ( 2% CHX). The difference among these three groups was not statistically highly significant. Group 3A( Chitosan) and Group 3B(Chitosan + CHX) have shown less reduction of the bacterial count. Group 4A ( BAG) reported the highest bacterial count. Group 4B ( BAG+ CHX) was found to decrease the bacterial load and statistically significant differences exist between Group 4A

(BAG) and Group 4B(BAG+ CHX). Conclusion Among all the groups, the highest antibacterial property against *E. Faecalis* was shown by 2% Chlorhexidine gluconate gel alone. Calcium hydroxide when used alone was less effective against *E. faecalis*. Calcium hydroxide combined with CHX showed almost equal antibacterial property as 2% CHX gel alone. Bioactive glass when used alone was least effective against *E. faecalis*. When it was combined with Chlorhexidine, its effectiveness improved. The Chitosan was not effective against *E. faecalis* when used alone. There was no improvement in efficacy when combined with CHX.

### Abstract 244

#### Effect of various root repair materials on the microhardness of human root dentin in different storage media

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**Aim:** Tricalcium silicate cements may improve the physical properties of dentin along with providing bioactivity and biocompatibility. The aim of this study was to evaluate 1) the effect of three calcium-silicate-based cements on the micro-hardness of adjacent dentin, and 2) the effect of phosphate-buffered saline and distilled water on the bioactivity of the materials as storage media.

**Materials and Methods:** Forty-eight extracted human maxillary first molars were randomly assigned to three groups (n=16). Group 1: Mineral trioxide aggregate (Angelus MTA, Angelus, Londrina, Paraná, Brazil), Group 2: EndoSequence Root Repair Material (ESRRM, Brassler, Savannah, GA, USA) and Group 3: Biodentine (Septodont, Saint-Maur-des-Fossés, France). The palatal roots were sectioned at a standard root length and were subjected to endodontic treatment. Two sections (control and experiment) were obtained from the middle third of each root. The root lumen of the experimental groups was filled with the respective reparative cements. The specimens of each group were further divided into two sub-groups depending upon the storage media (n=8). Subgroup 1: Phosphate buffered saline and Subgroup 2: Distilled water. Mean Vickers' Hardness Values for the specimen were recorded after a storage period of 2 months.

**Results:** One-way Analysis of variance and Tukey's test showed a statistically significant difference among the three cements (p< 0.05) and the two storage media (p<0.05). ESRRM showed superior micro-hardness values (87.59 ± 9.80) followed by Biodentin (75.29 ± 7.39) and then MTA (65.91 ± 2.67). Specimens immersed in phosphate-buffered saline showed better increase in micro-hardness values as compared to distilled water irrespective of the type of reparative material used.

**Conclusion:** Endosequence Root Repair Material resulted in a higher percentage increase in microhardness as compared to Biodentine and MTA. Phosphate-rich media increased the microhardness of adjacent dentin by enhancing the bioactivity of the materials.

### Abstract 245

#### Comparative evaluation of push-out bond strength of two different perforation repair materials mixed with graphene nanoparticles: An *in-vitro* study

Abstract

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Tamil Nadu, India

**Aim:** To evaluate the push-out bond strength of different perforation repair materials when mixed with Graphene Nanoparticles

**Materials and Methods:** A total of 40 freshly extracted human first permanent mandibular molars were taken for the study. To test the push-out bond strength, 40 mandibular molars are decoronated at the level of CEJ. Access opening done using #6 round bur. Perforation was created in the furcation area using the same round bur. Root sections were sliced 5 mm below the furcation using diamond disc. Perforation repaired using the following materials. Samples will then be divided into four groups (n=10)

GROUP 1 - Furcal perforation repair done with MTA.

GROUP 2 - Furcal perforation repair done with Biodentine.

GROUP 3- Furcal perforation repair done with MTA mixed with Graphene Nanoparticles.

GROUP 4 -Furcal perforation repair done with Biodentine mixed with Graphene Nanoparticles.

Push-out bond strength will then be determined by subjecting the samples to universal testing machine, with a cross head speed of 1 mm/min. The load was applied along the long axis of the tooth. All measurements were recorded in megapascals (MPa). Results so obtained were statistically analysed.

**Results:** The study showed that there is a decreased push-out bond strength of both MTA and Biodentine incorporated with graphene nano-particles than unmixed MTA and Biodentine.

**Conclusion:** Within the limitations of the study, it was concluded that the push-out bond strength has been reduced in both MTA and Biodentine incorporated with graphene nano-particle. In the present study the samples were tested after setting which is not the real clinical scenario, where the tooth is immediately subjected to masticatory stresses. Thus, there is a need to conduct more studies, considering the limitations.

**Abstract 246**

**To evaluate and compare the outcome of various pulp capping modalities in complete pulpotomy in mature permanent molars with acute irreversible pulpitis: A double-blinded randomized trial**

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AKSHAY RATHORE**

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**Aim:** To evaluate and compare the outcome of various pulp capping modalities after pulpotomy in mature permanent molars with irreversible pulpitis.

**Materials and Methods:** It is a randomized, superiority, pragmatic, parallel, double-blinded clinical trial registered under the Clinical Trial Registry-India. In total, 120 permanent maxillary and mandibular molars in the age group of 18-45 years with carious exposure and symptoms of irreversible pulpitis were randomized into three groups: Group 1: Biodentine, Group 2: Lyophilised freeze-dried platelet-rich concentrate (PRP + Biodentine), and Group

3: Low level laser therapy (LLLT+ Biodentine). Complete pulpotomy was performed followed by hemostasis and further pulp capping was performed in the three groups followed by restoration. The outcome was measured by the time taken for hemostasis, presence/absence of spontaneous postoperative pain using Visual Analog Scale (VAS) score, mean anti-inflammatory intake, periapical changes using Periapical Index (PAI), tenderness on percussion (TOP), and evidence of internal resorption or furcal radiolucency were assessed at 1 week, 3 months, 6 months and 1 year. Data were analyzed and subjected to statistical analysis. One-way ANOVA and post hoc Bonferroni test were used to analyze post-operative pain and anti-inflammatory intake.

**Results:** Post-operative pain and anti-inflammatory intake was minimum in the first week in Group 3: LLLT+ Biodentine ( $0.77 \pm 0.847$ ) and ( $0.03 \pm 0.180$ ) respectively followed by Group 2: PRP+ Biodentine ( $3.24 \pm 1.189$ ) and Group 1: Biodentine ( $3.27 \pm 1.07$ ) ( $p < 0.005$ ). The pain was relieved completely by 3rd week in all the groups. There was no difference in any other clinical and radiographic parameters among the groups.

**Conclusion:** All the three modalities exhibited 100% clinical and radiographic success at 6 months and 1 year with minimum postoperative pain observed in the case of LLLT+Biodentine.

**Abstract 247**

**A review on application of nanotechnology in endodontics**

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Nanotechnology has been used in different fields like electronic, energy, biomedicine, environment, food industry, textile industries. The use of nanotechnology in different fields has led to its application in dentistry, starting a new era called nanodentistry. Production of different resin based nano composites and bonding agents improved the surface chemistry of materials leading to enhancement of overall performance of the material. One of the reasons for the failure of endodontic treatment is incomplete eradication of microbes from the root canal space which further form biofilms. Diffusion and action of conventional irrigants and intracanal medicaments is limited within the root canal system, however with the incorporation of nanoparticles these properties can be improved such that the microbes present at greater depths in dentinal tubules can be eliminated. Application of nanotechnology in endodontic material science provide quality treatment outcome such as producing target specific drug delivery systems, early regeneration, repair of periapical tissues and enhancing aesthetics. This paper reviews on future prospects of nanotechnology in endodontics like incorporation of nanoparticles in irrigation and intracanal medicaments, in enhancement of the sealing ability of root canal sealers, obturating materials and post endodontic restorations.

**Abstract 248**

**Setting the stage for a rescue mission! – A case report**

**DEV SOUNDARYA, VERONICA ARUNA KUMARI,  
S LINDA CHRISTABEL, SHAMINI SAI, PE MUKUNDAN,  
ANAND V SUSILA**

Abstract

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Successful root canal treatment depends on judicious use of endodontic files and copious irrigation to assist in the cleaning and shaping of the complex root canal system. However, unpleasant mishaps, such as fracture of endodontic instruments may occur and can present as a nightmare to the dentist. Factors contributing for such mishaps most commonly include physical and mechanical properties of instruments, sterilization, irrigant characteristics, operator's negligence and root canal curvature. Broken files affect cleaning, shaping and filling processes of the root canal, thereby causing a potential failure. This is a case report which describes the successful management of a complicated file fracture in the root of lower right first molar tooth. A 39-year-old patient reported with a previously initiated root canal treatment to the post graduate clinic. The re-treatment was initiated and during treatment the rotary file fractured in the middle third of the root of lower right first molar. A staging platform was prepared using GG drills in the mesio-buccal canal coronal to the fragment. Hand instruments were used to penetrate alongside the broken instrument for half the length of the instrument by a #0.8 K-file. This bypass was prepared until a #25 K-file could be inserted. The broken fragment was loosened, dislodged and successfully removed using an ultrasonic U file and copious irrigation under the dental operating microscope. This report explains how an appropriate armamentarium complemented by ultrasonic vibration and magnification helps in successful removal of fractured instruments.

#### Abstract 249

##### Comparative evaluation of the effect of two single file rotary system on peri-cervical dentin removal: An *in vitro* cone beam computed tomographic study

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**Aim:** To evaluate and compare the effect of Truenatomy, and Hyflex EDM rotary single file system on pericervical dentin (PCD) using con-beam computed tomography (CBCT).

**Materials and Methods:** Twenty freshly extracted single rooted mandibular premolars were selected and divided into two groups (n=10). Teeth of both groups were mounted on an Alginate template. Preinstrumentation Cone Beam Computed Tomography (CBCT) imaging of all teeth was done at level of CEJ, 4mm above CEJ and 4mm below CEJ. Preinstrumentation cbct was taken. Group 1 was prepared with TruNatomy prime rotary single file and Group 2 was prepared with - Hyflex EDM rotary single file. Post-instrumentation CBCT imaging was done in a similar method as preinstrumentation scan and the amount of pericervical dentin removed was calculated. Student's t-test was used for inter-group analysis at all the three levels

**Results:** No significant difference between Truenatomy, and Hyflex EDM rotary single files on pericervical dentin removal ( $P > 0.05$ ).

**Conclusion:** within the limitations of this study it can be concluded that both the file systems have shown similar results in removing pericervical dentin.

#### Abstract 250

##### Nonsurgical endodontic management of maxillary canine with 3 root canals: A report of sporadic anatomical variant

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The root canal anatomy varies according to race, ethnic group and gender. These differences should be considered during the pre-treatment evaluation for root canal therapy. It can sometimes be challenging to identify and manage uncommon or complex root canal anatomies. Multiple root canals in single rooted teeth are caused by longitudinally running fins and a network of communication between the canal walls, and these have a high chance of being missed on conventional radiographs. Due to this complexity of root canal anatomy, Weine proposed classification of canal configuration which was further elaborated by Vertucci (for 3 canals configurations). Although most of the canal variations for a given tooth could be categorized under the Vertucci classification, some cases may present with unique configuration that are not reported in previous classifications. Hence, studies by Gulabivala et al and Sert & Bayirli have added more canal variations to the previous classifications. Permanent maxillary canines are considered universally as the "Corner stones" of dental arches and are mostly single-rooted, having a single canal with Vertucci type I (81.6%) configuration. Maxillary canine with Vertucci type II (2.8%), type III (11.6%) and type IV (0.8%) canal configuration are also reported. Literature search revealed no case was reported in a maxillary canine with 3 canals joining apically into one. Such a configuration according to Gulabivala et al.'s supplemental classification (to those of Vertucci) is type I (0.7%) in single rooted teeth. This presentation reports the non-surgical endodontic management of non-vital permanent maxillary canine with 3 canals. Awareness of complex root canal anatomy and careful radiographic interpretation are crucial in recognition and successful clinical management of uncommon root canal configurations.

#### Abstract 251

##### Recent advances in obturation

**RAVEENA P JOHN**

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Obturation occupies a prime position in the present endodontic triad. The clinical goal of root canal obturation is to fill the empty spaces, achieve a fluid tight seal and prevent bacterial infiltration into the periapical tissues. Endodontic obturation has witnessed a progression from the contemporary gutta percha to the adhesive bioceramic based hydraulic obturation techniques over the past decades. Traditionally root canal filling predominantly consists of gutta percha core material and accessory cones along with a sealer to fill in the spaces. Sealers ranged from contemporary zinc oxide eugenol sealers, glass ionomer sealers, medicated sealers, resin sealers to the presently available bioceramic sealers. Earlier sealers have a set of limitations restricted to shrinkage, dissolution in oral fluids and its inability to bond to the underlying dentin. With the advent of surface coated and modified gutta percha along with

## Abstract

bioceramic sealers, single cone hydraulic condensation techniques forming tertiary monoblocs is now possible. The sealer to gutta percha ratio can now be increased and the sealer now acts as the filling material. Bonded interface has resulted in minimally invasive root canal preparations aiming at tooth preservation. These newer advancements in techniques have helped to achieve better and simpler filling of the canals. This paper will discuss all the newer techniques and material advancements to achieve a successful 3D obturation.

### Abstract 252

#### Effect of strontium doped fluorophosphate bioactive glass on properties of mineral trioxide aggregate: An *in vitro* study

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**Background:** Mineral Trioxide Aggregate (MTA) a bioactive material, necessitate enhanced regenerative potential due to its extended use in the field of endodontics. Phosphate based glass with its unique property of inclusion of therapeutic dopants is extensively used in medicine due to enhanced angiogenesis and bone formation. Hence, 6% strontium doped fluorophosphate bioactive glass (6%Sr-FPG) was incorporated in MTA and evaluated its cytotoxicity and surface characteristics.

**Materials and Methods:** The experimental groups were based on varying wt% of Sr-FPG added to MTA. Control: M-MTA; Experimental groups: 1SM-1:99 wt %; 5SM - 5:95 wt % and 10SM - 10:90 wt %. The powder was mixed with distilled water to obtain a desired consistency and packed in moulds. Following curing for 3 hrs, samples were immersed in corrected-SBF (c-SBF). MTT assay (mouse fibroblast cells) and Field Emission Scanning Electron Microscopy (FESEM) was done to evaluate cytotoxicity and structural morphology on day 1 and 28. Results of MTT assay was subjected to Kruskal Wallis test followed by Wilcoxon signed rank test.

**Results:** MTT assay showed significantly increased cell viability for 5SM compared to the other groups on day 28 ( $p < 0.05$ ). FESEM revealed enhanced precipitation of crystals with evident surface morphological changes in all the experimental groups, as the concentration of Sr-FPG increased on day 1 and 28.

**Conclusion:** Strontium doped fluorophosphate bioactive glass incorporated MTA could be a viable alternative to conventional MTA in various clinical applications.

### Abstract 253

#### A review of minimally invasive surgical endodontics

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The role of surgical endodontics comes into play when the conventional root canal therapy fails to resolve the underlying infection and patient remains symptomatic in spite of repeated intracanal dressings. According to protocol, a portion of the buccal bone is removed to get access to the root apices of the infected

teeth, and resection is done after the surgical debridement of the peri-radicular area. Length of 3mm of the root end is advocated to be removed in a plane perpendicular to the long axis of the tooth to effectively seal any lateral canals present, minimize microleakage and reduce dentinal tubule exposure. Finally, the site is sutured after obturating the root end with suitable retro filling material. Although the advancements in 3-D technology and introduction of Cone Beam Computed Tomography (CBCT) has allowed personalized and accurate diagnosis in the field of dentistry, with this conventional surgical approach damage to vital structures, the removal of large amount of the buccal bone and prolonged surgical time due to limited visibility is inevitable. Research in this field unequivocally has suggested that modern microsurgical approaches yield higher success rates than traditional ones and it is agreed upon that guided root-end resection is more accurate and efficient than freehand surgery. Modern endodontic microsurgery due to continuous improvements in instruments, materials and techniques has been established as the futuristic method. The review paper aims to discuss the latest advancements in Endodontics with a focus on minimally invasive surgical techniques that would help in reducing the risk of iatrogenic damage to nearby anatomical structures, reduce postoperative discomfort leading to improved healing for the patient.

### Abstract 254

#### Micro-computed tomography: A revolutionary tool in endodontic research

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During the last few decades, numerous technological advancements have led to the development of innovative diagnostic modalities like Spiral CT, MRI, and Ultra Sound which revolutionized dental research, clinical practice, and dental education. Micro Computed Tomography (Micro CT) is an advanced imaging modality based on multiple-slice x ray images which allow three -dimensional reconstructions of the viewed structures. Micro-CT enables the high-resolution radiographic scanning of extracted teeth, which results in detailed 3-dimensional(3D) analyses of their internal anatomy without destroying the specimen. As micro CT creates non-destructive images, the same image can be viewed multiple times and the image remains incessantly for biological and mechanical testing. It has an edge over other techniques as it produces high-resolution and durable images the leading to precise measurement of the subject. It can provide high -resolution images as well as both qualitative and quantitative analysis of teeth, bone, and implants. It is an exciting tool for experimental endodontology and can analyze root canals before and after endodontic instrumentation. It can also evaluate the volume changes in tooth structure following endodontic procedures and post space preparation by 3D volumetric analysis. With further development of Micro-CT systems, a higher resolution will become available for both *in vitro* and *in vivo* studies, and it will be a powerful tool in future dental/endodontology research. There is also a need for improvement in mechanical tests in endodontic research which is possible with micro CT -based finite

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element analysis. This review highlights the significance of micro CT at its wide range of applications in endodontic research and its scope for routine clinical practice in the future.

**Abstract 255**

**Effect of calcium silicate cements on the physio-chemical properties of root canal dentin in diabetic patients: A narrative review**

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Diabetes Mellitus (DM) affects the outcome of any therapeutic treatment procedure with endodontics being no exception. DM impairs bone formation by interfering with osteoblasts activity and increases osteoblast apoptosis. DM adversely affects the formation of enamel and dentin in the early growth stage. Peritubular dentin is more affected by altered calcification and reduced mineralization in diabetic patients because it results in wider dentinal tubules and higher tubular density. The high tubular density has inverse correlation with the push out bond strength, i.e., in a given area of dentin, when the tubular density is increased, the density and mechanical properties of the surrounding inter-tubular dentin is low, thereby significantly weakening the root dentin. Also, the eradication of entombing bacteria from these dentinal tubules seems to be more difficult resulting in high failure rates. Most preferred endodontic cements for apexification and perforation repair procedures is calcium silicate-based cements (Ca-S) that includes mineral trioxide aggregate (MTA) and calcium enriched mixture (CEM). MTA has shown better sealing ability than other cements in diabetic root dentin. It has been proved that mineralization stimulated by MTA remains unaffected by hyperglycaemic conditions. In order to further increase the fracture resistance of endodontically treated dentin in diabetic patients, a modification of MTA by adding sodium hydrogen phosphate is studied. MTA mixed with phosphate buffered saline was also suggested to increase the bond strength of MTA in diabetic dentin. Also, CEM has significantly formed dentin bridge in diabetic tooth. However, there are no clinical studies so far correlating the significance of Ca-S based cements or their modifications for root canal therapy in diabetic patients. Further studies exploring the push out bond strength, fracture resistance, sealing ability and anti-microbial properties of various endodontic cements is the need of the hour. Hence, our review aims in highlighting the altered physio-chemical properties of radicular dentin following the use of Ca-S cements in diabetic patients.

**Abstract 256**

**Recent advances in root canal irrigation system: A review**

**DIVYA M PRADEEP**

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The success of root canal treatment depends on chemo mechanical preparation, irrigation, microbial control and complete obturation of

the root canals. However, the current cleaning and shaping techniques fall short of the goal of removal of all microorganisms and debris, due to anatomical complexity, the type of bacteria and resistance. The limitation of rotary instrumentation to remove all tissues from the surfaces during biomechanical preparation and the limited potential of commonly used irrigants to penetrate the dentinal walls also remain as challenges in endodontic disinfection. One way of circumventing such challenges is by combining ideal irrigants with an optimal irrigation technique to achieve maximum reduction of biofilm from the root canal system. The aim of this review is to emphasize on the latest irrigants and irrigation techniques.

**Abstract 257**

**Evaluation of immediate and delayed push out bond strength of apical plug of MTA mixed with 2% chitosan nanohydrogel: An *in vitro* study**

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**Aim:** To evaluate and compare the push out bond strength of MTA and MTA incorporated with 2% chitosan nanoparticles at 7 days (immediate) and after a period of 6 months and 1 year (delayed) when used as an apical plug in teeth with open apex.

**Materials and Methods:** 90 permanent maxillary central incisors were de-coronated and randomly divided into 2 groups (n=45), one into MTA and other into nano-chitosan modified MTA used as apical plug material and further subdivided within each group based on the duration of storage (1 week, 6 months, and 1 year).

- All the samples were sectioned perpendicular to the long axis to obtain 1mm thick slices.
- The push - out tests were performed using a universal testing machine.
- The data was tabulated and statistically analysed.
- SEM analysis was done for all de-bonded specimens to determine the bond failure pattern.

**Results:**

- Under immediate (1 week) and delayed (6 month time and 1 year) interval, nanochitosan modified MTA group showed the statistically significant higher push out bond strength when compared to conventional MTA.
- The difference in mean Push-Out Bond Strength was found statistically significant between Group 1 and Group 2 for immediate (1week) and 6 months time interval although there was no statistical difference between Group 2 for 6 months and 1 year time interval.
- The failure mode analysis showed predominantly cohesive failures for nano chitosan modified MTA whereas it showed more of mixed failures for the MTA group

**Conclusion:** Within the limitation of this *in vitro* study following conclusions can be drawn:

1. Statistically significant higher push out bond strength of nano-chitosan modified MTA to root dentin when used as an apical plug at both time intervals tested in the study.

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- SEM analysis of failed specimens showed mostly cohesive failures in the nano- chitosan modified MTA group at the cement-dentin junction, while MTA showed predominantly mixed failure further substantiating the results of our study.

### Abstract 258

#### Dynamic endodontic guidance: Navigating into the future

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Ideal access preparation is one of the most critical aspects of root canal therapy, as it is the portal through which all instruments, materials, and solutions must pass during treatment. Access into calcified root canal systems is the most anxiety provoking procedure in endodontics. Until recently, access has been done exclusively by freehand methods with a wide range of outcomes, depending totally on the clinician's innate skills, training, and experience. With the advent of "minimally invasive endodontics", preparation of a minimal access cavity, with decreased risk of iatrogenic damage, and preservation of structural integrity while meeting all the access requirements, is to be welcomed. "Guided endodontics" provides a highly accurate technique for the preparation of minimally invasive access cavities. Essentially there are two types of guidance: static and dynamic. To date, guided endodontics for access cavity preparation and canal location in endodontics has focused on the use of static guides. The utilization of dynamic navigation for guided endodontic access cavity preparation and root canal location is in horizon. No doubt it will take a paradigm shift by endodontists to embrace this potent new tool in managing the most difficult cases we treat. Notwithstanding the high cost involved the advantages of using dynamic guidance to cut the Gordian Knot of treating calcified root canal systems far outweigh the same.

### Abstract 259

#### Is constricted access for restricted use only?

**ANUSHKA ARORA**

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The success of endodontic treatment depends on three main factors i.e., cleaning and shaping, disinfection, and 3-dimensional obturation of the root canal system. Endodontic access is an important step to facilitate the cleaning and shaping of root canals during root canal treatment. In the last decade, several access cavity designs involving minimal removal of tooth tissue have been described for gaining entry to pulp chambers during root canal treatment. The premise behind this concept assumes that maximum preservation of the pulp chamber roof during access preparation would prevent the fracture resistance of teeth from being compromised. According to several reported studies, the minimally invasive access cavities do make it more difficult to visualize and debride the pulp chamber as well as locate, shape, clean and fill the canals. At the same time, a small

access cavity may increase the risk of iatrogenic complications as a result of poor visibility, which may have an impact on the treatment outcome. Overall, the literature search offered limited evidence to support the application of minimal access preparation in cases other than intact teeth. The aim of our review is to evaluate if the concept of modern molar access cavity preparation is really the future of the endodontic clinical practice.

### Abstract 260

#### Evaluation of stress distribution in endodontically treated teeth restored with only a core: A scoping review

**SANKET ARAS, NEIL LEWIS, SHALINI AGGARWAL,  
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**Introduction:** Endodontically treated teeth are more fragile than vital teeth and are prone to fractures microscopically and morphologically, as they lose tooth structure due to extensive caries and access cavity preparations. The loss of moisture and dentin after endodontic treatment also negatively affects the fracture resistance. Understanding the distribution of stresses in such teeth, would help to improve the clinical outcomes. This scoping review was conducted to evaluate stress distribution in endodontically treated teeth, which had been restored using core build-ups only, without the placement of a post system. A broad search was initiated using the principles of a Scoping Review to elicit studies that had evaluated the stress distribution, both with imaging and Finite Element Analysis. All materials used for core build-ups were included in this review. The aim of this study was to analyze and review endodontically treated teeth restored only with a core, and to review the effects of occlusal forces applied from different directions on stress in teeth and dental tissues that use three-dimensional (3D) Finite Element stress Analysis (FEA) and other methods.

**Focused Question:** What is the fracture resistance of an endodontically treated tooth to functional stress, when only a core is used as a post endodontic restoration?

- P - Extracted Human Teeth
- I -Restoration with a core.
- C - None
- O-Stress

**Materials and Methods:** Relevant articles (in-vitro studies including those of randomized controlled trials and reviews), published over a 5 year period were identified and retrieved from five internet databases:- Pubmed, Cochrane, Scopus, EBSCO and Google Scholar and 10 articles were finally included in the present scoping review.

**Conclusions:** An examination of the studies examined in this broad search indicates the following:

- 1- Stress values were found to increase with an increase in the modulus of elasticity of the restorative material
- 2- FEA was found to be a predictable and reproducible model to predict stress-strain behaviour.
- 3- Cusp coverage with condensable resin might be a safe

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option for restoring weakened endodontically treated teeth.

**Abstract 261**

**Resolution of inflammation via a specialized approach**

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The pulp-dentin complex is a dynamic functional structure of the tooth, playing a pivotal role in the defence mechanism against noxious stimuli. When the pulp and periradicular tissues are subjected to injury, the immune system triggers an inflammatory response to minimize this tissue damage by eliminating and digesting invading microorganisms and cellular debris. Inflammation, which is characterized by the sequential release of mediators, results in an immediate influx of polymorphonuclear leukocytes (PMNs), followed by phagocytosis via monocytes-macrophages leading to leukocyte clearance and resolution. However, because of anatomical and physiological constraints, the effectiveness of various processes during inflammation varies. Uncontrolled, excessive, or unresolved inflammation can lead to pulp tissue necrosis and subsequent periapical infections causing apical periodontitis. Thus, target therapy should be employed to neutralize this effect by bringing about the resolution of inflammation. This is brought about by a novel class of lipid-derived endogenous molecules called Specialized Pro-Resolving Lipid Mediators (SPMs). The development of resolution-based pharmacology and lipidomic-based therapies is expected to benefit from these specialized molecules. Interestingly, SPMs have no direct anti-inflammatory actions, but they can actively limit neutrophil recruitment into inflamed tissues while also inhibiting the generation of inflammatory cytokines. Thus, the aim of this review is to unveil the concept of SPMs in targeting the resolution of inflammation in endodontic therapies with a special emphasis of applying a new therapeutic approach adjunct to endodontic treatment. This may open a pathway to a new code of resolution friendly approach that is the key to the process of improving health.

**Abstract 262**

**Endodontic biofilm: A review of current status and future directions**

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Biofilms and microbial aggregates are the common mechanisms for the survival of bacteria in nature. In other words, the ability to form biofilms has been regarded as a virulence factor. Understanding the virulence of these endodontic microbiota within biofilm is essential for the development of novel therapeutic procedures for intracanal disinfection. It plays an essential role in several infectious diseases such as pulp and periradicular pathosis. Successful treatment of these diseases depends on biofilm removal as well as effective killing of biofilm bacteria. However, there is a need for all of this information to be translated into improvements in clinical practice

and treatment outcomes. This review paper describes the present status of endodontic microbiology, discusses perspectives for future research and directions, and emphasizes the need for a call to action in the field of applied endodontic microbiology.

**Abstract 263**

**Nanotoxicity in endodontics - the lurking hazards of nanomedicine**

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Molecular engineering has brought revolution into endodontics. Nanoparticles are particles of 1-100nm in dimension. Their small size, increased surface to volume ratio, specific surface properties and charge produces properties desirable for endodontic usage. It has been incorporated into sealers, obturating materials, restorative materials, disinfectants etc to name a few. However, there is other side to it. These micrometre-sized particles can easily cross biological barriers, and enter into various organ systems in the body causing damage at cellular level. These ultrafine particles can be "Nanotoxic". Nanotoxicology is the study of the nature and mechanism of toxic effects of nanoscale materials/particles on living organisms and other biological systems. It deals with the quantitative assessment of the severity and frequency of Nanotoxic effects in relation to the exposure of the organisms. As the next generation of endodontics moves towards nanotechnology, it is crucial to develop proper understanding of the processes happening when nanoparticle comes in contact with living system. Biocompatibility is achieved when a material interacts with the body without inducing any toxic, immunogenic, thrombogenic or carcinogenic response. Little is known about the toxicological impact of these nanoparticles. This review paper discusses the mechanism of nanotoxicity, factors affecting it, possible routes of nanotoxicity in endodontics, and its methods of assessment.

**Abstract 264**

**Management of internal resorption of a maxillary lateral incisor with type I dens-in-dente**

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Management of internal root resorption is a challenge to the endodontists. It may occur in cases with chronic pulpal inflammation, following caries or due to trauma in the form of an accidental blow. Most cases of internal root resorption are seen in anterior teeth, due to their susceptibility to trauma. However, it may be seen in posterior teeth, most likely because of carious involvement of the pulp. Early diagnosis, removal of the cause, proper treatment of the resorbed root is mandatory for successful treatment outcome. Dens invaginatus, also known as dens in dente, is a rare anomaly affecting human dentition. The condition results in invagination of an amelo-dental structure within the pulp. This case report discusses the current management protocol of dens invaginatus using a minimally invasive and nonsurgical treatment option.

### Abstract 265

#### Mindful practice in search of missing canals: A rare case report of mandibular molar with five root canals

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The main objective of successful endodontic therapy is thorough mechanical shaping and cleaning of the entire root canal system followed by three-dimensional obturation. Variation of the root canal morphology especially in multirooted teeth is a norm rather than exception and presents a constant challenge for diagnosis and successful endodontic therapy. Mandibular first molar is first to erupt in oral cavity and thus most often requires Endodontic treatment. An awareness and understanding of presence of additional root and unusual root canal morphology is essential as it determines the successful outcome of endodontic treatment. This is a case report of a twenty year old male patient who presented to department of conservative dentistry and endodontics with chief complaint of pain and swelling on right side of face since three weeks. Careful examination with angled radiographs and dental operating microscope revealed five canals ( additional middle mesial and distal canal).

### Abstract 266

#### Conducive restitution with sonicfill composites

**CHANDINI DEVI SRIDHARAN, NANDHINI KUMAR, SHAFIE AHMED, BHAVANI SREEKRISHNAPILLAI, RAJARAMAN GANGADHARAN**

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Dental research strives by scrutinizing various treatment procedures to perfect it and provide the quality care patients deserve. Posterior Composite Restorations have almost completely replaced Amalgam Restorations. However, the process of placing Posterior Composites is tedious requiring proper Isolation, Adhesive Systems and Composite material that concedes sculpting the Occlusal Anatomy of a compromised tooth. Introduction of Bulk-fill Composites reduced the procedure time and accelerated the Dental Enterprise. Per contra, the higher viscosity of these materials made their adaptation to the cavity walls difficult. Sonic-fill Composite carts this problem off. This Presentation kingpins on the Application of Sonic Activated Composites to sprint the Dental workflow without compromising its caliber.

### Abstract 267

#### Comparative evaluation of fracture resistance of endodontically treated mandibular premolars after instrumentation with different rotary file systems- An *in vitro* study

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**Aim:** The aim of the study was to evaluate and compare the vertical fracture resistance of mandibular premolars after instrumentation with K3XF, Hyflex CM, Pro Taper Gold rotary file systems.

**Materials and Methods:** Sixty human extracted mandibular premolar teeth with single straight canals were divided into four groups (n=15) Group A: Control (Intact teeth), Group B: K3XF, Group C: Hyflex CM, Group D: Pro taper gold. All the sample teeth were instrumented up to 0.06 taper size 20 as per manufacturer's instructions. After obturation and Nano hybrid composite core placement, the teeth were placed in a customized jig moulded on a universal testing machine where vertical force was applied and the force required to fracture the teeth was noted. One way ANOVA and Tukey's post- hoc test were used to analyze the data.

**Results:** The fracture resistance of roots instrumented with K3XF, Hyflex CM, Pro taper gold was significantly lower than that of the un instrumented control group ( $1165.90 \pm 178.70$ ). Amongst all the instrumented groups, Group B- K3XF ( $920.90 \pm 365.88$ ) depicted the highest fracture resistance followed by Pro taper gold ( $664.60 \pm 241.22$ ) and Hyflex CM ( $387 \pm 140.21$ ).

**Conclusion:** Root canals instrumented with K3XF files have better fracture resistance followed by Pro taper gold and least fracture resistance in Hyflex CM files.

### Abstract 268

#### Evaluation of stress distribution patterns with different bevel preparations for reattachment of fractured fragments of maxillary central incisors: A three-dimensional finite element analysis

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**Aim:** To evaluate the stress distribution patterns in reattachment of fractured fragment of maxillary central incisors with different bevel preparations using 3D FEA.

**Materials and Methods:** Three 3D FEA models of maxillary central incisors were generated using CAD technique. Standardized fracture was prepared on 3 models which were then divided into Group I - No bevel, Group II - Bevel on labial side, GROUP III - Bevel on both labial and palatal sides. All the models were then reattached with Filtek Z350 flowable composite and loaded under 200N at the tip of incisal edge and at an angle of 45 degrees to the longitudinal axis and stress distribution patterns were evaluated.

**Results:** Finite element analysis revealed that the stress distribution pattern in Group III was greater than that of Group I & II under loading at 45 degrees. There was no evident changes in the pattern and the magnitude of stress distributed in all Groups, when loading was done at the incisal tip.

**Conclusion:** In the present study, FEA revealed that Group III with labial & palatal bevels had a significant effect in stress distribution patterns of fracture fragment reattachment under loading at 45 degrees when compared to bevel on single side and with no bevel preparation.

### Abstract 269

#### Evaluation of bacterial reduction at various stages of endodontic retreatment after use of different disinfection regimens: An *in vivo* study

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**Objective:** The aim of the present study was to evaluate the presence of *E. faecalis*, *F. nucleatum*, *Propionibacteria* sp., *Actinomyces* sp., and their reduction at various stages of endodontic retreatment with the use of conventional protocol (5.25 % NaOCl + Ca (OH)<sub>2</sub> and advocated protocol (Smear OFF + CHX gel).

**Methodology:** Twenty eight patients fulfilling the eligibility criteria were selected for root canal retreatment and randomly allocated into two groups. Group 1- Final irrigant as SmearOFF + Chlorhexidine as intracanal medicament (n=14). Group 2- Final irrigant as 5.25% Sodium Hypochlorite + Calcium Hydroxide as intracanal medicament (n=14). With aseptic environment, access opening was performed followed by GP removal and sample S1 was collected for bacterial analysis. The biomechanical preparation was done by using Reciproc system and supplementary finishing with XP-Endo Finisher R. Sample S2 was then collected for bacterial analysis after the final irrigation protocol in the respective groups. Intracanal medicaments were placed for one week and sample S3 was collected. All the samples were subjected to qualitative analysis using PCR and quantification was done by Colony Forming Unit (CFU) analysis.

**Results:** *Propionibacterium* sp. [20/28], *F. nucleatum*[24/28] were the most frequently isolated in S1 sample followed by *Actinomyces* sp. [16/28] and *E. faecalis* sp. [19/28]. Chemomechanical preparation followed by irrigation resulted in significant reduction of all types of bacteria in both groups. Group-1(SmearOFF as the final irrigant) had significant superior efficacy against *E. faecalis* and *F. nucleatum*( $p < .05$ ) as compared to Group-2 (NaOCl). Both chlorhexidine gel in group-1 and calcium hydroxide in group -2 caused further reduction in all bacterial subgroups in sample 3 but reduction was insignificant against *Propionibacterium* sp. and *Actinomyces* sp. ( $p > .05$ ).

**Conclusion:** Chemomechanical preparation followed by irrigation resulted in significant reduction in bacterial load irrespective of the final irrigant. SmearOFF was significantly better than NaOCl in minimizing bacterial load of *E. faecalis* and *F. nucleatum*. Chlorhexidine gel and calcium hydroxide were less effective against both *Propionibacterium* sp. and *Actinomyces* sp.

### Abstract 270

#### Biodentine – Apical barrier for immature necrotic permanent teeth: A case report

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Managing open apex is a constant challenge to an endodontist. One of the aims of root canal treatment is to completely obturate the canal in order to prevent reinfection. But in case of an incomplete

root development it becomes difficult to achieve a three-dimensional obturation of root canal system. Apexification has been advocated in cases with open apices or where apical constriction is absent/destroyed. Apexification can be defined as a method to induce calcific barrier in the root with the open apex of an immature, pulpless tooth. Several Materials are now a days available that induce calcific barrier or apical development in root canals with necrotic pulp tissues. MTA is considered as a gold standard however, long setting time, poor handling characteristics, high cost, are some of its disadvantages. A novel Material Biodentine introduced by Septodont in 2010 has proved to have superior properties and easy handling hence considered as best substitute to MTA. This case report describes the management of open apices with periapical radiolucencies in maxillary central incisors by using Biodentine to form an apical barrier.

### Abstract 271

#### Biomarkers in endodontics: A diagnostic approach for pulpal and periapical inflammation – A review

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Endodontic diagnosis is highly critical and depends on the ability of the clinician to distinguish among the different stages of pulpal and periapical inflammation. At present, endodontic diagnosis is made by clinical symptoms, pulp sensibility tests, and periapical radiographs which have their own limitations as the clinical findings do not always correlate with the histologic status of the pulp or periapical tissue. In clinical practice, the treatment of teeth with necrotic, partially vital, and inflamed vital pulp is the same: complete pulpectomy. The modern understanding of pulp biology and the development of bioactive materials have undoubtedly led to a shift in the management of inflamed dental pulps: pulp capping and pulpotomy. The success rate of pulpotomy in mature permanent teeth with irreversible pulpitis depends on the accurate diagnosis and case selection as inadequate evaluations often result in underestimating inflammation severity and treatment failures. Biomarkers refer to cellular, biochemical and molecular alterations that can be measured in biological fluids as indicators of normal physiological and pathogenic process. Pulpal inflammation is a cellular and molecular mediated process in which the molecular phase precedes the macroscopic and microscopic inflammatory changes. Hence qualitative and quantitative assessment of these biomarkers such as proteases, growth factors, chemokines and cytokines can represent an objective method to obtain valuable information about the pulp and periapical status. The aim of this review paper is to determine the possibility to diagnose the pulpal and periapical inflammation through molecular biomarkers.

### Abstract 272

#### Metformin: An old drug with new ideas

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Abstract

**B MUHSINA**

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Metformin has been an important drug for treatment of Type 2 diabetes (T2D) for decades. Numerous studies have shown that metformin not only has hypoglycemic effects, but also modulates many physiological and pathological processes ranging from aging and cancer to fracture healing. Owing to the dual role of metformin in regulating blood glucose and promoting bone regeneration, it is worth exploring its considerable potential in dental tissue regeneration. Stem cell-based therapies are rapidly emerging as a potential strategy for tissue regeneration in many diseases and conditions. Metformin can enhance the odontoblastic differentiation of Dental Pulp stem cells through activation of the Adenosine monophosphate protein kinase (AMPK) signaling pathway and hence play an important pharmacologic role in triggering odontoblastic differentiation, providing new insights into the therapy of pulpal wounds. Anti-inflammatory activity of metformin has also been analyzed. In vitro studies showed that intracanal application of metformin decreased the size of periapical lesion, partially by modulation of osteoblast apoptosis. Recent evidence also suggested that metformin provides a synergistic advantage with chemotherapy or radiotherapy, increases photosensitivity and can be considered as one of the agents involved in the increasing cytotoxicity efficacy of anti microbial photo dynamic therapy (aPDT). This review focuses on the multiple effects of metformin with emphasis on regenerative endodontics, its molecular mechanisms, and clinical prospects.

**Abstract 273**

**Artificial intelligence in endodontics**

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India

Ever since the field of science has originated, researchers and technologists have been busy in solving the complexity of the human brain that is a maze of neurons interconnected with each other and transmitting signals to the whole body. To design a model that will mimic just like the human brain has remained a big puzzle to solve for the scientific community. Constant effort and hard work of researchers from several years results in the evolution of 'Artificial Intelligence'. The term "artificial intelligence" (AI) was coined in the 1950s and refers to the idea of building machines that are capable of performing tasks that are normally performed by humans. Types of artificial intelligence include Machine learning (ML), Neural network (NN) and Deep learning (DL). Artificial neural network (ANN), a subtype of machine learning is widely used in dentistry. Its applications in Endodontics includes detecting vertical root fractures from periapical and CBCT radiograph from endodontically treated and non endodontically treated tooth, to determine the working length of the tooth using artificial neural network (ANN), locating the minor apical foramen (AF) using feature-extracting procedures from radiographs and then processing data using an artificial neural network (ANN) as a decision making system. Deep Learning (DL)

algorithm is used for the automated segmentation of cone-beam computed tomographic (CBCT) images and the detection of periapical lesions. It can also be used in classification of the root morphology. Machine learning is used to generate an algorithm which can help predict the difficulty level of the case and decide about a referral. Increase in the number of researches on the development of artificial intelligence, and introduction of more powerful computing capability may help mature AI in dentistry. We may not have fully automated dental diagnosis and treatment by the computer programs and machines soon, but the future will be more enjoyable when many repetitive and straightforward tasks, not bothering us as clinicians anymore. This may increase and boost productivity as we can spend more time on more complex cases. Artificial intelligence therefore can have a promising future in Endodontics.

**Abstract 274**

**Endodontic access - conventional versus modern: An overview**

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Access cavity preparation is an important step during endodontic treatment procedures. Main objective of access preparation is to obtain a straight line access to canal orifices. A well-designed access is important for achieving successful treatment outcomes. Inadequate access leads to difficulties in visualization of canal orifices and subsequent negotiation leading to inadequate biomechanical preparation of the root canal system. Overzealous access preparation can lead to excessive removal of sound tooth structure weakening the tooth. Excessive loss of pericervical dentin during access preparation increases the risk of fracture of the tooth post endodontic therapy. Several access preparation modifications have been suggested in modern clinical endodontics. Different access designs with an aim to conserve tooth structure and minimal invasive approach is a new trend in endodontics, and specific nomenclature have been established such as the Traditional Access, Conservative Access, Ultra Conservative Access, Truss Access, Caries Driven Access, and Restorative Driven Access. An adequately prepared access cavity is crucial for effective instrumentation and delivery of irrigants into the root canal system. Equally important is maintaining the structural integrity of tooth. Unnecessary removal of tooth structure weakening the tooth results in fracture and leading to poor prognosis. So that every attempt to preserve tooth structure as much as possible. This review compares the traditional and modern approach to access preparation.

**Abstract 275**

**A micro-computed tomographic analysis of dentinal microcracks and residual filling material after endodontic retreatment procedures with rotary and reciprocating NiTi file systems**

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Abstract

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**Aim/Objective:** To evaluate the outcome of rotary & reciprocating instruments on dentinal microcracks in mandibular first molars during endodontic treatment & retreatment procedures along with their efficacy of filling removal using Micro-computed Tomography.

**Materials and Methods:** Twenty moderately curved mesial roots of mandibular first molars having two independent canals were selected and scanned in a micro-CT device. The scanned roots randomly divided into two groups based on the NiTi file systems: Group I = Reciproc Blue (RB) & Group II = ProTaper Gold (PTG), were treated & retreated (Group I with RB and Group II with PTG & ProTaper Retreatment file (PTR)) respective to their NiTi instruments. The samples were subjected to another micro-CT scan after endodontic treatment and retreatment procedures for a 3-D non-invasive image-based analysis of dentinal microcracks after treatment & retreatment and filling removal following retreatment of both the respective groups. Descriptive analysis, Independent t-test, ANOVA and post hoc analysis was used for inter & intra-group comparison and the Chi-square test was used to analyse filling removal after retreatment. The level of significance was set at  $P \leq .05$ .

**Results:** New dentinal microcracks were observed in both the RB and Protaper groups after treatment & retreatment procedures. Microcracks in the RB group were significantly more compared to the ProTaper group ( $P < 0.5$ ). Better filling removal was observed in the RB group compared to PTR without statistical significance.

**Conclusion:** Root canal preparation with PTG & PTR induced fewer microcracks formation than RB. Filling removal was better with the RB system. However, No statistical difference was observed between the techniques for effectively removing filling material from the moderately curved root canals of mandibular first molars.

### Abstract 276

#### Novel nano-endodontic irrigants: A review

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The persistence of endodontic biofilm poses a burden in treatment with recurrent endodontic infections. The conventional endodontic irrigation techniques fail to completely remove and prevent the re establishment of the biofilm in the infected root canals leading to inadequacies in disinfection. With improvements in technology and enhanced irrigant delivery systems, the shortcomings of disinfection can be overcome. Recent advances like the magnetic nanoparticles, nanobubbles etc can be considered as favourable alternative due to their biocompatibility, biodegradability and target- specific action. This paper presents the comprehensive review regarding the novel nano endodontic irrigation systems.

### Abstract 277

#### Effect of audio-visual distraction on pain during pulp extirpation: A randomized clinical trial

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**Aim:** To determine the effect of audiovisual distraction (A/V) on pain during pulp extirpation.

**Methodology:** Sixty patients with acute irreversible pulpitis were selected and randomly allocated into two groups. An informed written consent was obtained from each subject. Assessment of pain threshold was done during pulp extirpation in patients with acute irreversible pulpitis under local anesthesia and rubber dam isolation. The two groups were 1) Control: without A/V-Distracted 2) Test-group: with A/V-Distracted. Pain threshold was analyzed with visual analogue scale (VAS) using Mann-Whitney U Test. The results were then tabulated and statistically analyzed.

**Results:** The mean VAS score in the group without A/V-Distracted was 1.6 and with A/V-Distracted was 1.1, which was significant ( $P < 0.05$ ) on Mann Whitney U test.

**Conclusion:** Audiovisual Distraction can result in decreased pain perception during pulp extirpation. The portable video device and music through earphones provides a relaxed environment during treatment.

### Abstract 278

#### Root canal irrigants: An overview

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The success of root canal treatment depends on debridement of diseased tissue, elimination of bacteria and prevention of reinfection after treatment. Shaping and cleaning of root canal system along with the preservation of surrounding periodontal tissue is the principal goal of endodontic treatment. Complete disinfection of the pulp space cannot be achieved with instrumentation techniques alone. While most of the attention is paid to the mechanical aspects of the root canal treatment, an essential feature of it is the irrigation. The use of adjunctive aids like endodontic irrigants in achieving this goal is essential. It has several important functions, which may vary according to the irrigant used. It reduces friction between the instrument and dentine, improves the cutting effectiveness of the files, dissolves tissue, and furthermore, it has a washing effect and an anti-microbial/ anti-biofilm effect. Irrigation is also the only way to impact those areas of the root canal wall not touched by mechanical instrumentation. No single irrigating solution that can alone cover all the functions required from an irrigant. The purpose of this review is to discuss various root canal irrigants used in dentistry.

### Abstract 279

#### Retrieval of separated endodontic instruments: An overview

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Separated endodontic instruments has always been an enigma to the endodontists. Many of the post graduates, general practitioners try to salvage the instrument fracture at different levels. The biggest challenge

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is posed by the instruments separated at the commencement of canal curvature, at the junction of middle and apical of one- third, and at the apical one- third and thus disrespectful of the minor diameter and extruding through the periapex. Evaluation of current scientific data has revealed that the approach and mechanism of salvaging separated instruments do vary between different files of varying metallurgical properties, thermal treatments and cross- sectional designs. In most cases fractured instruments do not present diagnostic problems, with the exception of retreatment cases where the fragment in some instances might be “hidden,” obscured by root filling material and not very clearly visible. The recognition of remaining fragments is important for treatment planning. This involves the need to choose between various acceptable nonsurgical orthograde options such as ultrasonics, tube technique, loop techniques, canal finder system, laser techniques, electrochemical dissolution techniques, chemical means, magnets, multisonic ultracleaning system, softened gutta-percha, file removal system, bypassing and incorporation of dental operating microscope and in some specific cases surgical options are indicated. The delicate manipulations necessary for the management of a fractured instrument using an orthograde or a surgical approach include the risk of creating additional complications which includes separation of the ultrasonic tip or file used for bypassing, further separation of the fragment, perforation, ledge, extrusion of file into periapical tissues, tooth weakening due to dentin removal all of which will in turn jeopardize the treatment outcome. Evaluating, analysing, and comparing the performance of the techniques proposed for the management of intracanal fractured endodontic instruments are important prerequisites for the selection of the most appropriate strategy and for the prediction of the outcome. This review, scrutinizes the changes in thought process and methods regarding retrieval of separated instruments.

**Abstract 280**

**Nanoparticles: The micro-art of regeneration**

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Nanotechnology has essentially progressed in the past decades, giving rise to numerous possible applications in different biomedical fields. In particular, the use of nanoparticles in endodontics has generated remarkable interest due to their unique characteristics. As a result of their nanoscale dimensions, nanoparticles possess many divergent properties that may enhance the treatment of endodontic infections, such as heightened antibacterial activity, increased reactivity, and the capacity to be functionalized with other reactive compounds. The “ideal” material has yet to be devised. This has led to the development of various experimental nanoparticle-incorporated antibacterial efficacy and bioactivity. Nanoparticle applications also show promise in the field of regenerative endodontics, such as supporting the release of bioactive molecules and amplify the biophysical properties of scaffolds. Applying nano-scaffolds for pulp regeneration is another use of nanotechnology in endodontics that creates stirring development in the reconstruction of pulp structure.. The constantly growing body of research in this field has led to potential translational applications of nanoparticles

in regenerative endodontics. This review article aims to study the application of nanoparticles in different stages of regenerative endodontic therapy and provide an overview of its current advancement.

**Abstract 281**

**Mucormycosis: An endodontic perspective**

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Mucormycosis also known as Zygomycosis or black fungus is a mycotic infection caused by fungi of the order Mucorales. In the recent past, a bizzare variety of post-COVID complication appears to be on rise. In India, post-COVID mucormycosis is a recognized entity and even declared as an epidemic in some states. In the pre-COVID era, mucormycosis was seldom seen in the clinics by medical and dental professionals. However, during this pandemic era, there has been sudden surge in number of patients reporting with mucormycosis and even high degree of fatality is being observed. This life-threatening condition requires early diagnosis for a better prognosis. Mucormycosis is characterized by extensive course of angioinvasion with thrombosis and tissue necrosis. The most common type of mucormycosis, the rhino-cerebral variant comprises of atypical symptoms such as facial pain, earache, nasal or sinus congestion, or odontalgia so, the patients tend to seek dental treatment initially. The available studies on mucormycosis suggest that the rhinocerebral variant may present itself as dental pain, intraoral draining sinuses, swelling and ulceration. This paper aims to present the importance of proper history, clinical examination for oral signs and symptoms to rule out mucormycosis as a differential diagnosis for endodontic infections.

**Abstract 282**

**Pain again, how to contain? Decoding the enigma of post endodontic pain**

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Pain is one of the main reasons behind dental anxiety and it is the responsibility of the dentist to properly manage this pain. However, a common unexpected complication that can undermine the patients confidence in the clinician and acceptance of procedure is the development of Post Operative Pain after Root Canal Treatment. Post Operative Pain after endodontic treatment has a wide range of incidence varying from 3% to 69.3%. It ranges from mild to moderate and occurs even after optimally performing the procedure. It is a multifactorial phenomenon, observed as a result of various intra-operative as well as perioperative factors which have been listed in the literature including age, gender, tooth type, presence of perioperative pain, pulpal status, single / multiple visits, type of instrumentation and even obturation techniques. Management of

Abstract

postoperative pain is challenging and considered an indicator of clinical excellence. This review paper focuses on literature evidence of various factors influencing post obturation pain following non surgical root canal treatment along with numerous strategies and methods that can be applied for effective management of this complication so that the clinician can carry out an evidence based treatment for the same.

### Abstract 283

#### Lesions of endodontic origin: Could it be a looming threat for cardiovascular diseases?

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Cardiovascular diseases have vastly affected the global human population and are a major cause of death in developed and developing countries. There has been an alarming increase in the prevalence of coronary heart disease and mortality in India and other South Asian countries over the past two decades with a 4-fold rise in prevalence during the past 40 years. The risk factors commonly associated include diabetes mellitus, hypertension, smoking, hyperlipidemia, obesity, and psychosocial stress. Among the risk factors, Atherosclerosis is the major underlying cause of coronary heart disease. It is a chronic inflammatory state leading to the release of several mediators that play a role in causing endothelial dysfunction, initiation, progression, and rupture of atherothrombotic plaque. Several studies have proven that oral inflammations are potent inducers of systemic inflammation which may increase inflammatory activity in existing atherosclerotic lesions, thereby increasing the risk of cardiovascular diseases. Although researchers believe that there could be an association between lesions of endodontic origin and cardiovascular disease, no causal relationship has been found yet. Considering the prevalence of teeth with radiographic evidence of apical periodontitis as high as 65% in the Indian urban population, it is essential to recognize and address the effects of endodontic lesions on systemic health. Thus, this paper aims to review the current scientific literature about all the probable endodontic factors that could lead to cardiovascular diseases and give an overview of the studies conducted to date to establish this association. This less recognized entity must be assessed more among the dental and medical fraternity so that an integrative approach can be undertaken for the diagnosis and management of chronic diseases which could have shared etiopathogenesis. If a clear correlation or causation is established it could not only help in restoring optimum oral health but also prevent fatally and life-threatening cardiovascular diseases.

### Abstract 284

#### A systematic review on the role of antimicrobial efficacy of nano irrigants in endodontics

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**Introduction:** The removal of both necrotic and vital pulp substrates and microorganisms and their toxins from the root canal system is the basis for a successful endodontic treatment. It has been shown that endodontic lesions do not develop in the absence of bacteria. Primary infections of the endodontic space are mainly caused by obligate anaerobic species, while the most responsible one for endodontic failure is *Enterococcus faecalis*. This bacterium is able to withstand many intracanal medications and also represents an important microorganism in the biofilm development.

**Objective:** To compare and evaluate the antibacterial efficacy of nano irrigants and conventional irrigants against endodontic pathogens.

**Search Strategy:** The search was performed in electronic database (i.e. PUBMED CENTRAL, COCHRANE, LILAC, SCIENCE DIRECT, MEDLINE, Web of Science) using the following search items alone and in combination by means of PUBMED search builder. There was no restriction in the language.

**Selection Criteria:** Studies were selected if they met the following criteria: In vitro/ in vivo studies comparing and evaluating the reduction of microbial load on using irrigants containing nano particles.

**Data Collection and Analysis:** Two review authors independently selected studies, extracted data and assessed the risk of bias. Authors were contacted where further information about their study was required. The data collection form was customized. The primary outcome measure was to evaluate the antibacterial efficacy of nano irrigants and to compare its efficacy with conventional irrigants.

**Main Results:** The results showed that nano irrigants exerted an almost similar antibacterial effect against Endodontic pathogens when compared with conventional irrigants.

**Conclusion:** Based on this review, it may be concluded that nano irrigants can be used in place of conventional irrigants in routine endodontic procedures.

### Abstract 285

#### Removal of a 5 mm long separated endodontic instrument extending beyond the apex of mandibular right first molar using a guided surgical approach

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Procedural accidents during endodontic treatment often complicate the overall treatment plan of the patient. Separation of an instrument is one of the most frequently encountered procedural accidents in endodontics. In this case report, a 3-D guided surgical approach was chosen to remove a 5mm long separated endodontic file extending beyond apex of mandibular right first molar. This ultra-conservative approach utilising a 4mm diameter trephine bur through a 3-D printed surgical guide with a 4mm opening for the drill was done to minimise the risk of damaging the underlying inferior alveolar nerve which was in close proximity to the tip of the broken instrument. In the case, we removed the separated file through the 4mm hole with trephine bur after obtaining consent from the patient.

### Abstract 286

#### Broken instrument retrieval-case series

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Separated endodontic instruments may adversely affect the outcome of endodontic treatment, as it interferes with proper shaping, debridement and obturation of the root canal apical to the level of obstruction. Attempts should always be made to retrieve the separated instrument and if not possible, the instrument should be bypassed. Microscope, ultrasonics and loop devices have made the retrieval of separated instruments very predictable. Although the time needed for retrieval depends on various factors like canal curvature, length of separated instrument and the skill of operator. This presentation of cases shows the successful retrieval of separated endodontic instruments.

### Abstract 287

#### Comparative evaluation of canal transportation and centring ability of three rotary file systems: *In-vitro* study

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**Aim:** To compare the canal transportation & centering ability between ProTaper Gold, Trunatomy & Profit S

**Materials and Methods:** 30 freshly extracted maxillary premolar were included in the study. Pre-operative CBCT and calculation of a1 and b1 at 3,6,9 mm from the apex. Group 1: cleaning and shaping with ProFit S3 up to PF2 file (#25,0.06). Group 2: cleaning and shaping with TruNatomy up to prime shaping file (#25,0.04). Group 3: cleaning and shaping with ProTaper Gold up to F2file (#25,0.08) Post-operative CBCT and calculation of a2 and b2 at 3,6 and 9mm from the apex.

**Statistical Analysis:** One-way-ANOVA and the independent t-test were done for the pairwise comparison. The significance level was set at  $P = 0.05$ ; statistical analysis was performed with SPSS statistics version 20.0 (SPSS Inc., Chicago, IL, USA).

**Results:** There was a significant difference among the three groups. ProTaper Gold showed slightly more canal transportation compared to the other files this could be due to its variable taper (8 % taper). Trunatomy (26, 4% taper) and ProFit S3 (25, 6 % VV taper). There was a significant difference among the three groups. ProTaper Gold showed a lesser centering ratio compared to the other files this could be due to its variable taper (8 % taper). Trunatomy (26, 4% taper) and ProFit S3 (25, 4-8 % VV taper) had no significant difference i.e it had a better centering ratio, this could be due to the taper variations and offset design.

**Conclusion:** From this study, it can be concluded that Trunatomy and ProFit S3 had lesser canal transportation and a better centering ratio compared to ProTaper Gold rotary file system.

### Abstract 288

#### Root canal cleanliness and file distortion following three different nickel titanium rotary file systems

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**Aim:** This study aims to evaluate the root canal cleanliness and file deformation following instrumentation using three different nickel titanium rotary file systems by Scanning Electron Microscopy.

**Materials and Methods:** Forty single-rooted human mandibular premolar teeth were selected. Biomechanical preparation was done by using Trunatomy, Herogold and Heroshaper in sequence upto size 30 with a constant speed of 300 r.p.m. The crowns of the prepared teeth were removed and the roots of all the samples were sectioned using a hard tissue microtome. The sectioned samples were observed under SEM at 2000x magnification. The file systems which have been used for 10 samples were observed under SEM and assessed for deformation at 500x magnification. The debris and smear layers were assessed and scored and the files were analysed for the presence of microfractures and cracks. Statistical analysis was done using Kruskal Wallis Test.

**Results:** No statistically significant differences between the groups were demonstrated for debris and smear layer scores in the coronal, middle and apical parts of the root canals. Herogold and Heroshaper files produced cleaner canal walls than Trunatomy in the Coronal third, however the values were not statistically significant ( $P > 0.05$ ). The surface deformity was least with Trunatomy, while Herogold and Heroshaper files revealed slight metal fold over at the edges.

**Conclusion:** The files tested were not able to completely remove debris and smear layer. In terms of instrument distortion all the systems were found to be safe following instrumentation in ten canals.

### Abstract 289

#### The role of substance P in endodontic pain management: A systematic review

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**Introduction:** The aim of endodontic procedure is to reduce the dental pain due to inflamed pulp and periapical tissues. It is difficult to measure the efficacy of endodontic procedures in reducing pain since pain is subjective and its perception varies from person to person. Substance P (SP) is an inflammatory neuropeptide and it is claimed that the level of SP is associated with pain experienced by the patient. Hence, the efficacy of endodontic procedures can be determined by the effect of the procedures on the level of SP.

**Objective:** To compare and evaluate the efficacy of endodontic procedures in reduction of Substance P level. Search Strategy The search was performed in electronic databases (i.e. PUBMED CENTRAL, COCHRANE, LILAC, SCIENCEDIRECT, GOOGLE SEARCH, WEB OF SCIENCE, MEDLINE) using the following search items alone and in combination by means of PUBMED search builder till February 2021. Selection Criteria Studies were selected if they met the following criteria: In vivo studies comparing the Substance P level before and after various endodontic procedures.

**Main Results:** Database Search revealed 56 studies out of which 8 were included in the systematic review based on the inclusion criteria. Out

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of the 8 included studies, 5 studies were randomised controlled trials and 3 studies were non randomised controlled trials. The level of SP was measured in GCF, pulp tissue, root canal exudate and saliva. **Conclusion:** The present systematic review showed that the level of Substance P reduced after the endodontic procedures in 4 of the 8 included articles and there was no significant change in SP level before and after endodontic procedure reported in 3 studies and 1 study showed photobiomodulation increased SP level. Use of various irrigants or irrigation techniques did not have a significant effect on the level of SP. Pain was significantly reduced following root canal treatment but there was no concrete evidence to establish correlation between pain and level of SP.

**Abstract 290**  
**Management of C-shaped canal system**

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The C - shaped root canal configuration is an anatomical variation of root fusion and commonly seen in the mandibular second molar. An in depth understanding the root canal anatomy and its variation is an important parameter for determining the clinical success of an endodontic treatment. Radiographical and clinical diagnosis can aid in identification and negotiation of the C - shaped anatomy. Modification in the debridement and obturation techniques will ensure a 3D fill of canal system. This paper present successful endodontic management of mandibular teeth with C - canal system.

**Abstract 291**  
**Regenerative endodontics-to revive and to rejuvenate**

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Newer scientific technological advancement in dentistry provides an array of projects such as molecular biology, cell culturing, tissue grafting, and tissue engineering. Conventional root canal treatment, apexification with biomaterials, and extractions are the procedures of choice to treat a nonvital tooth. These treatment options do not give predictable outcomes in the regeneration of the pulp tissue. Regenerative endodontics is defined as biologically based procedures designed to replace damaged tooth structures, including dentine and root structures, as well as cells of the pulp–dentine complex. Regenerative endodontic procedures for immature permanent teeth with apical periodontitis confer biological advantages such as tooth homeostasis, enhanced immune defense system, and a functional pulp-dentin complex, in addition to clinical advantages such as the facilitation of root development. Regenerative endodontics applies the concept of the triad of tissue engineering, stem cells, scaffold and growth factors in the canal space to regenerate the pulp tissue damaged by infection, trauma or developmental anomalies. Clinically, regenerative endodontics was first developed for immature necrotic permanent teeth in order to achieve root end closure, with the additional goal of obtaining continued development of the root and

thickening of the canal wall. Subsequently, regenerative endodontics has been performed on necrotic mature permanent teeth, vital mature permanent teeth, teeth that have resorption and for retreatment of teeth obturated with gutta-percha and sealer. Regeneration of the lost tooth structure rather than replacement during treatment will ensure better prognosis and higher rate of success. Hence the future in dentistry would involve the regenerative procedures which could successfully replace lost dentine, cementum and the pulp tissue. Efforts are on through tissue engineering to create a biological tooth substitute that could completely replace the lost tooth structure. The purpose of this review paper is to discuss the current approaches in regenerative endodontics.

**Abstract 292**  
**Management of two variations of middle mesial canals: A case series**

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Thorough knowledge of the morphological variations of the root canal system is of paramount importance for successful endodontic treatment and to have a favorable prognosis. Recent imaging systems have shed more light on the possibility of detecting and evaluating such intricate anatomical variations. The mesial root of mandibular molars commonly have two main canals (mesiobuccal and mesiolingual), but the presence of an extra canal in this root, called middle mesial canal has been reported in 0.26% to 46.15% of cases worldwide. Failure to detect & effectively clean these canals can lead to a compromised treatment outcome. The need for the clinician to be aware of such variations and the use of newer technologies like dental operating microscope during treatment is imperative. This case report describes the successful management of three cases depicting the two variations of middle mesial canals. The first two cases depicts Type 2 variation (confluent) and the third case depicts type 3 variation (independent type), which were managed using digital x rays and dental operating microscope. On follow up, patients were asymptomatic and radiographs showed satisfactory healing.

**Abstract 293**  
**Systemic antibiotic therapy in delayed replantation of avulsed tooth: A systematic review**

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**Aim:** This Systematic review aimed to analyse the practising trends of clinicians on using Systemic Antibiotic Therapy (SAT) in delayed replantation of avulsed permanent anterior teeth.

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**Materials and Methods:** A search was performed for case reports and case series related to delayed replantation of avulsed permanent anterior teeth on databases like Medline/PubMed, Google Scholar and Cochrane from 2000 to 2020. The Prisma guidelines 2009 were followed and the protocol was registered on Prospero, an International prospective registry for systematic reviews. A total of 9 articles were selected after applying inclusion and exclusion criteria for this systematic review. Data was extracted and analysis was done.

**Results:** In this study, four case reports showed the primary use of systemic penicillin and others reported different antibiotic combinations in delayed replantation cases. While, only 1 case reported the use of tetracycline as SAT, despite it being the drug of choice as per the guidelines. Five case reports observed Ankylosis, resorption, and infra-occlusion as procedural complications. Successful treatment outcome was highly variable ranging from no complication in 6 months - 2 years period to 1 case that reported complication after 7.5 years.

**Conclusion:** The clinicians prescribed the same antibiotics for delayed replantation that were prescribed in routine endodontics. The use of these antibiotics in case of avulsion could be attributed to its easy availability, practice and trust of the clinician regarding the dosages and route of administration of these antibiotics and may be lack of knowledge about other antibiotics and their complications. The follow-up period for most of the cases was insufficient to observe the complications. Thus, effect of antibiotics on treatment outcome of delayed replantation of an avulsed tooth mandates more studies with longer follow up period.

#### Abstract 294

**Efficacy of chemical, mechanical and combination of both means to locate and re-negotiate root canals filled with mineral trioxide aggregate: An *in vitro* study**

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The successful use of MTA in DPC/Pulpotomy/Obturation in endodontics over the years poses a challenge in cases where retreatment is required at a later stage. The retrievability of canals is made difficult by hard set MTA so the question is how to renegotiate canals for retreatment.

**Aim:** To compare the efficacy of Chemical, Mechanical or Combination of both, for MTA removal while re-negotiating the canals filled with MTA retreatment.

**Materials and Methods:** 30 freshly extracted human anterior teeth were selected for the study. Access cavity was prepared and coronal flaring was done and root canal preparation was done up to 35-6% Ni-Ti Endodontic rotary files (NeoEndo flex-Orikam). A 3mm MTA (Proroot, Dentsply Tulsa) plug was placed at the root canal orifice and was verified by radiographs. After placement of MTA, a coronal seal was achieved by non-eugenol based temporary restoration (Oratemp-NE) and were stored in 100% humid environment for 1 month. After 1-month temporary restorations were removed. The samples were randomly selected and divided into 3 groups. In group

I- 35% HCl was used for 1 minute to remove MTA that was placed in the chamber. In group II- Ultrasonic instrumentation was used for 1 minute and in group-III combination of both the methods was used for 30 seconds each. Following that the sample teeth were subjected to hand filing (K-10 & 15 No.) for 60 seconds to negotiate each root canal and re-negotiation of the root canal was noted (Yes/No). The teeth were then sectioned and observed under stereomicroscope with magnification of 40x for amount of MTA left in the root canal.

**Results:** Data was analyzed with Kruskal-Wallis's test. Results showed that the remnants of MTA were present in all groups but Group-III had the least remnants and the root canals were re-negotiated the most. In Group-I canals could not be renegotiated in 60 second time.

**Conclusion:** It was concluded that though MTA cannot be completely removed from the root canal system by any of the method mentioned above in this study, however a combination of HCl and ultrasonic was best in renegotiate the root canals.

#### Abstract 295

**Comparative evaluation of canal transportation and centering ability of two off-centered rotary file systems using cone beam computed tomography: An *in-vitro* study**

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**Aim:** To evaluate the canal transportation and centering ability of Revo-S and TruNatomy file systems using CBCT.

**Materials and Methods:** Thirty single rooted human mandibular premolars with root curvature of 15°-25° (the Schneider method) were randomly distributed into two groups (n=15). Teeth were decoronated to standardize the working length to 18 mm and mounted on a wax template. Pre instrumentation scanning of all teeth were done at three levels: 3 mm, 6 mm and 9 mm from root apex. Group 1 was prepared with Revo-S file and Group 2 was prepared with TruNatomy file. Post instrumentation CBCT scans were done as similar to pre instrumentation scans. Canal transportation and centering ability were evaluated using CS 3D imaging software, Carestream 9600 s CBCT machine. Mann Whitney test was used for Inter-group canal transportation and centring ability analysis at all the three levels. The level of significance was set at  $P < 0.05$ .

**Results:** TruNatomy file showed statistically significant less canal transportation compared to Revo-S file at both mesiodistal region ( $P=0.007$ ) and buccolingual region ( $P=0.001$ ) at 3mm, but only at buccolingual region at 6 mm ( $P < 0.001$ ) and at 9 mm ( $P < 0.001$ ) from the apex. There was no statistically significant difference in the canal transportation between the two groups at mesiodistal region at 6 mm ( $P=0.19$ ) and at 9 mm ( $P=0.83$ ) from the apex. There was no statistically significant difference between TruNatomy file and Revo-S file for its centering ability at 3mm ( $P=0.11$ ), 6mm ( $P=0.36$ ), and 9mm ( $P=0.49$ ), from the apex.

**Conclusion:** Within the limitations of this study, TruNatomy file system showed less canal transportation compared to Revo-S file

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system. There was no significant difference between the two file systems for its centering ability.

#### Abstract 296

### Knowledge, attitude, and practice-based survey on the protocols followed for pulp capping among postgraduates, general practitioners, and specialists

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**Aim:** Pulp capping is a minimally invasive procedure that aims to preserve the vitality of the pulp. Several factors right from the case selection to the type of material may influence the success of pulp capping. The present survey aimed to assess the knowledge, attitude, and practice of the different protocols followed for pulp capping among postgraduates, general practitioners, and specialists.

**Materials and Methods:** A cross-sectional survey was conducted using a close-ended, multiple-choice questionnaire through Google forms and 209 responses were collected. The data obtained were analyzed using SPSS software. Descriptive statistics and Chi-square tests were done for selected questions to evaluate the association ( $p$  value < 0.05).

**Results:** 52.1% of the participants were general practitioners, 22% were endodontists and 21% were postgraduates. Calcium hydroxide was the most commonly used pulp capping agent (56.45%) although the majority of the participants felt MTA had a higher clinical success rate (44%). Chi-square test showed a significant association of the specialty of the participants with the knowledge on indications and contraindications, frequency and material used for pulp capping, and the attitude on rubber dam use and success rate of pulp capping ( $P < 0.05$ ).

**Conclusion:** Although the participants in this study had a fair knowledge about pulp capping, some key aspects like the indications, case selection, and advances in materials need better clarity. This will encourage more clinicians to perform pulp capping with more predictability.

#### Abstract 297

### Comparative evaluation of mineral trioxide aggregate and biodentine as dental perforation repair materials in patients undergoing endodontic treatment: A systematic review

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**Objective:** The root perforation, in spite of being taken as a challenging accident in root canal treatment, has to offer favorable results when exposed to appropriate therapeutic conduct and the usage of materials that have convenient properties. The aim of this systematic review to evaluate and compare case reports which used MTA and Biodentine as treatment modalities for dental perforation repair in teeth indicated for endodontic treatment.

**Methodology:** A comprehensive search was conducted by using

electronic databases (Google Scholar and PubMed use English-language literature) for this systematic review, using specific inclusion and exclusion criteria and keywords. The search lined all articles printed from 2004 to 2020.

**Results:** Eleven studies were included for the qualitative synthesis. Out of the 11 studies, 8 were randomized controlled clinical trials, 1 was a clinical trial, 1 was a prospective study and 1 was a retrospective study. The success rate was seen as encouraging in all the included studies, most commonly Biodentine gave better results than MTA. Biodentine was the commonly used repair material than MTA as was assessed by the outcome parameters.

**Conclusion:** Some of the researches have reported that no significant difference between both the agents, and most of the studies proposed better results (both rapid and long lasting) for MTA. However, it can be concluded that, from this study that Biodentine is more commonly used treatment modality giving better results than MTA in treatment of root perforations.

#### Abstract 298

### Scanning electron microscope evaluation of mineral trioxide aggregate interface upon immediate and delayed (after 24 h) placement of glass ionomer cement and composite: An *in vitro* study

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**Aim:** To evaluate the interface formed by GIC and Composite with MTA, when placed immediately and after 24 hrs.

**Methodology:** Twenty extracted molars were sampled and divided into four groups with  $n=5$  in each group. GIC and composite were placed as final restorations at two different timings after MTA placement. In group I ( $n=5$ ), immediate restoration with GIC was done over freshly mixed MTA. In group II ( $n=5$ ), immediate restoration with light cured composite was done. In group III ( $n=5$ ), a moist cotton pellet was placed over MTA and a final restoration with GIC was done over MTA after 24 hrs. In group IV ( $n=5$ ), permanent restoration with light cured composite was done after 24 hrs. The samples were then studied under scanning electron microscope (SEM) for gap and cracks at the interface.

**Results:** The SEM (at 400x) showed group III had significantly least adhesive separation of  $2.13\mu\text{m}$  at the interface ( $p$  value = .005), whereas Group IV showed gap formation of  $5.95\mu\text{m}$ . The specimens in Group I and II showed separation of  $6.64\mu\text{m}$  and  $9.12\mu\text{m}$  respectively. However, Group II showed the highest separation amongst all four groups.

**Conclusion:** These findings suggest that GIC over MTA is a better option than Composite over MTA whether seen after immediate or after 24 hr placement. Also, overall bond was better when GIC was placed over MTA after 24 hrs rather than immediately.

#### Abstract 299

### Tooth rift – Repaired in a swift

**SUVAANI KATARIA**

Abstract

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During root canal treatment, various procedural errors may occur that lead to the failure of endodontic therapy. Perforation is defined as a mechanical or pathological communication between the root canal system and the external tooth surface, which is caused by caries, resorption or iatrogenic factors (AAE,2003). There are mainly two types of perforations (coronal and radicular) that can occur iatrogenically. Destruction of periodontal tissues occurs as a result of furcation perforation, which may ultimately lead to loss of tooth from the dental arch. The prognosis of tooth depends upon distinct factors, i.e. (i) severity of initial damage to periodontium, (ii) location and size of perforation, (iii) bacterial contamination and (iv) sealing ability and cytotoxicity of the repair materials. This case report delineates the management of repair of iatrogenic furcation perforation with biodentine.

### Abstract 300

#### Comparative evaluation of smear layer removal by different concentrations of liquid and gel type ethylenediaminetetraacetic acid: A scanning electron microscope study

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**Aim:** The aim of the present in vitro study was to compare the effectiveness of varying concentrations of liquid and gel type EDTA in removal of the smear layer with the aid of – A Scanning Electron Microscope study.

**Materials and Methods:** Sixty human extracted single-rooted teeth, with completely formed apices were selected and decoronated with the diamond disc to obtain a uniform root length of 14 mm from the apex. Proper access was established, and the apical patency was determined by inserting a number 10 K-file. All root canals were prepared by rotary file system and thorough irrigation was performed with Sodium hypochlorite after each instrument change. The teeth were then randomly divided into four groups (n= 15) as follows:  
Group 1: 17% EDTA Gel was used for removal of smear layer.  
Group 2: 19% EDTA Gel was used.  
Group3: 17% EDTA Solution was used for removal of smear layer.  
Group4: 18% EDTA Solution was used.

After cleaning, all teeth were dried using paper points. The samples were sectioned longitudinally and examined under Scanning electron microscope at the coronal, middle, and apical third of the root canal.

**Results:** The overall minimum mean score of remaining smear layer observed was 1.48 in Group 4 (18% EDTA Solution), 1.91 in Group 3 (17% EDTA solution, 2.55 in Group 1 (17% EDTA gel),), 2.28 in Group 2 (19% EDTA Gel).

**Conclusion:** Solutions were more efficacious in smear layer removal at all levels as compared with gel type EDTA.

### Abstract 301

#### Retreatment of young permanent teeth with large periapical lesion

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Trauma to the permanent incisors represents about 18-22% of all dental traumatic injuries, among which 96% involve maxillary central incisors. It can result in the interruption of the development of incompletely formed roots in young patients. The biggest challenge while treating teeth with open apex is to successfully obtain an apical seal because of the lack of apical constriction, making it difficult for compaction of obturation material and there is risk of extending materials beyond apex. This can be overcome by apexification procedure. In addition, large periapical lesion makes healing difficult which can be treated thorough disinfection of the canals. In this case report, we are discussing a case with root canal retreatment with respect to 11 and 21. Teeth had open apices with symptomatic apical periodontitis and persistent periapical lesion of 8\*6 mm with respect to 11, 5\*5mm with respect to 21. Retreatment was planned for both the teeth. Single visit apexification with MTA was done for apical closure and thermoplasticized obturation technique was adopted. During 2 month follow up, patient was found to be free of symptoms following which zirconia crowns were placed. A 2 year follow up was done and there was satisfactory healing on the radiographs.

### Abstract 302

#### Comparative evaluation of different retreatment techniques in terms of residual root filling material, preservation of root dentin and time using cone beam computed tomography

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**Aim:** To evaluate the performance of ProTaper Universal Retreatment (PTUR) system, PTUR supplemented with XP Endo Finisher-R (XPF-R) and PTUR supplemented with Ultrasonic endodontic retreatment tips (E5 and E4D, Woodpecker) when used with and without solvent for efficiency in removing root canal material, preservation of root dentin and time taken in removal of root canal filling material.

**Materials and Methods:** 48 single rooted mandibular premolars were selected. The teeth were decoronated up to the cemento-enamel junction so that a working length of 15mm was obtained. All the teeth were mounted on a wax template. Biomechanical preparation was done using ProTaper Gold file system up to No. F2 file. Post-instrumentation Cone Beam Computed Tomography (CBCT) were done for all the teeth. The samples were randomly assigned into 6 groups according to the retreatment protocol used (n = 8): PTUR files with and without orange oil solvent, PTUR supplemented with XPF-R file with and without solvent, and PTUR supplemented with ultrasonic tip with and without solvent. After retreatment, the specimens were rescanned and volumetric analysis of remaining root filling material and volume of the canal

## Abstract

space were measured using ITK-SNAP Software Version 3.8.0. All the data were subjected to Kruskal Wallis test followed by Mann Whitney's post hoc analysis with a significance of  $P < 0.05$ .

**Results:** There was no statistical significance while using orange oil solvent during the retreatment procedures. PTUR supplemented with XPF-R file and ultrasonic endodontic tips removed statistically significant amount of root canal filling material when compared with only PTUR, even though statistically the supplementary groups required more time to complete the retreatment protocol. PTUR supplemented with ultrasonic tips preserved statistically significant amount of dentin when compared with other supplementary retreatment techniques where XPF-R was used in this study.

**Conclusion:** PTUR aided with ultrasonic retreatment tips is a promising method for removing root canal obturating material which preserves more amount of root canal dentin than PTUR supplemented with XPF-R.

### Abstract 303

**Morphological oddity – An enigma; demystified endodontic management of premolars and molars with unusual canal morphology: A case series**

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The axiom of endodontic treatment relies in proper debridement, disinfection and obturation of root canal in 3-dimensions to prevent reinfection of the tooth. Comprehensive understanding of variations in root canal morphology is also an important aspect for performing successful endodontic interventions. The presence of an untreated or missed canal is one of the main reasons for failure of endodontic treatment. Most of the time root canals are left untreated because the clinician fails to identify their presence particularly in teeth that have anatomical variation. The concurrent development of better techniques has resulted in greater understanding of the canal anatomy, greater treatment success and a more favourable patient response. The microscope-assisted dentistry enhances the visibility; allows the clinician to precisely locate and negotiate anatomical variations that had previously remained unnoticed. This case series discusses successful endodontic management of premolars and molars with aberrant canal morphology. Each case presented its own morphological configuration and challenges. Correlation between radiographic findings, use of dental operating microscope and knowledge of atypical anatomy helped to identify, locate and successfully treat the unusual morphology of the teeth. Success largely depended on the use of magnification, which aided in identifying the location of root canal orifices; thus emphasizing the need to familiarize ourselves with dental microscopy, to obtain maximal anatomic information in endodontic practice.

### Abstract 304

**In-office teeth whitening technique post orthodontic treatment: A case report**

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This case report provides information on the protocol for external bleaching techniques to restore discolored teeth post orthodontic treatment. A 25-years-old female complained yellowish discoloration after using orthodontic braces for  $\pm 3$  years, the patient wanted to improve the color of her teeth. After the prophylactic procedure and the assessment of tooth color initiation, a light-cured gingival barrier was applied. Then apply 40% hydrogen peroxide for 20 minutes. There was a change in color that was brighter from a score of 8 to 5 using a shade guide. Tooth discoloration post orthodontic treatment can be treated effectively using in-office external bleaching technique.

### Abstract 305

**Effect of polydopamine pretreatment on wettability, surface morphology and shear bond strength of mineral trioxide aggregate to resin composite**

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**Background:** The success of vital pulp therapy is crucial to preserve the integrity of teeth and to enable uninterrupted root formation in a young permanent tooth. This warrants an intact permanent seal immediately in contact with the pulp capping material. Mineral trioxide aggregate (MTA) sets by hydration and deters placement of an immediate permanent resin composite restoration over it. The aim of this in vitro study is to evaluate the wettability, surface morphology and shear bond strength (SBS) of polydopamine (PDA)-pretreated MTA to resin composite (RC).

**Methods:** The contact angle (CA) and morphological changes caused by self-etch (SE) adhesive on untreated and PDA-pretreated MTA was analyzed using contact angle meter and scanning electron microscope (SEM) respectively. To evaluate SBS, 144 MTA samples were prepared using a custom-made mold and were randomly divided into two groups of 72 samples each based on whether their surface was pretreated with PDA or not. Under each group, RC restoration was done either immediately or after a delay of 3 h, 24 h and 96 h. SBS of the MTA/composite assembly was tested in a universal testing machine.

**Results:** SE adhesive made a significantly lesser contact angle with PDA-pretreated MTA compared to untreated MTA ( $p < 0.05$ ). SEM micrographs showed that while etching with SE primer eroded the MTA surface, PDA coating minimized the erosive effect of the acidic primer and preserved the original crystalline plate-like structure of MTA. At all time intervals, PDA pretreatment significantly increased the SBS of MTA to RC, compared to untreated control. Immediate bond strength of PDA pretreated MTA (26.30 MPa) was equivalent to the SBS value achieved at 96 h with untreated MTA (27.82 MPa).

**Conclusion:** Within the limitations of this in vitro study, it can be concluded that PDA pretreatment of MTA surface improved its wettability, prevented loss of surface integrity following etching and increased the SBS of MTA to RC.

### Abstract 306

#### Emerging concept - Magnetic resonance imaging for guided endodontics

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Root canal treatment is done to treat pulpal and periapical pathosis. The initial step in root canal treatment procedure is access cavity preparation. In situations like calcified root canals, location of canal orifice is difficult and time consuming. Recently guided endodontics has emerged as a new approach to locate the root canal orifice of the teeth with calcified canals. Guided endodontics requires a CBCT with an intraoral scan for template fabrication that aid in positioning the bur towards the root canal orifice in cases of calcified canals. CBCT scan uses the ionizing radiation which can have harmful effect on the patients. To overcome this recently MRI is being probed more as a diagnostic tool in Dynamic navigation technology. The physics of producing image with MRI (Magnetic Resonance Imaging) is different from Computed Tomography (CT) and Cone Beam Computed Tomography (CBCT). Consequently MRI is fast outpacing imaging modality of choice for in vivo representation of hard and soft tissues without any invasive procedure and ionizing radiation. With the development of dental and face specific MRI coils, plus the freedom found in sequence design and image processing, MRI has paved the way for guided endodontics. This review emphasises on the feasibility of using MRI as an alternative to CBCT imaging for guided access cavity preparation which is considered to be safer and effective tool in Dynamic navigation technology.

### Abstract 307

#### Decision tree analysis on management of calcified canals

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Calcific metamorphosis is also called pulp canal obliteration. Canals can be partially or fully obliterated. Most common reasons for calcified canals are trauma and aging. These calcific deposits can cause a considerable challenge to the dental practitioner in locating the canals, reaching the working length and also cleaning and shaping the canals. Attempt to negotiate the canals and perform biomechanical preparation without proper and thorough knowledge on management of calcified canals can lead to iatrogenic errors caused by the clinician such as perforation, fracture of instrument, transportation etc. Most important thing before attempting to negotiate such calcified canals is to have a thorough knowledge on the normal anatomical form and morphology of the root canal system of the particular tooth. Practicing under dental loupes or microscope can add to the clear vision and aid in locating and negotiating the canal. Different armamentarium is available for this purpose like basic small size k file, c pilot files, Endo guide burs, ultrasonic, chelating agents, endodontic surgery to advanced Guided Endodontics. For proper understanding, based on the extent of calcification, whether One third canal is calcified, two third or fully calcified canals, this decision tree has been made. Though negotiating and managing calcified canals can be challenging, they

can be managed if a proper protocol is followed. Positive approach with patience along with Operator's skill, attitude, and a proper armamentarium are the requisites to overcome the difficulties posed by these calcified and obliterated canals for their successful treatment.

### Abstract 308

#### Managing the complex root canal anatomy: Case report

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Anatomy is the science that deals with morphology. A clear understanding of the anatomy is a prerequisite to perform all kind of dental procedure including the root canal therapy that deals with the internal anatomy of teeth. Simple root canal morphology is a rarity than a norm. The root canal system is complicated and has many anatomical variation including numbers of roots, canals and their configuration. Here this paper presentation highlights cases of Radix Entomolaris, C-Shape canals and Lateral canals. The complex anatomy is possible complication to successful diagnosis management and favorable prognosis.

### Abstract 309

#### Comparative evaluation of the push-out bond strength and failure mode of bond of fibre reinforced composite posts in endodontically treated teeth: An *in-vitro* study

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**Aim:** To comparatively evaluate the push-out bond strength and failure mode of bond of four different Fibre Reinforced Composite Posts cemented using a self-adhesive resin cement in endodontically treated teeth.

**Materials and Methodology:** A total of 20 freshly extracted single-rooted, non-carious human premolars were used for this study. The teeth were decoronated at the Cemento-enamel junction to obtain a minimum root length of 13mm, and standard root canal procedure was carried out. After endodontic treatment, the coronal ends were sealed and the specimens were incubated for one week. Post space preparation was carried out maintaining a 4mm apical seal, following which the sample was divided into four groups: Group 1: Pre-fabricated glass fibre reinforced composite post (control), Group 2: Individually fabricated glass fiber reinforced composite post, Group 3: Individually fabricated fibre reinforced composite post with ultra-high molecular weight polyethylene (UHMWP) fibres and Group 4: Experimentally fabricated fibre reinforced composite post using aromatic polyamide fibres. Post cementation was done using self-adhesive resin cement and teeth were sectioned into coronal, middle and apical discs. The Push-out bond strength was measured using a Universal testing machine for all sections and the failure mode was examined under Stereomicroscope.

**Results:** After statistical analysis, a significant difference ( $P < 0.05$ ) was found between the push-out bond strength for the fibre reinforced composite posts. Experimentally fabricated fibre reinforced composite post using aromatic polyamide fibres (Group

4) and Individually fabricated glass fiber reinforced composite post (Group 2) showed highest values for bond strength. The failure mode was found to be variable for all specimens with adhesive failure between dentin and luting agent and cohesive failure within the luting cement to be the most prominent.

**Conclusion:** Experimentally fabricated composite posts using Aromatic Polyamide fibres showed promising results in the field of post-endodontic restoration of teeth. These high-strength tensile fibres hold potential to be incorporated into endodontic posts.

### Abstract 310

#### Management of necrotic mature tooth with regenerative endodontic procedure: A case report

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Regenerative endodontics is defined as “biologically based procedures designed to replace damaged tooth structures, including dentin and root structures, as well as cells of the pulp-dentin complex”. Preservation of the natural dentition remains a primary objective in endodontic practice. When the pulp is diseased or necessitates removal for restorative reasons, it is replaced with an artificial filling material. Endodontists are looking forward to using natural resources instead of artificial ones. The regenerative endodontic procedures are examples of tissue engineering and were limited to immature teeth, but recently, REPs have been extended to treat necrotic mature teeth as an alternative to conventional endodontic treatment. This treatment also resulted in the elimination of clinical signs/symptoms and resolution of apical periodontitis. Conventional endodontic treatment is a major etiologic factor for tooth discoloration and tooth fracture. The difference between conventional root canal treatment and an REP is that the disinfected canals are filled with biocompatible, non-vital foreign materials in the former therapy and vital tissue in the later therapy. Therefore, the gain of nerve function in regenerated pulp tissues and maintaining possible proprioceptive defensive mechanisms of the pulp will provide an alarm system during tissue injury and protect the pulp from further damage or the probability of tooth fracture. Although these tissues are not true pulp tissue, they are host's own vital tissue, which is inherited with immune defense mechanisms to protect itself from foreign invaders. In regenerated tissue natural killer cells, lymphocytes and macrophages are restored by blood vessels and represent an innate immune system. Innate immunity within the root canal, which is disallowed after conventional endodontic treatment and can be restored after regenerative endodontics, may offer the potential to reduce reinfections. Furthermore, regenerated tissue may be structurally more resistant to fracture than endodontically treated teeth. This presentation of a case discuss the management of necrotic mature tooth with regenerative endodontic procedure.

### Abstract 311

#### Management of mandibular lateral incisor with vertucci's Type IV canal configuration

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The anatomy of the root canal system determines the parameters under which the endodontic treatment will be accomplished and directly affects the success of the root canal treatment. Hence, a thorough knowledge of the root canal morphology, careful radiographic interpretation and access cavity modifications are essentials for enhancing endodontic procedures. Mandibular incisors are recognized as usually having one root and one root canal in most cases, although approximately 36% may have two canals. The main reason for unfavorable outcome in endodontic treatment of mandibular incisor is the inability to detect the presence of second canal. Pain even after extirpation of complete pulp tissue from root canal of vital teeth is the main indication of hidden canals. The present case report is on management of pain because of neglected canal in right mandibular lateral incisor.

### Abstract 312

#### Biofilm: A plethora of endodontic pathogens – An overview

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India

Biofilms are models of bacterial growth where sessile cells interact to form dynamic communities linked to a solid substrate, located in a matrix of extracellular polymeric substances. Biofilms provide pathogens a favourable habitat and a more structured metabolic diversity. Besides, these coordinated functional communities offer protection against other competitive microorganisms, antimicrobial agents and host defences, accentuating their pathogenicity. The location of biofilm can be intra-radicular or extra-radicular. More often than not, in 77% of cases, biofilms are intra radicular, while about 6% represents the extra radicular share. Diverse microbial species interact during infection, producing microbial population shifts. The pulp space milieu is particularly conducive to harbour anaerobic bacteria that ferment the available amino acids and peptides for metabolic needs. These microorganisms have distinctive properties, which help them resist the disinfection measures: the ability to form biofilm, to thrive in areas impervious to shaping techniques, synergism, the ability to express survival genes and activate alternative metabolic pathways. To survive in a sealed system, microorganisms have to endure the intracanal disinfection measures and have to adapt to an environment with inadequate nutrients. In addition, bacteria located in areas such as apical deltas, isthmuses, lateral canals, irregularities and dentinal tubules, often escape endodontic disinfection procedures. The objective of this literature review is to identify the key microorganisms that induce & perpetuate endodontic biofilms, nature of biofilms, as well as the reasons that enable them to survive basic disinfection measures. Pertinent microorganisms namely *E.faecalis*, *Actinomyces*, *Fusobacterium* and their state of the art eradication techniques will be appraised. Another important consideration in endodontic treatment is the elimination of fungi from the pulp space. Major proportion of fungal oral micro biota is made up of *Candida* species. Although studies

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demonstrated that fungi are atypical members of the micro biota in primary endodontic infections, *Candida albicans* has been associated with root canal infections resistant to nonsurgical therapy. In this review, we confer the role of microbial biofilms in endodontics and the extermination measures.

### Abstract 313

#### A blooming boon: Application of Artificial intelligence in endodontics

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Dentistry has rapidly developed over the past few years with new inventions that help in improving the quality of treatment. With the advancements in science, newer technologies such as artificial intelligence (AI) have been introduced in healthcare sectors for various purposes. This technology comprises of a neural network architecture similar to the human brain and intern mimics the human thinking. This convolutional network pattern is made up of neurons that have strong interconnections, which mainly operate as a data-processing systems to solve a specific problem. AI has been applied in dentistry mainly for diagnosis of dental diseases, treatment planning, clinical decision-making, and prediction of prognosis of dental treatment. Further, these models have demonstrated various applications in endodontics such as studying root canal system anatomy and assessment of root morphologies, detecting periapical lesions and root fractures, determining working length measurements, predicting the viability of dental pulp stem cells, locating apical foramen, and predicting the success of retreatment procedures. It is also found that artificial neural network is similar or more accurate than the professional experts as it allows better accuracy and precision. However, it is still necessary to further verify the reliability, applicability, and cost-effectiveness of AI models before transferring these models into day-to-day clinical practice. This review paper provides an insight about the potential application, limitation and future of Artificial Intelligence in endodontics.

### Abstract 314

#### Effect of sodium hypochlorite on the cyclic fatigue resistance of newer nickel-titanium rotary instruments: An *in vitro* study

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**Aim:** The study compared the effect of 5.25% NaOCl on the cyclic fatigue resistance of Protaper Gold F2, Hero Gold, and Edge File X3 endodontic files and compared it against distilled water. The surface changes were studied under a scanning electron microscope (SEM). **Materials and Methods:** A total of 60 new Protaper Gold F2 (group 1), Hero Gold (group 2), and Edge Taper X3 files (group 3) were selected. There were 20 files of each type, which were further divided into sub-groups of 10 each depending upon the immersion solution (5.25% NaOCl or distilled water). 16mm of the shaft of each instrument was dynamically immersed in the solution for 5 minutes. Cyclic fatigue testing was performed using artificial

canals milled in stainless-steel blocks (curvature angle = 60°, a curvature radius = 5 mm, and a center of curvature located 6 mm away from the tip). The number of cycles to failure (NCF), until the instrument broke, was recorded. Data were statistically analyzed by the Mann-Whitney U test and Kruskal-Wallis test. Statistical significance was set at  $p < 0.05$ .

**Results:** There was a significant difference between the groups for NCF. The mean and SD of NCF in group 1 was  $499.75 \pm 46.95$ , group 2 was  $655.33 \pm 54.21$ , and group 3 was  $1103.66 \pm 135.47$ . Thus, group 3 (Edge Taper X3 files) showed the highest cyclic fatigue resistance among the three groups. There was no difference between the impact of 5.25% NaOCl and distilled water on fatigue resistance. SEM analysis of the fracture fragments showed increased crack initiation areas, fatigue striations, and fast fracture zone with dimples in instruments treated with sodium hypochlorite when compared to saline.

**Conclusion:** The resistance to cyclic fatigue of Edge Taper X3 files was significantly better than ProTaper Gold F2 and Hero Gold. The NiTi files undergo increased surface changes when immersed in 5.25% NaOCl solution when compared to saline.

### Abstract 315

#### Assessment of antioxidant and anti-inflammatory activity of a novel intracanal drug: An *in vitro* study

**M SHAMLY, NASIM IFFAT**

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**Aim:** To evaluate the antioxidant and anti-inflammatory activity of green synthesized silver nanoparticle based intracanal medicaments.

**Materials and Methods:** The experimental groups were calcium hydroxide incorporated silver nano particles and graphene oxide incorporated silver nanoparticles. The control group was calcium hydroxide. The antioxidant activity was checked by DPPH assay and Nitric oxide assay whereas anti-inflammatory activity was checked using Protein denaturation and Xanthine oxidase inhibition assay.

**Results:** Based on DPPH and Nitric oxide assay, both the experimental groups showed better antioxidant activity compared to the control group. Based on Protein denaturation and Xanthine oxidase inhibition assay, calcium hydroxide incorporated with silver nanoparticles showed better anti-inflammatory activity.

**Conclusion:** Silver nanoparticle based intracanal medicaments can be used effectively during root canal preparation. It shows effective antioxidant and anti-inflammatory activity compared to traditional calcium hydroxide based intracanal medicaments.

### Abstract 316

#### To compare the antifungal efficacy of three endodontic sealers with and without the incorporation of oreganum vulgare oil against *Candida albicans*

**ROHIT AMBURLE**

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**Aim:** The aim of this study was to compare the antifungal efficacy of three endodontic sealers (AH Plus, Sealapex, and MTA Fillapex)

## Abstract

with and without the incorporation of oreganum vulgare oil against *Candida albicans*.

**Materials and Methods:** In the present study *C. albicans* were cultured in Potato Dextrose Agar plates. Filter papers (n = 10) were placed in the cultured Petri dishes and the sealers were mixed according to the manufacturer's instructions and placed on the top of the filter papers. Group division of sealers is as follows: Group I – AH Plus, Group II – Sealapex, and Group III – MTA Fillapex. Group IC, Group IIC, and Group IIIC were the addition of 25 µg/ml of oreganum vulgare oil with respective sealers. Plates were incubated for 18 h, and the zone of inhibition was measured with a measuring scale and values (in millimeter) were recorded.

**Statistical Analysis:** Statistical analysis was done by one-way analysis of variance followed by post hoc multiple pair-wise comparisons.

**Results:** All the tested groups showed statistically significant difference (P < 0.05) from each other. Essential oil of oreganum vulgare showed superior zone of inhibition compared to sealers used alone. Group IC (16.35 ± 0.71 mm) had the highest zone of inhibition followed by Group I (13.8 ± 0.86 mm). For the remaining groups, the zone of inhibition was in the following order: Group IIC > Group II > Group IIIC > Group III.

**Conclusion:** AH Plus sealer mixed with oreganum oil showed significantly higher antifungal property. Mixing of oreganum oil with endodontic sealer provides an added advantage so that endodontic re infections can be minimized and will be helpful in retreatment cases.

### Abstract 317

#### Three-dimensional printing – Digital endodontics

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The ultimate goal of dentistry is to provide finest dental care to satisfy the patient needs. It is necessary to obtain high precision and accuracy for almost all the work carried out intraorally to achieve superior function and esthetic. 3D printing is a budding technology especially in the field of dentistry and is also a rapidly developing technology to provide precision & state of art imaging & scanning methods. Compared to conventional lost wax technique and subtractive manufacturing process like CAD CAM where a block of material is reduced to reproduce the object, 3D printing offers process engineering advantage like additive manufacturing, that involves the actual layer by layer addition of a material to fabricate an object. This technique of digitalization helps to complete task faster, easier, in an accurate manner and permits customization. 3D printing has been used for a number of clinical applications in medicine and dentistry. Digital dentistry assists the dental practitioners in quickly and precisely recording and evaluating the dentofacial structures. This allows us to bypass several manual techniques and replace them by using automated devices, thus minimizing the chance of errors. Today, most dental disciplines utilize the advantage of 3d printing to provide patient-specific custom-made prosthesis and restorations. With persistent efforts among dentists for refining their practice, dental clinics are

now upgrading from conventional treatment methods to a fully digital workflow to treat the patients. 3D printing also helps in making precise models for dental education and patient education regarding their treatment plan. In this narrative review, we discuss the evolution and current trends in 3D printing applications in various aspects of endodontics.

### Abstract 318

#### An *in-vitro* comparative evaluation of microleakage in Class V cavities restored with conventional and chitosan-modified glass ionomer cement: A stereomicroscopic study

**AJISHA RAJU**

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Ganganagar, Rajasthan, India

**Aim:** The aim of this study was to investigate the effect of modifying the liquid phase of conventional GIC with 10% v/v Chitosan on the microleakage property of enamel in comparison to conventional GIC.

**Materials and Methods:** Thirty freshly extracted human molar teeth were obtained. Two groups of samples were created for the study which comprised of group I (glass ionomer cement—GIC) and group II (Chitosan modified glass ionomer cement). Chitosan modified GIC was prepared by mixing 10% v/v Chitosan into liquid component of GIC, after dissolving it in 1% acetic acid. Class V cavities were prepared on the buccal and lingual surfaces. The prepared cavities were restored and varnish was applied all tooth surfaces except the restoration. The teeth were subjected to thermocycling 1500 cycles at 5 and 60°C, with 20 seconds of dwell time. The samples were then immersed in 2% basic fuschin dye solution for 24 hours. The teeth were sectioned into two halves buccolingually in an occlusoapical direction. Sections were viewed under stereomicroscope and the degree of microleakage was evaluated using specific scoring criteria. For comparative evaluation of microleakage scores between Conventional and Chitosan Modified GIC, a nonparametric Mann-Whitney statistical analysis was done.

**Results:** Statistical analysis showed no significant differences between groups I and II with the p-value at >0.05.

**Conclusion:** Chitosan-Modified GIC holds great promise for general dentistry as a future restorative material with properties equivalent to GIC.

### Abstract 319

#### Bioceramic: A new horizon in endodontics

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Bioceramics and multi-substituted hydroxyapatite or similar compounds have the ability to induce a regenerative response in the organism, Bioceramics are ceramic compounds obtained both in situ and in vivo, by various chemical processes. Bioceramics exhibit excellent biocompatibility non toxicity, dimensional stability and most importantly being bio-inert due to their similarity with biological materials, like hydroxyapatite In Endodontics, they can be broadly classified into Calcium Phosphate/ Tricalcium/ Hydroxyapatite based, Calcium Silicate based or mixtures of Calcium Silicate and Phosphates. The paper presentation highlights the currently available "BIO-CERAMIC MATERIAL" in endodontics on

their specific characteristics which may over the course of years help us move towards the new era of bio-ceramic dentistry.

### Abstract 320

#### Influence of irrigation techniques on the dentinal tubular penetration of final irrigants: A confocal laser scanning microscope study

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Ghaziabad, Uttar Pradesh, India

**Aim:** To comparatively evaluate the effect of four different irrigation techniques (Conventional Syringe Irrigation, Passive ultrasonic irrigation, EndoActivator and Pro Agitator Tip System) on the dentinal tubular penetration of two final endodontic irrigants ( 5.25% Sodium hypochlorite, 2% Chlorhexidine)

**Materials and Methods:** Forty single-rooted mandibular human premolars were decoronated and chemomechanically prepared (ProTaper Gold upto F3). The prepared samples were randomly divided into two groups according to the final irrigants used (n = 20) Group I 5.25% Sodium Hypochlorite, Group II 2% Chlorhexidine. Specimen of each group were further subdivided into four subgroups (n=5), according to the irrigation techniques used during final irrigation: Subgroup A (n=5) Conventional Syringe Irrigation (CSI), Subgroup B (n=5) Passive Ultrasonic Irrigation (PUI), Subgroup C (n=5) Endoactivator (EA), Subgroup D (n=5) Pro agitator Tip System (PATS). The teeth were sectioned at coronal, middle and apical levels and viewed under CLSM to record the penetration depth of NaOCl and CHX. The data were statistically analysed using Independent t test and one way ANOVA.

**Results:** Intergroup comparison shows that 2%CHX shows statistically significant better depth of penetration than 5.25% NaOCl irrespective of the irrigation technique and root levels. Intragroup comparison showed that PUI showed significantly highest depth of dentinal tubular penetration followed by EndoActivator, PATS and CSI. Coronal third of the root canal showed maximum depth of dentinal tubular penetration followed by middle third and least in apical third with significant differences between them.

**Conclusions:** Depth of irrigant tubular penetration depends on the type of irrigant, irrigation technique and root levels.

### Abstract 321

#### Nanotechnology in endodontics: An upcoming era in dentistry

**AYYAGARI VIRESH, SHESHADRI RAMYA**

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Nanotechnology is an upcoming field in dentistry leading to a very rapid development which became a important tool in dentistry as well as in field of biomedical sciences. This has a wide application in regeneration of tissues, gene transformation. This review focuses on the concepts of nanotechnology in endodontics. Nanotechnology is used to prepare advanced biomaterials with unique physical, chemical and biological properties termed as "Nanoparticles". Nanoparticles like graphene, silver, chitosan,

hydroxyapatite, titanium dioxide were introduced in the field of endodontics such as irrigating solutions, intracanal medicaments, root canal sealers and obturating materials. Nanoparticles-based treatment strategies have the potential to improve antibacterial/antibiofilm efficacy, showed considerable improvement in bonding and sealing abilities promising better restorative outcome. Thus, this field warrants translational research based on sound scientific and clinical tenants to optimize the potential of nanoparticles in clinical endodontics.

### Abstract 322

#### Evaluation of biodentine pulpotomy in fractured young permanent anterior teeth: A case series

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Traumatic dental injuries occurs frequently in children and young adults, comprising 5% of all injuries. Fracture of maxillary anterior teeth is most common amongst them. Conservative management of these fractures helps in preservation of tooth structure, vitality and esthetics. It depends on multiple factors such as time lapse between trauma and the initiation of treatment, level and position of tooth fracture line, stage of root development, pulpal involvement, availability of displaced tooth fragments and concomitant alveolar bone injury. A conservative approach should be our first choice for treating such fractures owing to advancements in vital pulp therapy and adhesive dentistry. Fracture reattachment is widely accepted technique. It restores the tooth integrity and color by conserving original tooth structure. Vital pulp therapy which includes pulpotomies are conservative treatment for reversible pulpal injuries that promotes pulp tissue healing and stimulates hard tissue formation in order to preserve pulp vitality. Traditionally, calcium hydroxide was the material of choice, Mineral trioxide aggregate is considered as a more suitable option. However, discoloration was a major drawback for its use in anterior teeth. To overcome this recent alternatives such as Biodentine have been introduced. It is a biocompatible and bioactive material that promotes pulp healing when applied directly in contact with the pulp tissue. This case series aims to describe and evaluate the outcome of re-attachment of a fractured segment of a mature anterior tooth with pulpal exposure treated with biodentine pulpotomy followed by immediate restoration. The teeth were assessed clinically through pulpal vitality tests and radiographically for periapical healing. At each recall (24 hours, 1 week, 1, 3 and 6 months) no spontaneous pain was observed, the pulp showed signs of vitality and absence of periapical radiolucency at 6 months. Biodentine pulpotomy is recommended as a treatment option for cases of vital pulp exposure in permanent incisors due to trauma.

### Abstract 323

#### Vital pulp therapy with bioceramic material: A case report

**PARVATHY SUNNY, KHADDEJA MUHAMMED,  
AMAL DEVADAS, PRAVEENA GEETHA,  
RADHAKRISHNAN NAIR**

## Abstract

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Aim of vital pulp therapy is to stimulate the remaining pulp to regenerate dentin pulp complex in order to preserve the functionality and therefore ensuring that a tooth remains in the oral cavity for a long duration. Direct Pulp Capping is a conservative treatment strategy, where the infected coronal pulp can be removed, and the pulp wound is completely sealed off with a bio ceramic material placed in direct contact with the pulp wound to prevent micro leakage and result in the development of a reparative hard tissue bridge to preserve pulp vitality. The case report describes the management of a left mandibular first molar with iatrogenic pulp exposure. Patient reported with the history of fractured restoration and pain on chewing food. Under strict isolation, faulty restoration removal was completed and mesial pulp horn was exposed. A portion of inflamed tissue was curetted under dental operating microscope. Haemostasis was achieved and a calcium silicate liner (theracal) was placed followed by GIC and composite restoration. In five months follow up patient was asymptomatic with intact periapical area.

### Abstract 324

#### Anatomical variations in mandibular premolars: An enigma to endodontist

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Mandibular premolars have earned the reputation of having aberrant anatomy because they are the transitional teeth; they display features of both molars and canines and hence are considered as an enigma to dentist. Though most frequent type of tooth configuration reported in premolars is presence of single root and root canal; root canal morphology can be unpredictable and requires cautious assessment before root canal therapy. The dental operating microscopy facilitated the observation of anatomical landmarks in pulp chamber floor and helped to identify supplementary root canals and root canal aberrations. A thorough knowledge of root canal anatomy and its variations, careful interpretation of the radiographs, close clinical inspection of floor of pulp chamber and proper modification of access opening are essential for a successful treatment outcome. Vertucci determined the incidence of type 2 canal in 4% of cases, type 4 in 24% of cases. This case series consist of three cases with anatomical variations in mandibular premolars with weine's Type II [Vertucci type 2], Type III [Vertucci type 4] and Type IV [Vertucci type 5] canal configurations.

### Abstract 325

#### SPMs: An ally against inflammation

**SONALI SAPRA**

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Use of lipid mediator as an anti-inflammatory agent is in

consideration for some time in medical science. From past few years its importance in dentistry has come forward. Lipid mediators or referred to as specialized pro-resolving lipid mediators (SPMs) are derived from Poly unsaturated fatty acids. SPMs are not actually anti inflammatory but they act by decreasing the neutrophil infiltration into inflamed tissue, inhibiting cytokine production and increasing bacterial phagocytosis. These include lipoxins, resolvins, protectins and maresins. Now why are we here, talking about these mediators so specifically. Well answer to this lies in the proverb "prevention is better than cure" by which I mean preventing, acute inflammation turning into chronic inflammation. It is better as acute inflammation can be reversed but once chronic inflammation appears it leads to the necrosis of the tissue, here pulpal tissue. For necrosis, the treatment modality is pulp extirpation which makes the tooth non vital and brittle which further has its own complications. SPMs not only help in resolving inflammation, but also as studies are being carried on, has shown that it has effect on pain control and bone regeneration too. Endodontics being the branch that is directly associated with the pulp tissue cannot ignore the benefits of SPMs. Though pulp tissue has its own defence system comprising of immunocompetent cells that help fight against the pathogens, but within certain limit. Early treatment of pulpitis with an agent that can restrict its complication can be a game changer. And for that purpose, this review paper focuses to analyse the involvement and potential of SPMs in endodontic therapies or in general.

### Abstract 326

#### Protective hood in dentistry

**DIKSHA GUPTA**

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The ongoing COVID-19 Pandemic, a disease caused by Coronavirus (SARS-CoV-2), has a strong impact on dental healthcare workers. There is high risk of professional contagiousness because of spread of this virus through aerosol and droplet contamination. Oral health care providers (Dentists, dental assistants) are in close proximity to patients' face during dental procedures, use of high-speed handpieces and ultrasonic scalers which produce aerosols of patients' blood and saliva. Also, these aerosols cause contamination of the environment, instruments and various surfaces. Thus, the importance of infection control in dental setup is crucial in limiting effects of virus diffusion. There was a major halt in the dental healthcare facilities provided to the public during the beginning of the pandemic and getting back to patient care is multifactorial. It includes proper patient triage, use of protective personal equipment and mitigating aerosol spread. A reasonable approach for fulfillment of this objective is creation of a physical barrier for protection. The methods already available are not enough and there has been an emerging use of Extraoral suction units which are high airflow vacuum systems intended to scavenge aerosols and droplets from the vicinity of the patient's mouth and trap them by depth filtration for safe disposal. This review paper describes one such device. It has a rigid translucent acrylic structure adjusted to dental chair covering the patients head, neck and chest. There is also a piping system to generate negative pressure for aspiration and filtering of air inside the chamber. The operator will

Abstract

be able to work through three holes provided in the chamber, at 9 to 3 O'clock position. The device is being used and tested by various professionals and has created a possibility for managing infection control during such unpredictable times.

### Abstract 327

#### Endodontic cryotherapy: The evolving pain relieving therapy

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The management and prevention of post-endodontic pain is an integral part with patients undergoing endodontic treatment. According to literature, prevalence of pain is estimated to be from 1.5% to 50% or more. Attempts to acquaint the patient with post-operative pain (PEP) and prescribing medications to control it can increase patient confidence in their dentists and ameliorate their attitude towards further dental treatment. According to previously published data root canal treatment (RCT) and pulp therapy, cause more severe and frequent postoperative pain when compared to other dental operative procedure. The utmost priority in such situations would be its management. Premedication with prophylactic antibiotic and analgesics prior to endodontic treatment, occlusal reduction, and administration of long-lasting anaesthesia, are some of the strategies which have been developed for post endodontic pain management. Felho et al. 2005 investigated the use of cryotherapy in the dental field in reducing pain, swelling, and trismus. In the field of endodontics, cryotherapy has been reported to be used after periradicular surgeries and during root canal treatment to minimize postoperative pain and inflammation. The word cryotherapy is originated from the Greek word cryos, meaning "cold." Cryotherapy has been reported to be effective at reducing oedema, pain, inflammation, and recovery time with short term applications in orthopaedic, abdominal, gynaecological and hernia operations. An ice pack, gel pack, ice chips, melted ice water, ice massage, prepackaged chemical ice pack, and ice in a washcloth are the modes of cold application. Clinical and physiological evidence suggests that a decrease in the conduction velocity of nerve signals, hemorrhage, edema, and local inflammation can be achieved by applying cold through various methods and is therefore effective in the reduction of musculoskeletal pain, muscular spasm, and connective tissue distension. In dentistry, after intraoral surgical procedures, the cold application has been frequently used for controlling postoperative pain. It has been reported that cryotherapy is a long-established therapeutic method for reducing inflammation, pain, and edema. Cryotherapy could be contemplated as an uncomplicated, harmless, and cost-effective therapy for controlling postoperative pain in single visit root canal treatment.

### Abstract 328

#### Auto irrigate: The continuous irrigant delivery and aspiration system

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Karnataka, India

**Aim:** To compare the delivery of irrigant to the apical third of root canals using a novel ingeniously designed continuous irrigation and intracanal aspiration system to manual dynamic agitation and passive ultrasonic activation.

**Materials and Methods:** Sixty-six freshly extracted single rooted teeth of similar dimensions with a single straight canal were selected and divided into three groups (n=22) based on the irrigation technique employed – manual dynamic activation (group 1), passive ultrasonic activation (group 2) and the continuous irrigation and intracanal aspiration system designed by the authors (group3). Access cavities were prepared. This was followed by working length estimation by inserting a #15 K-file to the root canal terminus observed under 3.5x magnification with loupes and subtracting 1 mm. Instrumentation was completed using ProTaper F2 rotary files at working length. Each group was irrigated with 2.5% NaOCl and saline, a prefinal rinse with EDTA and a final rinse with saline combined with the respective irrigation techniques. Apical delivery of irrigant for each group was evaluated by flooding the root canals with 1% toluidine blue dye for 30 seconds. The specimens were then decoronated and split vertically in a labiolingual direction using a diamond disc. These sections were visualised under a stereo microscope at 5x magnification and photographed. The digital images were analysed using ImageJ software to measure the unstained apical region. One-way ANOVA with Tukey's post-hoc test was used for statistical analysis of the results ( $p < 0.05$ ).

**Results:** The ingeniously devised irrigation delivery and intracanal aspiration system showed a significantly higher apical delivery of irrigant as compared to the other methods studied ( $p < 0.001$ ).

**Conclusion:** This simple root canal irrigating device can be made with materials readily available. Comparing the same to standard passive ultrasonic irrigation and the manual dynamic irrigation techniques showed better delivery of irrigants to the apical region. With further studies planned to evaluate smear layer removal and canal disinfection, we hope that this can serve as an efficient, cost effective novel device that can be easily incorporated into clinical practise.

### Abstract 329

#### A comparative evaluation of effect of four different methods of surface pretreatment on the push-out bond strength of glass fiber post – *In vitro* study

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Mumbai, Maharashtra, India

**Aim and Objectives:** Comparative evaluation of the Push-out bond strength of the glass fiber post when subjected to the following surface pretreatment using universal testing machine:

- Silane
- 9% Hydrofluoric acid
- Airborne-particle abrasion
- Titanium tetrafluoride

**Materials and Methodology:** 75 extracted, non-carious, single-rooted permanent human teeth will be decoronated, endodontically

Abstract

treated, post space prepared and divided into five groups (n = 15); according to the method of surface pretreatment applied on the post as follows:

Group 1: Silanization, a silane agent will be applied on the post & air dried for 60 seconds.

Group 2: Etching with 9% Hydrofluoric acid for 1 min

Group 3: Airborne-particle abrasion with Aluminium oxide particles.

Group 4: posts will be treated with TiF<sub>4</sub> (4 wt/v% for 4 min)

Each root will be sectioned to get slices of 2 ± 0.05mm thickness. Push-out tests will be performed using Universal Testing Machine by applying Load in apical-to-cervical direction at crosshead speed of 0.5 mm/min until failure.

**Results:** All the tested surface pre-treatments enhanced the bond strength between the post and the resin cement. It was observed that TiF<sub>4</sub> treatment gives comparatively higher bond strength.

### Abstract 330

#### Three-dimensional dynamic navigation system - digital dentistry's foray in guided endodontics

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In root canal treatment access cavity should be prepared minimally and kept as conservative as possible. However, there are some clinical situations that make the tooth conservation aim challenging. For example, Obliteration of the root canal system due to accelerated dentinogenesis and dystrophic calcifications can challenge the achievement of the treatment goals. A novel dynamic navigation method was therefore introduced to attain minimally invasive access cavity preparations and to evaluate its 3-dimensional (3D) accuracy in locating highly difficult simulated calcified canals. In endodontics, it was first introduced by Dr. Charles M. Dynamic Navigation facilitates real-time computer guidance technology using an imported CBCT dataset. Overhead tracking cameras relate the position of the patient's jaw and the clinician's bur in 3- dimensional space. Development of dedicated surgical navigation systems for endodontic surgery could facilitate the operator's maneuvers and reduce the risk of iatrogenic errors.

### Abstract 331

#### Laser activated irrigation: An innovative tool in modern endodontic practice

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Endodontics is a dental practice which has evolved over time without a pause. From using clove oil for sedation effect to using lasers and microscopes; we have come a long way. Lasers play a huge role in dentistry as they increase the efficiency, ease, specificity, cost effectiveness, and comfort of the treatment. There have been many recent advances in different steps of treatment, which have enhanced the quality of the treatment and given better results. In the field of endodontics, lasers have been used for a long time for the optimization of endodontic irrigation in particular. The laser-

activated irrigation (LAI) technique is based on the photomechanical effects of the lasers at low settings. They create a specific cavitation phenomenon and acoustic streaming in intracanal fluids. More recently, a new technique with a Er:YAG laser has been used with sub-ablative energy (20 mJ, 15 Hz) and ultra-short pulses (50 μs). This leads to intracanal cavitation and shockwaves as a result of photoacoustic and photomechanical effects. This phenomenon is called photon-induced photoacoustic streaming (PIPS). PIPS and Laser activated irrigation are described in the literature as a revolutionary and powerful method to activate the irrigant.

### Abstract 332

#### Effectiveness of diode laser in the treatment of endo-perio lesions: A clinical and microbiological study

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**Aim:** To evaluate the effectiveness of two different modes of Diode laser on reduction of bacterial load organized in biofilms in teeth with Endo-Perio lesion.

**Objective:** To evaluate the effectiveness of two different modes of Diode laser on reduction of colony forming units(CFU's) of anaerobic gram negative bacteria present in biofilm of teeth with Endo-Perio lesion.

**Materials:**

1. Saliva sample
2. Robertson's cooked meat medium
3. Blood Agar
4. Aerobic jar
5. Diode Laser

**Methods:**

Twenty samples of Endo-Perio lesions will be collected from the pockets with the help of paper points. After collection the samples will be transported in Robertson's Cooked meat medium to the microbiology lab within one hour of collection. The samples will be plated on blood Agar plates following which they would be loaded in the anaerobic jar. After this the CFU's will be calculated in each sample.

The specimens will be randomly divided into two experimental groups as follows:

Group I - Diode Laser used in a continuous mode on CFU's

Group II - Diode laser in a pulsed mode on CFU's

**Results:** Awaited.

**Conclusion:** Awaited.

### Abstract 333

#### Continuous soft chelation in root canal therapy: A review

**ARYA SINAI KHANDEPARKAR,  
IDA DE NORONHA DE ATAIDE, MARINA FERNANDES**

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The primary goals of root canal treatment are proper cleaning and shaping of the root canal system followed by three dimensional obturation of the canal space with an adequate apical seal. During

## Abstract

root canal preparation, a smear layer of dentin debris, including pulp remnants, bacteria and endotoxins forms on the canal walls. This smear layer prevents the sealer from penetrating the dentinal tubules, increasing the possibility of microleakage. Hence, complete debridement with smear layer removal is advantageous and may aid in the success of the root canal treatment. During root canal therapy, irrigating solutions and chelating agents are used to help remove the smear layer and improve sealer bonding. Although these solutions make root canal instrumentation easier, they also interfere with the chemical structure of dentin, altering the Calcium/Phosphorus ratio of the surface and affecting dentin microhardness, permeability, and solubility.

Ethylenediaminetetraacetic acid (EDTA), a mixture of tetracycline, acid, and detergent (MTAD) and maleic acid are commonly used chelating agents to remove the inorganic phase of smear layer. Etidronate, a new chelating agent has recently been introduced in Endodontics. Etidronate which is also known as Bisphosphonate, Etidronic acid or HEBP (1-Hydroxyethylidene-1, 1-Bisphosphonate) is non-toxic and has been systematically applied to treat bone diseases. It is a soft biocompatible chelating agent effective in smear layer removal with less detrimental erosive effects on root canal dentin, compared with other strong chelating agents like EDTA and citric acid. Etidronate can be mixed with Sodium Hypochlorite (NaOCl) without affecting its antimicrobial or dissolving activity, whereas EDTA retains its calcium-complex when mixed with Sodium Hypochlorite limiting its tissue dissolving capacity. This review paper discusses etidronate as a promising candidate for final irrigation of root canal and a potential replacement for conventional treatment with EDTA.

### Abstract 334

#### A review on photobiomodulation in endodontics

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PHOTOBIMODULATION THERAPY (PBMT) can have a significant role in reducing postoperative dental pain after endodontic treatment, increasing depth of anesthesia, improving tooth hypersensitivity, reducing inflammation of the tissue and helping wound healing in endodontic surgery, as an adjuvant in the Direct Pulp Capping (DPC) technique, reducing postoperative sensitivity after bleaching and also influence the outcome of regenerative endodontic procedures. The term "Photobiomodulation" (PBM), provides a more accurate interpretation of low-power treatments, because it includes a wide range of electromagnetic wavelengths such as broadband lights, LED and lasers. PBM can have both photostimulation and photoinhibitory effects on target tissues, each of which can be used in therapeutic applications. In the PBM technique (including low-level light/laser therapy and low-level laser irradiation), electromagnetic with visible wavelengths (380–700 nm) or near infrared region (700–1070 nm) are used, which have low absorption in water with 3–15mm depth of penetration in soft and hard tissue. Also, radiation power range of this group of treatments is between 250 and 500mW, or less than 250mW. The

basis of the PBM technique involves direct application of light energy with the ability of biological stimulation to cells of the body. Cellular photoreceptors, such as cyto-chromophores and pigments, can absorb this group of radiation and by transferring it to the mitochondria and affecting activity of cytochrome oxidase and the Krebs cycle, can also increase the production of adenosine triphosphate (ATP). Stimulation of ATP production leads to increased cellular activity. These changes affect macrophages, fibroblasts, endothelial cells, proliferation of mast cells, secretion rate of bradykinin, and neurotransmission. Thus, PBM therapy after endodontic treatment showed a significant decrease in prevalence of postoperative pain and may benefit patients who need endodontic treatment and also in endodontic surgery and regenerative endodontic procedures.

### Abstract 335

#### Nanoparticles in regenerative endodontics: A valuable asset

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Regenerative endodontics is one of the emerging treatment modalities in dentistry. Endodontic treatment for immature permanent teeth with pulp necrosis/apical periodontitis presents with a challenging clinical situation. The very basis of regenerative endodontics is the tissue engineering concept, which uses stem cells, scaffold, and growth factors to regenerate the pulp–dentin complex. These strategies aim to restore the form and function of a tooth by eliminating infection, promoting the development and closure of immature root apices and re-establishing pulpal vitality. Stem cell dimensions cannot be decreased to a nano size; however nano-based scaffolds and drugs can be applied in regenerative systems. Nanoparticles have been customised to develop various forms of scaffolds, which is a key component of regenerative endodontic therapies. Scaffolds are temporary structures that mimic the extra-cellular matrix to support the growth and differentiation of stem cells and aid the controlled release of drugs and bioactive molecules. They can also be combined with nano-carriers to allow multiple bioactive molecule releasing mechanisms. Nanoparticle-based carrier systems have been proposed as a method for the sustained release of bioactive molecules, which are a crucial component of regenerative endodontics as they modulate cellular activity, such as proliferation, migration and differentiation. As nanoparticles possess enhanced solubility, high surface-area-to-volume ratio and minute dimensions, nanoparticle-based carrier systems may improve the dissolution and absorption of bioactive molecules and drugs. Several nanoparticles like chitosan, bioactive glass, zinc oxide, silver and poly lactic-co-glycolic acid (PLGA) have been incorporated in various aspects of endodontic treatment including irrigation, as intra canal medicaments and in regenerative therapies. Nanoparticle applications show promise in the field of regenerative endodontics, such as supporting the release of bioactive molecules and enhancing the biophysical properties of scaffolds. Given the constantly growing research in this field, it is important to study the current evidence

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pertaining to the properties and clinical applications of various nanoparticles in regenerative endodontics.

**Abstract 336**

**Regenerative endodontics – Does it really sprout life in an immature open apex tooth?**

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The regenerative endodontics has garnered more and more popularity over the recent years. It involves complete regeneration of all original tissues to regain the tooth vitality along with root completion in non-vital immature tooth. It focuses on substituting traumatized and pathological pulp with normal functional pulp tissue. Regenerative endodontics provides hope but still fails to re-establish the original form of pulpal tissue and is known to provide variable results. Presently, many researchers are working to improve the quality and efficiency of the treatment. There are several problems associated with the technique of regenerative endodontics such as extraction, isolation and storage of dental pulp stem cells; handling and placement of scaffold into the canal and identification and positioning of growth factors in the canal. There are also problems associated with the technique of regeneration even after the completion of the treatment such as discoloration, extended duration of therapy, challenging histological outcomes, inadequate development of root, insufficient bleeding during revascularization process, root canal calcification and the unpredictable outcome of the treatment. There are certain loopholes in the existing treatment protocols that might sometimes result in undesired and unstable results. This scientific presentation describes the challenges faced by the endodontist while treating the patient and the final outcome with regards to the regenerative endodontic therapy.

**Abstract 337**

**Compendium of pain management in endodontics**

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Pain is one of the primary reasons for patients to seek dental treatment. Though the etiology of pain is multifactorial, the most frequently experienced dental pain is of endodontic origin. Odontogenic toothache is highly unpleasant and causes extreme anxiety for patients requiring endodontic therapy. Therefore, an effective approach to control pain in endodontics poses a significant challenge to the clinician. Pain management comprises of three phases. It begins with an accurate diagnosis, anxiety reduction and a comprehensive history. It is essential for an astute clinician to have a good knowledge about local anesthesia, the steps in endodontic treatment and clinical pharmacology for better pain management. The alternative methods include the use of low power lasers or photobiomodulation and cryotherapy mainly attributed to their painless and non-invasive function. This review highlights the current strategies for managing

pain before, during and after the endodontic treatment.

**Abstract 338**

**Effect of XP-endo Finisher and ultrasonic activation on the push-out bond strength of bioceramic based sealer to root dentin**

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**Aim:** To compare the effect of XP-endo Finisher (XP) and passive ultrasonic irrigation (PUI) on the push-out bond strength (POBS) of bioceramic based sealer (Cerafill, Prevest Denpro, India) to root dentin.

**Methodology:** Twenty four single canalled maxillary anterior teeth were selected and divided into two groups, Group 1- XP (n=12) and Group 2- PUI (n=12). Teeth were decoronated and root length standardized to 16 mm. To simulate a close ended system, the root apex of each tooth was sealed and then embedded in polyvinyl siloxane. All samples were prepared with Protaper Universal files and irrigated with 5.25% sodium hypochlorite & 17% EDTA. In Group 1, samples were subjected to XP at 800rpm for 1 min and in Group 2, samples were subjected to I SuperTip in EMS scaler for 1 min. Specimens were filled with Cerafill and stored in 100% humidity for two weeks. Each specimen was sectioned horizontally with a water-cooled diamond saw at depths of 4, 7 and 10 mm to produce slices approximately 1-mm thick from apical, middle and coronal thirds. The thickness of each slice was confirmed with a digital calliper. The POBS was performed with a universal testing machine at a crosshead speed of 0.5mm/minute from the apical to the coronal direction until bond failure occurred. This was done by applying a continuous load to the apical side of each slice using a 0.5-mm-diameter stainless steel cylindrical plunger for the apical thirds, 0.7-mm for the middle thirds and 0.8-mm for the coronal third slices. The bond strength in MPa was obtained after dividing the load at failure by the area of the bonded interface. Results were tabulated and subjected to post hoc Tukey analysis.

**Results:** POBS of Cerafill to root dentin of Group 1 was significantly more than that of Group 2 ( $p \leq 0.05$ ) at all three levels. In group 1, POBS was significantly more at 4mm compared to 7mm and 10mm ( $p \leq 0.05$ ).

**Conclusion:** Use of XP-endo Finisher after biomechanical preparation improves the POBS of bioceramic based sealer to root dentin.

**Abstract 339**

**A comparative evaluation of the effect of various chelating agents on the microhardness of root canal dentin: An *in vitro* study**

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**Aim:** To compare and evaluate the effect of various chelating agents on the microhardness of root canal dentin.

**Materials and Methods:** Eighteen freshly extracted single rooted mandibular premolars were selected and divided into 3 groups (n=6). Teeth were decoronated at the cemento-enamel junction. The root

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canals were prepared upto file F3 (ProTaper Universal, Dentsply) and were irrigated using 2 ml of 3% sodium hypochlorite after each instrument. Teeth were sectioned longitudinally into buccal and lingual halves and mounted in acrylic resin blocks while exposing the dentin surface. One half of each tooth served as a control. The test solutions, i.e., 17% liquid Ethylenediaminetetraacetate (EDTA), 10% Citric Acid (CA) and 9% 1-hydroxyethylidene-1,1-bisphosphonate (HEBP) or etidronate were delivered using an open vented needle to cover the entire root canal for 5 minutes. Dentin microhardness was measured with a Vickers indenter at 1000 $\mu$ m, 1200 $\mu$ m, 1400 $\mu$ m from root canal orifice and 100 $\mu$ m from pulp-dentin junction under a load of 50 g and 15 seconds dwell time. Data was analysed statistically by one way ANOVA, post hoc tukey and independent t test at  $p \leq 0.05$ .

**Results:** At 1000 $\mu$ m distance from root canal orifice, highest microhardness was seen in HEBP group followed by CA and least microhardness was seen in EDTA group. Difference in microhardness at 1000 $\mu$ m among three chelating agents was significant. At 1200 $\mu$ m distance from root canal orifice, highest microhardness was seen in HEBP group followed by CA and least microhardness was seen in EDTA group. Difference in microhardness at 1200 $\mu$ m among three chelating agents was significant. At 1400 $\mu$ m distance from root canal orifice, highest microhardness was seen in HEBP group followed by CA and least microhardness was seen in EDTA group. Difference in microhardness at 1400 $\mu$ m among three chelating agents was significant ( $p \leq 0.05$ ).

**Conclusion:** All chelating agents which were tested reduced the microhardness of the root canal dentin. HEBP caused the least reduction in microhardness, whereas, EDTA reduced microhardness the most followed by CA.

#### Abstract 340

#### Comparative evaluation of push out bond strength of polyetheretherketone and glass fibre posts cemented with different luting cements: An *in-vitro* study

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**Aim:** To Compare and evaluate push out bond strength of Polyetheretherketone (PEEK) and Glass fibre posts cemented with different luting cements-An *in-vitro* study.

**Materials and Methodology:** Eighty extracted, non carious single-rooted permanent human teeth were decoronated, endodontically treated, post space prepared and divided into four groups ( $n = 20$ ); Group I: FRC postec plus post (Ivoclar Vivadent) and RelyX U200 (3M ESPE), Group II: FRC postec plus post (Ivoclar Vivadent) and Variolink N (Ivoclar Vivadent), Group III: PEEK post and RelyX U200 (3M ESPE) and Group IV: PEEK post and Variolink N (Ivoclar Vivadent). Each root was sectioned to get slices of  $2 \pm 0.05$ -mm thickness. Push-out tests were performed using a Universal Testing Machine by applying the Load in an apical-to-cervical direction at a crosshead speed of 0.5 mm/min until failure.

**Results:** Polyetheretherketone (PEEK) showed to have better bond strength than glass fibre post and better bond strength when luted with Variolink N than RELY X U200.

#### Abstract 341

#### To compare the radiographic and clinical outcomes of permanent teeth with open apex, necrotic pulp and periapical lesion with resorption using different regenerative endodontic procedures

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**Aim:** To compare the radiographic and clinical outcomes of permanent teeth with open apex, necrotic pulp and periapical lesion with resorption using different regenerative endodontic procedures.

**Materials and Methods:** 48 cases of permanent single rooted teeth with open apex, necrotic pulp and periapical lesion with resorption were selected and divided into 4 groups: Group I- Blood clot, Group II- Platelet rich plasma, Group III- Platelet rich fibrin, Group IV- Blood clot along with collagen scaffold. In first appointment: Under local anesthesia (if necessary), rubber dam isolation followed by access cavity was prepared. Irrigation with 1.5% NaOCl (20mL/canal, 5 min) followed by saline (20 mL/canal, 5 min) using closed end side-vent needle was done after minimal preparation. Canals were dried with paper points and ledermix paste was placed in the canal. In second appointment (one to four weeks after first visit), If there were signs/symptoms of persistent infection, additional treatment with antimicrobial was considered. Anesthesia without vasoconstrictor, dental dam isolation, copious irrigation with 20 mL of 17% EDTA was done. Canals were dried. Scaffolds were then placed according to the assigned group: Group I: Bleeding was created by over-instrumentation induced by rotating K-file at 2 mm past the apical foramen, Group II: 5ml venous blood was mixed with citrate dextrose phosphate and centrifuged, Group III: 5ml blood was centrifuged without an anticoagulant, Group IV: collagen fibres were added in blood clot scaffold. Follow up of the patient was done at 3, 6, 9, 12 months. The clinical findings were assessed on the basis of symptoms such as percussion/palpation, resolution of sinus tract and swelling. The radiographic examination was evaluated for an increase in root length, decrease in apical diameter, increase in root thickness, periapical healing.

**Results:** PRF showed better result with respect to resolution of clinical symptoms, periapical healing, apical closure, increase in root length and thickness than other above-mentioned scaffolds.

**Conclusion:** Platelet rich fibrin (PRF) was found to be better in successful treatment of permanent teeth with open apex, necrotic pulp and periapical lesion with resorption.

#### Abstract 342

#### Endodontic management of immature open apex with mineral trioxide aggregate and biodentine: A case report

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The completion of root development and closure of the apex happens up to three years after eruption. Causes of an open apex are necrosis of pulp due to caries / trauma before completion of root formation,

Abstract

extensive root end resorption, iatrogenic enlargement of the apex and root end resection during periapical surgery. Teeth with open apices continue to be a challenge for endodontists because obtaining a complete seal of the root canal system is difficult and extravasation of irrigating solutions/ sealer into the periradicular tissues can occur. Therefore, various techniques have been described for safe root canal filling of immature necrotic teeth such as apexification and revascularisation. In single step apexification with MTA/ Biodentine, number of patients' visits and total time taken for an apical barrier to form is less when compared with multiple step apexification with calcium hydroxide. This case report describes a split mouth technique of apexification with MTA and Biodentine in a patient who reported with large periapical lesions in the maxillary left and right quadrants.

### Abstract 343

#### Efficacy of single dose of diclofenac transdermal patch as a postoperative analgesic after single visit root canal treatment

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**Aim:** To evaluate the efficacy of single dose of Diclofenac Transdermal Patch as a Post-Operative analgesic after single visit root canal treatment.

**Materials and Methods:** 400 patients with symptomatic irreversible pulpitis were divided into 2 groups, i.e., control and test group (n=200) and single visit root canal treatment procedure was performed in both the groups. The control group (Group 1) was not given any medication whereas the test group patients (Group 2) were administered a transdermal diclofenac patch on the arm. The post-operative pain in both the groups was assessed at baseline, 4, 8, 24 and 48 hours after the treatment using VAS scale.

**Results:** In test group (Group 2) 167 patients out of 200 reported decrease in intensity of pain as compared to only 27 patients in control group (Group 1). Also, 173 patients of Group 1 had to take oral analgesic to relieve the post-endodontic pain. Inter group difference at different intervals was compared using Mann Whitney U Test.

**Conclusion:** Diclofenac transdermal patch was effective in allaying the post-endodontic pain experienced by the patients after single-visit root canal treatment up to 48 hours. It was easy to use with painless application mechanism and caused no significant systemic adverse effects.

### Abstract 344

#### Effectiveness of intracanal cryotherapy using different irrigants on reduction of post endodontic pain: A systematic review and meta analysis

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**Introduction:** Recently the non-pharmacological management of post endodontic pain has been extensively studied. The aim of this

systematic review was to evaluate the effectiveness of intracanal cryotherapy in reducing postoperative endodontic pain.

**Methods:** A comprehensive search was conducted by accessing electronic databases like PubMed, Google Scholar, Google and EBSCO. Articles evaluating the effect of intracanal cryotherapy in reducing postoperative pain using different irrigating agents which were published till November 2020 were included in the study. Risk of bias was assessed using the Cochrane risk of bias criteria. Meta-analysis was performed for ten studies and tested the heterogeneity using I<sup>2</sup> index.

**Results:** Qualitative and quantitative analysis was done for thirteen and ten studies respectively. Intracanal cryotherapy was found to be effective in reducing post-operative pain at 6 hours and 24 hours.

**Conclusion:** Within the limitations of the study, it can be concluded that intracanal cryotherapy using cold saline or 17% EDTA at a temperature range of 2.5°C to 6°C as final irrigating agent helps in reducing postoperative pain at 6 hrs and 24 hrs following single-visit or multi visit root canal treatment in teeth diagnosed with irreversible pulpitis with apical periodontitis.

### Abstract 345

#### Management of an intracanal separated instrument in a case of radix entomolaris

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Radix Entomolaris (RE) is one of the anatomical variant found in a permanent mandibular molar and was first described by Carabelli. It is characterized by the presence of an additional or extra third root, which is typically found disto-lingually. Radix Entomolaris can be found in the first, second, and third mandibular molars, occurring the least frequently in the second molar. As like any other tooth in the oral cavity, mandibular first molar is also prone for malformations and anomalies in its development. Mandibular first molars normally have two roots, the mesial and the distal ones. The major variant is the occurrence of a third root, which is often reported in the literature. If this additional root is located mesiobuccally, it is called radix paramolaris and if located distolingually, it is called Radix Entomolaris (RE). The frequency of RE in Caucasians and Africans is <5%, whereas in populations with Mongoloid traits (like Chinese, Inuit, and Native Americans), it occurs with a frequency that ranges from 5% to > 30%. In these populations, it is considered to be a normal morphological variant and can be seen as an Asiatic trait. Otherwise, Radix Paramolaris is very rare and occurs with a prevalence of < 0.5%. The presence of this extra root may lead to missed canal, instrument separation due to severe curvature, aberrations in cleaning and shaping while doing endodontic therapy, and so on. Thus, a very accurate clinical and radiographic diagnostic procedures and meticulous canal preparations are necessary. In the following case report, the endodontic treatment of mandibular first molars with RE and clinical guidelines for successful management are explained.

### Abstract 346

#### One step apexification with biodentine: A case report

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Open apices are a constant challenge to an endodontist. The one-step apexification technique in which an apical barrier is placed to achieve an adequate apical stop has become a popular procedure nowadays. With traditional means, induction of an apical barrier, regardless of the material used, takes at least 3–4 months and requires multiple appointments. Patient's compliance with this regimen may be poor and they may fail to return for scheduled visits. Even the temporary seal may fail resulting in reinfection and prolongation or failure of treatment. For all these reasons, one-visit apexification has been suggested. Some traditional treatment options have stood the test of time and are still valid until today. Others have been reviewed and modified with the passage of time, as new science and new materials evolve to prove, disprove, or facilitate approaches to the management of these cases. Practitioners always need to be aware of changes that occur from time to time with respect to these recommendations for treatment, and of scientific studies that support or disprove treatment rationales. Novel biocompatible materials such as MTA and BIODENTINE are a boon in effective management of teeth with open apices. This case report describes single visit apexification in maxillary central incisor with necrotic pulp and open apex using Biodentine as an apical barrier with two years follow up.

### Abstract 347

#### Efficacy of low level laser therapy in the management of post endodontic pain: A systematic review

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India

**Objectives:** The aim of this systematic review is to evaluate the effectiveness of postoperative pain reduction of low level laser therapy for Root canal treatment, Root canal retreatment or endodontic surgery.

**Materials and Methods:** The PICOS strategy was used to identify randomized clinical trials comparing low-level laser therapy and mock laser therapy to manage postoperative pain after endodontic treatment, retreatment, and endodontic surgery. An electronic search was performed in MEDLINE through PubMed, Web of Science, Scopus and Cochrane Library and Google Scholar. Quality assessment was performed using the Cochrane Collaboration's tool for assessing the risk of bias. The quality of evidence was rated on the basis of the GRADE approach.

**Results:** Within the 12 studies seven studies were classified as "low risk of bias." Four studies were considered "unclear risk of bias" because of a lack of information for judgment. One study was considered "high risk of bias" due to the lack of blinding of the patients participating in the study. One study also presented "high risk" in "other bias" because of the significant difference in the

number of participants in each group (41 patients in the laser group and 20 patients in mock laser group). Most of the studies reported significantly less postoperative pain after LLLT in different time periods; two studies found no differences. The certainty of evidence was classified as low and very low to treatment / retreatment and endodontic surgery, respectively.

**Conclusions:** In view of the present literature, the use of LLLT for pain control in post endodontic therapy showed good results and looks promising. The lack of standardization in laser parameters, use of medications and the low certainty of evidence indicate the need for further studies. More high-quality randomized controlled trials are needed.

### Abstract 348

#### Regenerate to recreate: Novel scaffolding patterns

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Root canal therapy has enabled us to save numerous teeth over the years. The most desired outcome of endodontic treatment would be when diseased or non-vital pulp is replaced with healthy pulp tissue that would revitalise the teeth through regenerative endodontics. This approach has generated enormous interest in tissue engineering principles to regenerate the pulp-dentin complex, thereby permitting root development. The American Association of Endodontists Glossary of Endodontic Terms defines Regenerative Endodontics as "biologically based procedures designed to physiologically replace damaged tooth structures, including dentin and root structures, as well as cells of the pulp-dentin complex." The triad of tissue engineering consists of Stem cells, a Scaffold of the extracellular matrix and Growth factors acting as signals for morphogenesis. Scaffolds are the biomaterials that act as carriers for specific cell-type guide and support tissue regeneration. Natural scaffolds including collagen, chitosan, silk, and fibrin, as well as synthetic scaffolds like polyglycolide and polyglycerol sebacate, have been frequently utilised for Regenerative treatments. The use of growth factors and injectable biomaterial scaffolds has improved dental tissue engineering and hastened clinical translation. The absence of an adequate vascularised scaffold to facilitate the development of massive tissue constructions is one of the most prevalent issues with scaffolds. The 3-dimensional (3-D) cell-printing technology allows for precise cell groupings and the creation of tissue constructs that mimics the natural tooth pulp. Utilising this technology, extracellular matrix-like scaffold can be produced with finer details at a micrometer level. Pulp tissues can be supplied to the action site as a 3-D matrix using an injectable scaffold delivery method. Patients and dentists should benefit from employing scaffolds, tissue engineering and growth factors to improve the success of regenerative endodontic procedures. Hence this review highlights recent advances in scaffolds.

### Abstract 349

#### Biomimetic synthesis of silver nanoparticles using plant extract, characterisation and it's recent applications

**P APARNA**

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Nanotechnology is a significant rising domain of research. With novel features and properties of nanoparticles, their essential applications are growing on diverse fronts like biomedical, pharmaceutical, drug delivery, etc. Nanoparticles have significant antibacterial performance due to their enormous surface area to volume ratio. Scientists are hoping to overcome the challenges of microbial resistance, with the antimicrobial effect of nanoparticles. Recently Ecobenevolent approaches are becoming more popular as part of green chemistry, where the researchers are becoming more sensible about diverse ecological issues. Silver oxide nanoparticles have been used for various applications including antioxidant, cytotoxic activity, photocatalytic, antibacterial, antifungal agents, etc. The green synthesis of silver oxide nanoparticles has been investigated using plant tissues, bacteria, etc. Various natural bio-compounds in plant broths, such as flavonoids, proteins, and phenols can work as both reducing and/or stabilizing agents for the fabrication of silver oxide nanoparticles. Biomimetic syntheses of silver oxide nanoparticles provide an alternative to the conventional method involving complex chemical reactions. Here, the broth of the plant is simply blended with the water solution of the silver metal salt precursor at normal room temperature. Studies have proved significant antimicrobial performance and photocatalytic activity of such particles. Characterization techniques provide information about the stability, size, shape, surface charge, elemental composition, purity, crystallinity, surface area, and magnetic behavior of the nanoparticles. This article discusses the recent developments for the preparation of the silver oxide nanoparticles using few plant broths and their efficacious applications.

**Abstract 350**

**Biodentin as retrograde filling material in periapical surgery using cone beam computed tomography: A case report**

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This paper reports a case of a periapical cyst treated with enucleation of the lesion, apicoectomy, and root end obturation on a lower left central incisor. The authors have performed root-end resection and root end cavity is prepared using ultrasonic tip under local anesthesia on a lower left central incisor; The root canal filling is placed within the new cavity using biodentine to close the path of communication between the infected root canal system and periradicular structures with an intermediate restorative material. Bony socket is filled with PRF and Bonegraft. The lesion was fully enucleated and sent for histopathology. The 26-year-old male patient was followed up at 2 weeks, 3, 6 and 12 months using CBCT presenting as a functional and symptomless tooth. Radiographic findings showed a clear and progressive refilling of the cavity with bone. All these factors highlight a positive prognosis for the tooth after periradicular surgery, which is now considered a valid treatment to keep the tooth as a functional unit in the oral cavity.

**Abstract 351**

**Extricating the intricacies of “C” shaped canal**

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Root canal system often presents with anatomic variations, one of the most important amongst them being “C” configuration which was first documented by Cooke and Cox in 1979. “C” configuration often presents with complex anatomy with irregular areas housing infected tissue remnants and debris thus requiring supplementary effort to accomplish proper root canal treatment. This morphology is uncommon hence a proper diagnosis accomplished with radiographic and clinical aids is mandatory. It can assume many variations hence a comprehensive classification can help in its effective management. The essence of successful endodontics lies in knowledge, respect and appreciation of root canal anatomy and careful, thoughtful and meticulously performed cleaning and shaping procedure. Alternate disinfection techniques with improved irrigant volume and activation using sonics and ultrasonics is recommended to improve cleansability of root canal system. C configuration is known for its challenges in instrumentation and obturation that advocates the application of modified techniques. This paper highlights a case series of three different types of C shaped canals that was effectively and successfully managed in the clinical practice.

**Abstract 352**

**Regenerative capacity of resolvin D2 on stem cells of apical papilla and a novel combination of resolvin D2 and calcium hydroxide as an intracanal medicament**

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**Introduction and Aim:** Resolvins are lipid mediators that are released during the resolution phase of inflammation to regulate tissue repair. Previous literature has also identified their antimicrobial potential. The present study was conducted with the aim to evaluate whether resolvin D2 (RvD2) is capable of inducing hard tissue formation by its action on stem cells of apical papilla in comparison to concentrated growth factor (CGF). It was also aimed at evaluating if the combination of RvD2 and calcium hydroxide has any synergistic antimicrobial effect.

**Materials and Methods:** The root apical papilla tissues were carefully isolated from the root apex. Enzymatic separation was used for the cells of the primary apical papilla. The cells were subjected to the three groups namely RvD2, CGF and a combination of CGF and RvD2. Mineralized nodule formation was analyzed by alizarin red staining and dentin matrix protein 1 secretion was analyzed using ELISA test. The antimicrobial efficacy was evaluated using the agar diffusion test by determining the zone of inhibition. MIC was defined as the minimum concentration of extract that caused 80% inhibition in growth of test microorganism.

**Results:** The combination of RvD2 and CGF had the highest values for mineralized nodule formation and DMP1 secretion followed by CGF. These were statistically more significant than the control group.

## Abstract

However the results for RvD2 alone did not exceed that of CGF. The maximum zone of inhibition was seen around the disc impregnated with a combination of RvD2 and calcium hydroxide ( $15.4 \pm 0.98\text{mm}$ ) which was highly significant. The MIC value of RvD2 was  $1.5 \mu\text{g/ml}$  and the MBC value was  $2.0 \mu\text{g/ml}$ .

**Conclusion:** Although RvD2 possesses regenerative potential and is capable of inducing stem cells of apical papilla for formation of mineralized hard tissue, its potential by itself does not surpass that of CGF. However the combination could be a promising new strategy in the management of immature necrotic permanent teeth with the additional antimicrobial potential of RvD2.

### Abstract 353

#### Knowledge about management of avulsed teeth among dental professionals in Kerala

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Government Dental College, Thiruvananthapuram, Kerala, India

**Aim:** To assess the level of knowledge about the management of avulsed teeth, based on the latest IADT guidelines, among dental professionals in Kerala.

**Materials and Methods:** A total of 336 dental professionals were sent a questionnaire through email or WhatsApp. The questionnaire based on IADT guidelines 2020 was divided into 4 parts. Part I inquired about personal Information; Part II assessed previous knowledge and experience with dental avulsion whereas Part III and part IV evaluated knowledge on emergency and clinical management of dental avulsion respectively. The questions in part III and part IV were assigned 1 point each for correct answers and 0 points for wrong answers. The maximum possible score was 18 which was graded as poor, satisfactory, good and excellent knowledge. The survey data obtained were analysed using Chi square test and Kruskal Wallis test. The level of significance was set at  $P < 0.05$ .

**Results:** The questionnaires were answered by a total of 336 dental professionals including 244 specialists. Only 56 participants were aware of IADT guidelines 2020. More than half of the dental professionals had only satisfactory knowledge (59.5%). 43.9% specialists had good knowledge while 78.3% of general practitioners had only satisfactory knowledge. Among the specialists, 57.6% and 12.1% of pedodontists had good and excellent knowledge respectively, while 48.3% endodontists had good but 41.6% had only satisfactory knowledge. Even though there was no significant difference in knowledge score among different specialties in emergency management; there was significant difference in clinical management. Majority of dental professionals who have not treated any avulsion cases had only satisfactory knowledge (70.5%) but no significant pattern was observed with more number of cases treated.

**Conclusion:** Although dentists are supposed to have an advanced level of knowledge, it is found to be only satisfactory. Guidelines for managing tooth avulsion promotes appropriate treatment and is regularly updated, but dentists are not often refreshing their knowledge; only 16% were aware of recent guidelines. Efforts should be focused on how information should be provided to them because

an incorrect intervention is an irreversible decision.

### Abstract 354

#### Evaluation of rotary retreatment file system for removal of gutta percha: A volumetric analysis: An ex-vivo study

**PALLABI SARKAR**

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**Aim:** To evaluate three different rotary retreatment system in removal of gutta percha by analyzing the residual volume of root canal filling material using three dimensional imaging modality i.e. Cone Beam Computed Tomography. The three file systems used were:

- 1) Hyflex Remover (Coltene)
- 2) R-Endo (Micromega)
- 3) Neoniti (Neolix)

**Materials and Methods:** 60 Freshly Extracted Human Permanent Mandibular First Premolars were collected. Roots were decoronated and standardized using diamond disc to the length of 16mm. Working length was radiographically determined and root canal was biomechanically prepared using K hand files by step back technique. The obturation of canals were done using no. 35 (2%) gutta percha cone with AH plus sealer using lateral condensation technique. Coronal access was sealed with temporary filling material. CBCT evaluation of gutta-percha volume in the canal was done. Retreatment procedure was done on the teeth using three different comparison groups of rotary retreatment systems where Group 1 was prepared with Hyflex Remover, Group 2 was prepared with R-Endo and Group 3 was prepared with Neoniti file system. CBCT images after retreatment was taken to evaluate percentage of volume of residual filling material. After completion of the study all the data were collected and subjected to statistical analysis.

**Results:** Hyflex remover was more efficient in removing gutta percha and had less residual gutta percha volume than the two file systems followed by R-endo and Neoniti.

**Conclusion:** It was concluded that Hyflex remover was better at removing gutta percha than R-Endo and Neoniti System. However larger sample size along with clinical trials is necessary to validate the results of present study.

### Abstract 355

#### Comparative evaluation of the fracture resistance of the three different recent composite systems in class 2 mesio-occlusal distal cavities: An in-vitro study

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**Objective:** To compare the fracture resistance of the three different recent composite systems in class 2 MOD cavities.

**Materials and Methods:** 36 human permanent posterior teeth were collected. Standardized MOD cavities were prepared using a tungsten carbide straight fissure bur in high-speed water-cooled hand piece, burs were changed after every 10 cavity preparations. Dimensions of cavities was  $2 \text{ mm} \pm 0.2 \text{ mm}$  pulpal width,  $1.5 \text{ mm}$

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$\pm 0.2$  mm gingival width, and  $2 \text{ mm} \pm 0.2$  mm buccolingual width and were verified using periodontal probe. Facial and lingual walls of the occlusal segment was prepared parallel to each other with the cavosurface angle at  $90^\circ$ . Teeth were mounted in square blocks of cold cure acrylic resin. Prepared cavities were etched for 10s then cavities were rinsed for 30s and air dried. Bonding agent was applied and cured for 20s. Teeth were then randomly divided into three groups ( $n=9$ ). Group 1 is the positive control. In Group 2 teeth were restored with omnichroma universal resin based dental restorative. In Group 3 teeth were restored with Wonder Bulk flow posterior composite. In Group 4 teeth were restored with fiber reinforced composite GC Ever X posterior. Thermocycling was carried out. The fracture resistance of the teeth was measured using universal testing machine.

**Results:** Highest fracture resistance was seen in Wonder Bulk Flow material followed by Ever-X posterior. Least fracture resistance was seen in Omnichroma material and difference in fracture resistance among three groups was significant ( $p=0.018$ ).

**Conclusion:** Within the limitation of this in vitro study, it can be concluded that Wonder bulk flow composite showed the highest fracture resistance followed by Ever X posterior and least in Omnichroma.

### Abstract 356

#### Artificial intelligence in endodontics

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The goal of endodontic treatment is to provide excellent treatment. To achieve this target, accuracy in diagnosis and clinical decision-making plays an important role. Artificial intelligence, a recent technology imbibed in dentistry uses technology that can replicate human cognitive skills such as problem solving. Artificial intelligence is mostly made up of neural networks that are similar to those found in the human brain. Locating the apical foramen, identifying periapical diseases, detecting and diagnosing vertical root fractures, retreatment predictions, and assessing root morphologies can all be assessed with artificial intelligence. Dental surgeons should be able to forecast prognosis, which necessitates the use of precise clinical decision-making skills. Dentists, on the other hand, don't always have the information to make the best clinical judgement in a short period of time therefore artificial intelligence software can assist them in making better judgments and doing better tasks. This article reviews the use of artificial intelligence in endodontics and to understand its implications.

### Abstract 357

#### Tooth restorability index

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The tooth restorability index (TRI) has been designed to describe on a clinical level, the 'practicality' of dental restorative treatment. It provides a framework for evaluating teeth and planning treatment. The TRI, which can be used in regular clinical practice, intends to

help clinicians decide when to seek guidance and/or refer a patient to secondary or tertiary dental treatment. This tool is expected to aid in the systematic assessment of dental restorative difficulties, improve communication amongst collaborating practitioners, and help manage patient expectations before restorative treatments are performed. In dental practice, restoring teeth with substantial structural damage is a crucial clinical treatment. Despite the fact that a range of materials, techniques, and research are available in the scientific literature, the criteria for selecting such teeth for restoration remain unclear. If restoration is indicated, it must conserve and protect the remaining tooth structure. The approach to severely compromised teeth should be based on consistent scientific evidence to reduce dental error and improve the prognosis. Clearly, further research is required to establish the clinical usefulness of the proposed index and to clarify the relationship between the TRI scores and subsequent restorative outcomes.

### Abstract 358

#### Apical fenestrations: The hidden piece of post endodontic pain

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After a successful endodontic treatment, a patient may return with a complaint of persistent pain particularly on mastication and palpation. After ruling out all the possibilities of post endodontic pain, it is at this time that a clinician may consider the possibility of an apical fenestration with concurrent endodontic pathology. Apical fenestration is an isolated area in which the root is denuded of bone and root surface is covered only by periosteum and overlying gingiva. When the denuded area extends through the marginal bone, the defect is called dehiscence. Fenestrations are seen more commonly in the maxilla and in particular on the buccal aspect of the alveolar bone. It can be because of reasons like buccally inclined roots, thin cortical alveolar bone, chronic periapical inflammation with bone destruction, tooth malposition and orthodontic movement. Although presence of fenestrations does not necessitate treatment, the quantum and magnitude of clinical implications can be avoided in cases of its association with endodontic infections. There are a variety of clinical signs and symptoms that can be seen in patients with apical fenestrations associated with endodontic pathologies; some of them being - traumatic dental injuries, aesthetic concerns, gingival defects or discomfort while some of them may even be asymptomatic. Due to the uncommon association between the two, misdiagnosis and overlooking is a common occurrence. To prevent such situations and to achieve a successful management, a thorough understanding of the lesions and timely diagnosis is pertinent. Because of the variety in clinical signs and symptoms cone-beam computed tomography is adapted as an important tool for diagnosis. The correct approach for the successful management of the lesion should be eradication and controlling of the focus of infection. Nonsurgical root canal treatment is first needed to disinfect and seal the root canal system, whilst subsequent surgical treatment by root-end resection coupled with root debridement of the exposed surface is often necessary to manage an apical fenestration with concurrent endodontic pathosis.

### Abstract 359

#### Comparative evaluation of effect of various endodontic irrigants on the push out bond strength of mineral trioxide aggregate plus, biodentine, endosequence and theracal IC: An *in vitro* study

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**Aim:** The purpose of the study is to compare the push out bond strength of MTA Plus, Biodentine, Endosequence and Theracal LC in the presence of 2.5% NaOCl, 2%CHX using Universal Testing Machine.

**Materials and Methods:** Midroot dentin of single-rooted mandibular premolar teeth were sectioned into 2-mm-thick slices horizontally. The canal space of each dentin slice was enlarged with a 1.4-mm-diameter diamond bur. The samples were divided into four groups based on the type of perforation repair material placed, ie. MTA Plus, Biodentine, Endosequence, Theracal LC. The samples were wrapped in wet gauge for 10 min, each group is further divided into three subgroups, to be immersed into 2.5% NaOCl, 2% CHX respectively, for 30 minutes, rinsed with distilled water, and allowed to set for 48 hours at 37C with 100% humidity in an incubator. As a control group, a wet cotton pellet will be placed over each test material without any irrigation. The dislodgement resistance of the samples was measured using a Universal Testing Machine. Outcome variable will be measured in megapascal(MPa) for each group. One specimen from each group will be randomly chosen for stereomicroscope examination at 25x magnification.

**Statistical Analysis:** Descriptive statistics such as mean and standard deviation will be used for summarizing the collected raw data. Inferential statistics such as Anova and Duncan's test will be used for comparison of various groups based on pushout bond strength.

**Results:** EndoSequence proved to have the highest push-out bond strength followed by Biodentine, MTA Plus and Theracal LC. In subgroups, 2% CHX increased the push-out bond strength of Endosequence. Biodentine and Theracal LC demonstrated more push-out bond strength with NaOCl when compared to CHX. While analyzing the failure pattern of the samples, MTA Plus groups have adhesive failures, Theracal LC have mixed failures. But cohesive failure mode was found to be present in maximum number in both Endosequence and Biodentine groups predominantly.

**Conclusion:** Pushout bond strength of EndoSequence was found to be significantly higher than Biodentine, MTA Plus and Theracal LC. Endodontic irrigants influence the resistance to dislodgement of EndoSequence, Biodentine, MTA Plus and Theracal LC.

### Abstract 360

#### Prions in endodontics

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Prion diseases, also known as transmissible spongiform encephalopathies (TSEs), are degenerative disorders of the

nervous system caused by transmissible particles that contain a pathogenic isoform of the prion protein a normal constituent of cell membranes. Stanley B. Prusiner discovered and defined prions as infectious, transmissible proteinaceous particles that lack nucleic acid and are composed exclusively of a modified isoform of the noninfectious cellular prion protein (PrPc). Prion diseases are incurable neurodegenerative conditions affecting both animals and humans. They may be sporadic, infectious, or inherited in origin. Human prion diseases include Creutzfeldt–Jakob disease (CJD), Gerstmann–Straussler–Scheinker disease, Kuru, and Fatal familial insomnia. Periodontal and pulpal tissue exposed by disease or trauma might represent a clinically relevant entry point for prions incorporated orally and thus a possible mode of infection. The unique resistance of prions to classic decontamination methods and evidence that prion diseases can be transmitted iatrogenically by medical devices pose a serious infection control challenge to health care facilities. Because of the widespread tissue distribution of the variant Creutzfeldt–Jakob disease agent in human beings, new practicable decontamination procedures are urgently needed. Decontamination of instruments is a prerequisite for their potential reuse but may affect surface integrity. Despite meticulous cleaning under laboratory conditions, all solutions used could not completely clean rotary instruments of organic debris. Significant corrosion was observed with NaOCl immersion. Therefore, the single use of rotary instruments is recommended to prevent the transmission of infectious diseases and reduce the hazard of corrosion.

### Abstract 361

#### A comparative evaluation of incidence of crack formation and microleakage in the resected root end of single rooted teeth with and without retropreparation: An *in vitro* study

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**Aim:** To evaluate and compare the incidence of crack formation and microleakage in the resected root end of single rooted teeth with and without retropreparation using stereomicroscope and spectrophotometer respectively.

**Materials and Methods:** 30 human maxillary and mandibular single rooted premolars with single canal were selected. Teeth were decoronated at cementoenamel junction and working length was determined. Cleaning, shaping and irrigation was done. Teeth were divided into 2 groups with 15 samples each. In group 1, teeth were apically filled with MTA upto 6mm and backfilled with thermoplasticized gutta percha and AH plus sealer and 3mm of the root was resected at the apex. In group 2, teeth were obturated with thermoplasticized gutta percha and AH plus sealer. Apical 3mm of teeth was resected. Retrograde preparation was done to a depth of 3mm and Root-end cavity was restored with MTA. All the samples were examined under stereomicroscope for cracks at a magnification of 30x. Samples were stored in 100% relative humidity for 24hours (h). Samples were coated with nail varnish leaving apical 3mm. After varnish is dried, each group was placed in separate Petri dish containing

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rhodamine B dye. All samples were stored for 48 h. Teeth were rinsed under tap water for 30 minutes. Each tooth was stored in a vial containing 5 ml of concentrated nitric acid for 3 days. The solutions thus obtained were centrifuged at 3500 rpm for 5 minutes. Four milliliters of the supernatant liquid was then analyzed in an ultraviolet (UV) visible spectrophotometer. Obtained readings were statistically analyzed using one-way analysis of variance and Tukey multiple comparisons tests.

**Results:** Teeth treated with root resection alone showed better result as compared to root resection and retropreparation and difference between two groups is statistically significant ( $p < 0.05$ )

**Conclusion:** Apical downpacking of MTA prior combined with root resection alone could be considered as a viable alternative during periapical surgeries.

### Abstract 362

#### Evaluation and comparison of the push out bond strength of mineral trioxide aggregate fillapex and BioRoot RCS sealers in endodontically treated teeth: An *in vitro* study

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**Aim:** To evaluate and compare the pushout bond strength (POBS) of MTA Fillapex (MF) and BioRoot RCS (BRCS) sealers in endodontically treated teeth – an *In vitro* study.

**Materials and Methods:** 60 intact premolars were divided into two groups.

Group A – Bioroot RCS (BRCS)  $n = 30$

Group B – MTA Fillapex (MF)  $n = 30$

All 60 teeth were root canal treated and obturated using warm vertical compaction and then sectioned horizontally at the apical third (1.5 mm thick).

The POBS was studied using a Universal Testing Machine (Autograph AG 1).

The sample size was calculated using the statistical package G\*Power (3.1.5).

**Results:** It was found that the POBS of Group A was significantly higher than the POBS of Group B.

**Conclusion:** Of the two sealers, it was seen that BioRoot RCS showed the higher Push Out Bond Strength value than MTA Fillapex sealer.

### Abstract 363

#### Biomimetic microenvironment: Revolutionizing regeneration

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The natural environment of the dental pulp has been proven to be capable of regulating homeostasis, proliferation, and differentiation of undifferentiated mesenchymal cells. Various approaches have been applied to simulate the natural dental pulp microenvironment

optimizing the efficacy of pulp regeneration during endodontic therapy of immature permanent teeth with a necrotic pulp. The biomimetic microenvironment is composed of synthetic nano scaled polymeric fiber structure that functions as a scaffold of pulp dentine tissue complex, recruiting pluripotent stem cells from the vicinity of the apex. The polymeric nanofibers are produced by methods of self-assembly, electrospinning and phase separation. The biomimetic microenvironment mimics the characteristic properties of the natural extra-cellular matrix, self assembles into a 3-Dimensional network and accomplishes the dentin-pulp regeneration by orchestrated efforts of cells, bioactive molecule and extra-cellular matrix that eventually is replaced by host extra-cellular matrix. Encouraging regenerative outcomes achieved by incorporating various moieties and features are mainly developed through peptide amphiphiles, cell homing, stem cells (Stem cells from Human Exfoliated Deciduous teeth, Stem cells from Apical Papilla, Dental Pulp Stem Cells), growth factors (Bone Morphogenic Protein, Transforming Growth Factor- $\beta$ , Insulin-like Growth Factor) and scaffolds (Natural polymer Bioactive molecular carrier systems such as collagen, hyaluronic acid, alginate and chitosan; Synthetic polymer Bioactive molecular carrier systems such as hydrogel and VitroGel 3D). The poster will be focusing on the current prospects of biomimetic microenvironments as a scaffold for neotissue regeneration via current tissue engineering concepts and electronspun polymer nanofibres for intracanal drug delivery. Therefore, we can build up an imperative future stating that vitality is not just an ability to persist but is an ability to start over.

### Abstract 364

#### Evaluation and comparison of endodontically treated teeth using different irrigants 5.25% sodium hypochlorite, 17% ethylene diamine tetra acetic acid and 0.2% chitosan

**ANN MARIYA SUNNY**

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**Aim:** To evaluate and compare endodontically treated teeth using different irrigants 5.25% Sodium Hypochlorite (NaOCl), 17% Ethylene Diamine Tetra Acetic acid (EDTA) and 0.2% Chitosan.

**Materials and Methods:** 60 intact premolars were divided into three groups:

Group 1: 17% EDTA + 5.25 % NaOCl ( $n = 20$ )

Group 2: 0.2% Chitosan + 5.25 % NaOCl ( $n = 20$ )

Control Group: 5.25 % NaOCl ( $n = 20$ )

Biomechanical preparation was done using irrigants as per the allotted Groups.

After obturation, the teeth were sectioned at the apical third horizontally (1.5 mm thick).

The POBS was studied using a Universal Testing Machine (Autograph AG 1).

The sample size was calculated using the statistical package G\*Power (3.1.5).

**Results:** Increased chelation was observed in Group 2. It had significantly higher chelating effects than Group 1 and the Control Group.

**Conclusion:** The irrigation regimen of 0.2% Chitosan with 5.25% NaOCl (Group 2) was found to have better chelating effects and thus in turn better debriding effect on the root canal when compared

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with 17% EDTA with 5.25% NaOCl (Group 1) and the Control Group.

### Abstract 365

#### Mature tooth regeneration using umbilical cord stem cells – Cord striking a chord

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Conventional root canal therapy replaces the pulp tissue with artificial means without restoring the function of pulp. Regenerative endodontic procedures (REPs) are biologically based tissue engineering technology which is a remarkable achievement in the field of endodontics to replace damaged structures, including dentin and root, as well as cells of the pulp tissue. REPs are based on 3 principles of tissue engineering: cellular component including mesenchymal stem cells (MSCs), scaffolds (Platelet poor plasma) and growth factors. Mesenchymal stem cells are specialized human cells that have ability to develop into different cell types. Mesenchymal Stem cells are divided into two main forms, Embryonic stem cells (Human Umbilical cord Mesenchymal stem cells) and adult stem cells (Somatic stem cells). Scaffolds promoting cell proliferation are classified as natural or synthetic. Platelet-poor plasma (PPP) is a platelet-derived natural scaffold in blood fraction with a reduced count of platelets. Drawbacks of conventional Adult Stem Cells therapy include; Technical difficulties, ethical concerns, and risk of carcinogenesis with lower capacity of differentiation and can only used in treatment of immature teeth. Human Umbilical cord Mesenchymal Stem Cells hUC-MSCs helps in biomimicking the most immunocompatible odontogenic microenvironment to drive their differentiation towards a specific cell lineage. They can differentiate into odontoblast like cells and functional endothelial cells providing an alternative seed source for angiogenesis and regenerating dentin pulp complex. MSCs from foetal origin, compared to other sources of adult stem cells are non-invasive, shows reduced risks of viral contamination due to protection provided by placental barrier. This poster reviews a different approach to regain vitality in necrotic pulp tissue of mature teeth with the benefits of allogenic therapy which includes isolation of human umbilical cord mesenchymal stem cells, their encapsulation in plasma-derived biomaterial and direct transplantation in mature permanent teeth with apical lesions.

### Abstract 366

#### Oroactive biomaterials: A promising novel adjunct for endodontics

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Biomaterials have become the epicentre of modern day medical science. An oroactive biomaterial is defined as any material or device that is used within the confines of the oral cavity for the diagnosis and treatment of diseases, conditions, and disorders. Endodontic biomaterials are used for vital pulp therapies, irrigation, intracanal medicaments, obturation and regenerative procedures. These materials offer several functions including: antimicrobial

activity, mechanical reinforcement, aesthetics, and therapeutic effects. Vital pulp therapies have seen an improvement in clinical results with an incremental approach to build on the strengths of past materials such as calcium hydroxide and calcium silicates. While sodium hypochlorite remains the gold standard for canal irrigation, numerous nanoparticle formulations have been developed to promote sustained antimicrobial action. Modern trends across the globe will continue to motivate patient holistic health. However, while multiple studies focus on the development of novel formulations containing drugs, glass derivatives or ionic-, polymeric-, or drug-loaded nanoparticles, a lack of reliable and long-term clinical evidence obligates further study as experienced clinicians prefer to use what has worked for decades.

### Abstract 367

#### Cryotherapy in endodontics

**SABATINA JAMES**

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Cryotherapy refers to decreasing the tissue temperature for therapeutic purposes. The concept of cryotherapy actually does not imply cooling the target tissue but rather extracting heat from the tissue of higher temperature to the subject of lower temperature. Three basic physiological tissue effects of cryotherapy are vascular, neurologic, and tissue metabolism. Cryotherapy has been frequently applied in medicine and other fields of dentistry. For the majority of clinicians, it seems that the chief challenge is pain control. Root canal treatment is more frequently associated with severe postoperative pain than other dental procedures. Therefore, management of postoperative pain is crucial in endodontic practice. In the field of endodontics, cryotherapy has been reported to be used after periradicular surgeries and during root canal treatment to minimize postoperative pain and inflammation. Other implementation of cryotherapy in endodontics is deep cryotherapy of nickel-titanium (NiTi) endodontic files, which offered enhanced cyclic fatigue resistance, reducing potential file separation. In addition, irrigation with 2–5 mL cold sodium hypochlorite from the beginning to the end of cleaning and shaping showed the lowest level of interleukin 6 expression. More recently, cryotherapy was successfully tried as a useful adjunct for hemostasis in vital pulp cryotherapy in conjunction with bioceramic materials. Cryotherapy is a simple and cheap supplementary method for minimizing postoperative pain in cases of symptomatic apical periodontitis and for controlling pulpal hemorrhage during vital pulp therapy. Undoubtedly, it is also an indispensable measure for controlling postsurgical swelling and pain after endodontic surgery.

### Abstract 368

#### End-o-biofilms: The road less taken

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Microbial infection of the root canal system is the primary etiological

## Abstract

factor in pulpal and periapical pathology. A multicellular biofilm community is resistant to most antimicrobial agents and hence, poses a considerable clinical challenge. Accordingly, the primary goal of endodontic treatment is to remove biofilms and eliminate microorganisms from the root canal system by instrumentation, irrigation, use of locally intracanal medicaments and antibacterial root filling materials. The use of chemical agents during instrumentation is crucial for the complete disinfection of the root canal system. Sodium hypochlorite (NaOCl) being the most potent, is often used in conjunction with EDTA to remove the smear layer from the root canal surface. However, NaOCl causes dentin collagen denaturation and dissolution, especially at high concentrations. Hence, there is a need to explore alternative novel strategies. Among these, antimicrobial peptides are a wide ranging class of host defence biomolecules that provide the early stage protection against invading microbes. Natural antimicrobial peptides are synthesized in by several cells in pulp as an innate immune response. The fact that these naturally occurring antibacterial peptides are susceptible to degradation by peptidases evokes the need of stabilization of these peptides by formulating synthetic antimicrobial peptides. They can be potential alternatives to conventional irrigants against multidrug resistant pathogens and biofilm related pathologies. Another emerging modality is the antibacterial nanoparticles which have a wide range of therapeutic efficacy. They target the microbial biofilm and prioritise to render substrate less or non-amenable to microbial adhesion. They facilitate the irrigant to reach specific areas that are inaccessible to conventional instrumentation techniques. Lastly, to combat the existing challenges, probiotics have been recognised to be the next, most important immune defence system as current antibiotics are becoming useless because of the development of bacterial resistance. The organisms that have been used in the past as probiotics are certain strains of *Lactobacillus* and *Bifidobacteria*. Instead of attempting to eliminate pathogens by antimicrobial agents, probiotics acts by substituting the microflora by replacement therapy and creating a favourable pathogen free environment. Hence, this poster aims to explore these newer approaches focusing on antimicrobial peptides, nanoparticles and probiotics.

### Abstract 369

#### Effect of smear layer on push out bond strength of three resin based sealers: An *in vitro* study

**SHWAN UKE, ZINNIE NANDA**

JMF's ACPM Dental College, Dhule, Maharashtra, India

**Aim:** To evaluate the effect of smear layer on push out bond strength of three resin based sealers (EpoSeal, Resino-Seal and AH Plus).

**Materials and Methods:** Sixty single rooted mandibular premolars were assigned for the study. Each tooth was decoronated to maintain the standardized length of 16mm. The root canals were instrumented with a series of ProTaper Universal file system to #40/06 using 2.5% NaOCl. Then prepared roots were randomly assigned to two groups (n=30) as follows:

Group 1: Smear layer were preserved

Group 2: Smear layer were removed by irrigation with 3 mL of 17%

EDTA for one minute using a 30-gauge needle inserted to 1 mm short of the working length.

The canals were obturated using single cone technique. Then each group were further assigned to three subgroups (n=10) according to the root canal sealer used.

Under Group 1:

Subgroup A: Gutta percha with EpoSeal sealer

Subgroup B: Gutta percha with Resino-Seal sealer

Subgroup C: Gutta percha with AH Plus sealer

Under Group 2:

Subgroup A: Gutta percha with EpoSeal sealer

Subgroup B: Gutta percha with Resino-Seal sealer

Subgroup C: Gutta percha with AH Plus sealer

The roots were then sectioned horizontally with carborundum disc at depths of 4, 7 and 10mm to produce a slice of approximately 1-mm thick from apical, middle and coronal thirds respectively. These specimens were subjected to push out test using universal testing machine. Results were tabulated and subjected to statistical analysis using One Way ANOVA.

**Results:** In intergroup comparison, Group 2(smear layer removed) shows better results than Group 1(smear layer preserved) and AH Plus shows significantly better results in Group 1 and Group 2. Intragroup comparison shows highest values of push out bond strength at 4mm from root apex followed by 7mm and 10mm sections.

**Conclusion:** Removal of smear layer shows significant difference in values of push out bond strength with respect to AH Plus sealer as compared to the group in which smear layer is preserved.

### Abstract 370

#### Biomechanical properties of first mandibular molars with different endodontic access cavities: A finite element analysis

**LAKSHMISETTY HARIKA**

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**Aim:** The aim of this study was to compare the biomechanical properties of first mandibular molar with different endodontic access cavities using the finite element method.

**Methods:** Three finite element analysis models of a mandibular first molar were designed and constructed with 3 different types of endodontic access cavities: a truss endodontic access cavity, a conservative endodontic access cavity, and an extended endodontic access cavity. An intact tooth model was used for comparison. Each model was subjected to 3 different force loads directed at the occlusal surface. The stress distribution patterns and the maximum von Mises (VM) stresses were calculated and compared.

**Results:** The peak VM stress on all models was at the site of the force load. The occlusal stresses were spread in an approximate actinomorphic pattern from the force loading point, and the stress was much higher when the force load was close to the access cavity margin. The peak root VM stresses on the root-filled teeth occurred at the apex and were significantly higher than that on the intact tooth, which appeared on the pericervical dentin. The

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area of pericervical dentin experiencing high VM stress increased as the cavities extended and the stress became concentrated in the area between the filling materials and the dentin.

**Conclusions:** The stress distribution on the occlusal surface were similar between the conservative endodontic access cavity, the truss endodontic access cavity, and the extended endodontic access cavity. With enlargement of the access cavity, the stress on the pericervical dentin increased dramatically.

**Abstract 371**

**Retreatability of bioceramic-based root canal sealers: A review**

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K PAVAN KUMAR**

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The application of bioceramics in the field of medicine (kokubo, 2008) has greatly expanded. Therefore, the formation of new bioceramic root canal sealers have emerged into existence. Soon, these materials have proven to be an advantageous technology in endodontic practice. The successful outcomes of root canal treatment, also depends upon the prevention of re-infection of root canal space among other multitude of factors. But retreatability of these bioceramic sealers in cases of persistent periapical inflammation or postoperative pain is difficult using the conventional treatment techniques. The aim of this review was to consider laboratory experiments and clinical studies on the retreatability of these bioceramic sealers. An extensive search of endodontic literature was made to identify publications related to retreatment of bioceramic based sealers and the clinical outcomes are assessed.

**Abstract 372**

**Direct anatomic fiber post in mandibular left second premolar with flared root canals: A case report**

**MEILISA RACHMAWATI, ADITYA WISNU PUTRANTO**

Department of Conservative Dentistry, University of Indonesia, Central Jakarta, Indonesia

The restoration of endodontically treated teeth continues to be a challenge to clinicians particularly when there is extensive tooth structure lost. In such cases, the final restoration can be well retained only by means of a post core system. Presently the use of prefabricated fiber post is increasing in restorative dentistry due to its esthetic appearance, flexibility, and similar mechanical properties when compared to that of dentin. This case report describes about a 20 years old female that was indicated for endodontic treatment followed by post, core, and crown restoration for her mandibular left second premolar. Flared shaped canal was detected in this teeth and no prefabricated fiber post could accurately adapted to the canal. This report focuses on the clinical technique of fabricating direct anatomic fiber post as one among the modifications of the fiber post which provides a three dimensional fit to the flared canals. It is obtained through molding and relining the prefabricated fiber directly with composite resin and transferred into the flared root canals. The direct anatomic fiber post was fixed with resin cement. Direct anatomic fiber post

was found to be radiographically adapted to the flared root canals creating a uniform and thin layer of resin cement without any voids detected. The anatomic fiber post mimic the flared anatomy of the root canal and adhesively bonded to the tooth structure based on the monoblock concept.

**Abstract 373**

**Nonsurgical removal of extruded gutta percha in maxillary central incisor endodontic retreatment: A case report**

**NURUL RAMADIANI, IKE DWI MAHARTI**

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Extruded gutta percha is one of the local contributing factors that can lower the endodontic treatment success rate from 94% to 76%. Endodontic treatment failure can be solved with non-surgical endodontic retreatment, surgical endodontic retreatment, or a combination of both. Non-surgical endodontic retreatment is indicated for inadequate previous endodontic treatment and cases with coronal or apical leakage. The most critical phase in endodontic non surgical retreatment is removing gutta percha and sealer from root canal system. Based on some studies, no single instrument is capable of removing gutta-percha completely from the root canals. Hence, visualization using a dental microscope plays an important role. Removal of extruded gutta percha is a quite challenging procedure with the risk of gutta percha pushed away to the periapical region. This case report will present the non-surgical removal of extruded gutta percha in maxillary central incisor endodontic retreatment.

**Abstract 374**

**Endodontic management of mandibular second premolar with three root canals and hyper-taurodontism: A case report**

**RAKHMAWATI CAESARIA, ENDANG SUPRASTIWI**

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The primary objective of endodontic treatment is to prevent and intercept pulpal/periradicular pathosis and to preserve the natural dentition when affected by pathosis. The variety and complexity of root canals is a challenge and can also make it difficult to achieve successful endodontic treatment. The purpose of the present article is to report a successful retreatment of a mandibular second premolar with three canals and taurodontism. This case report discussed the clinical management of previously treated teeth mandibular second premolar with three canal systems dan taurodontism. Mandibular second premolar commonly have one canal, but at some rare cases it can have more than two canals. This mandibular second premolar have elongated large pulp chamber, apically positioned furcation, short root, dan the three orifice root canals found in apical third. Based on the classification given by Shiffman and Chanannel, the mandibular second premolar was Hypertaurodontism. The post endodontic radiograph shows the successful obturation to working length in all three canals,

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two canals in distal (distobuccal and distolingual) dan one canal in mesial. This case report highlights the importance of a comprehensive knowledge of variations root canal complexities and morphologies mandibular second premolar to produce an effective and successful endodontic retreatment.

**Abstract 375**

**Successful nonsurgical management of endodontic-periodontal lesion in mandibular first molar: A 1 year follow-up case report**

**MARISSA DWI BESTARI, ADITYA WISNU PUTRANTO**

Department of Conservative Dentistry, University of Indonesia, Central Jakarta, Indonesia

In the existence of pulpal problem and inflammatory periodontal disease, the presence of interrelationships between pulp and periodontium could facilitate bacterial transportation between the two structures, resulting in endodontic-periodontal lesion. Diagnosis and management of endodontic-periodontal lesions are often more challenging to clinicians and the treatment outcomes are not as predictable as lesions of single origin. Accurate identification of the primary etiological factor through a thorough clinical and radiograph examination to determine correct diagnosis and prognosis is very vital in the management of endodontic-periodontal lesion. This case report evaluates the efficacy of non-surgical endodontic treatment in the management of bone loss and tooth mobility associated with primary endodontic lesion and secondary periodontal involvement in the right mandibular molar. A twenty-seven years old female patient with endodontic-periodontal lesion was treated with non-surgical endodontic therapy followed by simple hygiene phase therapy. One month after the endodontic treatment was initiated, an increase of the clinical attachment level was found, reduction of the lesion size was identified on the radiograph, and tooth mobility was no longer present. On one year evaluation following the endodontic treatment, the tooth remained asymptomatic and radiographic evidence showed significant resolution of bone defect.

**Abstract 376**

**Management root canal treatment on mandibular first molar with radix entomolaris: A case report**

**BADRUL QOMAR ISROI, ADITYA WISNU PUTRANTO**

Departement of Conservative Dentistry University of Indonesia, Central Jakarta, Indonesia

The main objective of root canal treatment is preventing periapical infection by disinfection and closure of root canal system with high success rate. The main cause of failure root canal treatment is failure to locate and treat all root canals. Mandibular first molar have the greatest possibility of additional roots and increased risk of missed root canals. Additional roots in mandibular first molars are called as Radix entomolaris and Radix paramolaris. Frequency of entomolar roots is more common in the Mongoloid race which is around 5-30%. This case report will discuss about root canal treatment in a 58 years old female patient of mandibular first molar with an obliterated entomolar root. Entomolar roots are usually not detected when

radiograph is taken, due to overlapping of distal root canal. So it is necessary to combine clinical and radiographic examination. Radiographic identification of anatomical variations of the distal root canal was carried out using radiographic angle technique. First molar with Radix entomolaris need special attention during root canal treatment procedures because the auxiliary roots are usually smaller in size than the mesial and distal roots. The majority of entomolar roots also have root canals that form moderate to severe curvature so that the orifice of the root canal will be covered by the canal wall of the pulp chamber which will make it difficult to determine location of the orifice. Magnification and endodontic scalers can assist locating and opening entomolar root orifices. Negotiations and exploration can be done using C+ instrument that has mechanical resistance to torsion and buckling, so it can withstand the forces to gain access to the apical. Knowledge and understanding of identification of the canal and treatment using special instruments such as endodontic scalers, C pilot instruments and magnification in these cases with radix entomolaris are important to reduce the risk of root canal failure.

**Abstract 377**

**Effect of hyperbaric pressure in diving simulation on fracture strength and fracture pattern of different post system in endodontically treated teeth: An *in-vitro* study**

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Faculty of Dentistry, Universitas Sumatera Utara, Medan, Indonesia

**Aim:** To evaluate the effect of hyperbaric pressure in diving simulation on fracture strength and fracture pattern of different post systems in endodontically treated teeth.

**Materials and Methods:** Forty single root mandibular premolars were decoronated 2 mm above Cemento Enamel Junction and endodontically treated. The teeth were divided into two groups according to post system used (single prefabricated fiber post and anatomic fiber post). The fiber post was cemented with etch-and-rinse adhesive, hand-mixed dual cure resin cement (relyX Ultimate). Half of each groups were subjected to 24 pressure cycles from 1 ATA to 4 ATA. All sample was fractured by compressed loading with Universal Testing Machine (UTM). The mean of fracture strength was calculated and statistically analyzed using ANOVA. The fracture pattern was characterized by observation using dental loupe then statistically analyzed using Kruskal Wallis test ( $\alpha = 0.05$ ).

**Results:** Regardless of the pressure, anatomic post achieved the highest fracture strength  $668.82 \text{ N} \pm 90.84$  compare with single prefabricated fiber post  $541.30 \text{ N} \pm 79.50$  ( $p = 0.01$ ). The fracture strength were significantly lower after they were subjected to the pressure cycles which is  $482.69 \text{ N} \pm 81.57$  for anatomic post and  $428.23 \text{ N} \pm 68.34$  ( $p < 0.05$ ) for single prefabricated fiber post. No statistically significant differences ( $p = 0.958$ ) were found in fracture pattern between all groups and 90% of the fractures were repairable.

**Conclusion:** Barometric changes in diving may have an adverse effect on retention of fiber post which can reduce the fracture strength of post system. The impact may be caused by the presence of smear

Abstract

layer or the microbubbles when mixing or application of the cement. However the fracture pattern was not be affected by pressure change.

**Abstract 378**

**Endodontic retreatment of a maxillary second premolar with protaper universal retreatment: A case report**

**WIGIARTI, RATNA MEIDYAWATI**

Department of Conservative Dentistry, University of Indonesia, Central Jakarta, Indonesia

Understanding root canal morphology and its complexity is essential during endodontic therapy. The anatomy of the root canal has a variety of shapes and configurations and is always accompanied by complex shapes so that at the time of mechanical and chemical debridement and obturation have their own challenges. The purpose of this article is to report the success of root canal retreatment used pro taper universal rotary retreatment. A 40 years old female patient with a diagnosis of chronic apical periodontitis on a previously treated tooth was root canal retreatment. Endodontic retreatment included removal of obturating material, improvement of damage in the root canal, determination of the appropriate working length, obturation, and final restoration. The pro taper universal rotary retreatment system proved to be an efficient and effective method of removing gutta-percha and sealer from the root canal. The rotary movement of engine-driven files produces a certain degree of frictional heat which might plasticize gutta-percha, the plasticized gutta-percha would thus present less resistance and be easier to remove. Pro taper universal retreatment system having larger tapers can be expected to result in a cleaner canal than stainless steel hand files. The better performance of pro taper universal retreatment instrument may be attributed to their design D1, D2 and D3 have three progressive taper and lengths, these features may enable them to cut and full the gutta-percha into the file flutes and direct it toward the orifice. Root fillings were removed with a rotary instrument which was manipulated in a brushing action, the rotational speed was set at 500-700 rpm as recommended. Rotary instrument retreatment pro taper offers a greater benefit and better ability to preserve tissue with minimal invasion and smaller risk iatrogenic, gutta-percha resulted in increase cleanliness and provide a good prognosis. This case report highlights the importance of knowledge and application of root canal re-treatment techniques which play an important role in the success of endodontic retreatment.

**Abstract 379**

**Rehabilitation of endodontically treated mandibular second premolar using anatomical fiber post: A case report**

**DARIN SAFINAZ, RATNA MEIDYAWATI**

Faculty of Dentistry, University of Indonesia, Central Jakarta, Indonesia

After endodontic treatment, it is necessary to select the appropriate restoration based on functional load, the amount of remaining tooth tissue structure, and aesthetic needs. This case report discusses the clinical restoration management of a widened canal space which

involved a great loss of crown tissue of the endodontically treated mandibular second premolar. A tooth that has lost more than two crown walls requires a post and core to increase retention and stability of the final restoration. Various types of posts can be used to restore endodontically treated teeth. Glass fiber post is known for its excellent retention by its adhesive cementation system. In addition, it has similar modulus elasticity to dentin which allows better distribution of masticatory stresses and reducing the risk of root fractures. Its translucent color makes it able to transmit light for polymerization of resin luting agents and produces a good aesthetic appearance. In a widened canal space, prefabricated fiber post does not always adapt to the root canal's shape and diameter, which is possible to form a void of resin cement at the interface of the root canal wall. To eliminate this possibility, an anatomical fiber post is used to improve the fitness of the post within the canal. This technique requires the anatomical shaping of the prefabricated fiber posts with a light-cured composite resin into the root canal to achieve a better adaptation and retention of the post. The aim of this clinical case is to describe the usage of anatomical fiber post, highlighting the importance of knowledge and its clinical steps in the management of restoration widened canal space which plays a crucial role in the success of endodontically treated teeth.

**Abstract 380**

**Hemisection as a management of iatrogenic complication on right mandibular first molar**

**SAMMY HENRY LAY, ANGGRAINI MARGONO**

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Iatrogenic complications can occur when performing root canal treatment. Most common iatrogenic complications may occur during endodontic access cavity preparation. Such perforation may compromise the endodontic treatment outcome. However, there are several alternative treatments to correct procedural errors and maintain tooth structure. Hemisection is a procedure that can be performed to maintain tooth structure and function. In this case report, we report the management of hemisection of the mandibular first molar. A 59-year-old female patient came to the Dental Conservation Clinic of RSKGM FKG UI on a referral from a dentist at one of the primary clinics citing limited facilities. The chief complaint was swelling in mandibular molar region since 4 months and pain aggravated during chewing. Clinical findings revealed right mandibular first molar with temporary restoration. The cold thermal test did not elicit a response. The tooth was sensitive to percussion and palpation test. Preoperative radiograph showed radiolucency in the bifurcation area and the apical one third of the distal root. Based on clinical examination and radiographic findings, a diagnosis of chronic apical abscess caused due to pulp necrosis was made. Cone beam computed tomography (CBCT) showed radix entomolaris on distal root and perforation area on bifurcation, CBCT Periapical Index score is 4+ D. Hemisection procedure was done under anaesthesia, vertical cut was made with long shank carbide bur at bifurcation area and distal tooth root was extracted and the socket was irrigated with sterile saline to remove bony chips and sutured with 3.0 nylon

Abstract

sutured. At 4 weeks follow up, healing was found to be satisfactory and mobility was within the normal limits. Also, the tooth was not tender to percussion and palpation tests. Restoration of fixed bridge including retained mesial half and mandibular second molar with sanitary pontic was planned.

**Abstract 381**

**Management of flare up caused by over instrumentation in root canal treatment of lower molar with chronic apical abscess: A case report**

**RAHMAT IBRAHIM,  
DEWA AYU NYOMAN PUTRI ARTININGSIH**

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Root canal treatment aims to eliminate microorganisms and debris in the root canal system to prevent and treat periapical infections. Procedures for obtaining patency and cleaning and shaping the root canal may irritate the periapical tissue by bacterial contamination, bacterial by-products, necrotic pulp tissue, or the irrigation fluid's caustic potency. One of the problems during treatment is pain or swelling during or after root canal treatment, called a flare-up. Over instrumentation can push debris infection to periapical tissues, alter the balance between bacteria and the host's immune system, stimulate an acute inflammatory response and cause pain. This case report discusses the management of inter appointment flare-up of mandibular molar in a 28-year-old female patient diagnosed with chronic apical abscess after over instrumentation of the root canal. Flare-up can be managed appropriately by accurate measurement of working length, re-instrumentation of root canals, irrigation and application of intracanal medicament. Evaluation of one day and two weeks did not show any subjective and objective complaints so that the management of flare-ups was a success.

**Abstract 382**

**Management of pulp canal obliteration in mandibular first molar with periapical lesions by conventional root canal treatment: A case report**

**RIZKA ANDINI PRATIWI, ANGGRAINI MARGONO**

University of Indonesia, Jakarta, Indonesia

Endodontic treatment should be initiated in obliterated canal experiencing tenderness to percussion with a PAI scores  $\geq 3$  and displaying a negative response to sensibility testing. Treating an obliterated canal can be of a challenge due to the narrowing of the pulp canal which will lead to the difficulty in locating the access of the canal and also during cleaning and shaping. This case report presents a successful completion of the conventional endodontic treatment in pulp canal obliterations of molar with periapical lesions. A 26-years-old man went to RSKGM FKG UI for treating his mandibular first molar that felt chewing discomfort since tooth fracture at lingual and distal side 4 month ago. Radiographs showed radiopaque area from occlusal to pulp chamber floor, obliterated canal and periapical lesions in mesial and distal root. Three obstructed root canal can be done by using C+ files and C-pilot files with chelating agent (EDTA and RC-Prep). Endodontic

therapy consisted of rotary instrumentation with ProTaper Gold® (Dentsply Maillefer, was filled by warm vertical compaction) and final restoration of a dowel crown PFM. A one-month follow-up, there were no complaints of pain and periapical radiolucency showing signs of diminution and disappearance.

**Abstract 383**

**Endodontic treatment of maxillary second premolar with vertucci II canal configuration: A case report**

**MAHARINA DIYAH, ENDANG SUPRASTIWI**

Departement of Conservative Dentistry, University of Indonesia, Cental Jakarta, Indonesia

Successful endodontic treatment depends on knowledge in root canal morphology, correct access cavity preparation, complete debridement of the root canals, and subsequent obturation to facilitate healing of periapical pathosis. However, this process becomes complicated with the presence of additional root canal systems. The maxillary second premolars usually have one root canal, however in several cases there is more than one root canal with a variety of configurations. This variability of root canal morphology affects the diagnosis, root canal treatment success rate and prognosis that have been always a challenge for a clinician. The purpose of the present article is to report successful endodontic treatment of a maxillary second premolars with two root canals and one apical foramen (Vertucci Type II). The post-treatment radiographs show successful obturation to length in all canals. This case report highlights the importance of knowledge to confirm canals configuration and its application in the management of abnormal anatomic variants which play a crucial role in the success of endodontic treatment.

**Abstract 384**

**Prefabricated metal post removal in non-surgery endodontic retreatment of maxillary first incisive using ultrasonic instrument: Case report**

**ZAHRA KHAIRIZA ANRI, IKE DWI MAHARTI**

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Endodontic retreatment often requires intraradicular post removal that is usually difficult and increases the risk of perforation and fractures and weakens the remaining tooth structures. Factors that complicate the removal process are its type, design, depth, and type of cement. There are many techniques used to remove post, including bur, device that grasp the posts so that they can be pulled out of the root, and ultrasonic instrument. In the ultrasonic techniques, the tip of instrument will produce energy that is transferred through the post and break down the cement until the post loosens. This case report will discuss prefabricated metal post removal in non-surgery endodontic retreatment of maxillary first incisive using ultrasonic instrument.

**Abstract 385**

**Retrieval of broken instrument from apical third of mesiobuccal root of maxillary second molar using bypass technique: A case report**

Abstract

**WANDY AFRIZAL PUTRA, DINI ASRIANTI BAGIO**

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Fracture of root canal instrument is one of the iatrogenic factor that can affect the prognosis of endodontic treatment. This might be due to the limited physical properties combined with the improper use of endodontic instrument, that can cause deformity on the instrument surface. The bypass technique is one of the minimally invasive options of the broken instrument management. One of the indications is for a case with instrument fragment located in the apical one-third of the curved root which could not be visualised with the aid of magnification. The bypass-technique was done by bypassing the fractured instrument fragment with small file followed with the use of lubricating agent and copious irrigation, negotiation till full working length followed by obturation. This procedure was done under dental operating microscope. Furthermore, the successful management of broken instrument by by-pass technique was achieved by successful bypassing of fractured instrument completely, without pushing the fragment apically. This case report presents the management of broken instrument from the mesiobuccal root of maxillary second right molar of 64 years old male patient that was referred to Department of Conservative Dentistry Clinic of RSKGM Faculty of Dentistry Universitas Indonesia. The management of the broken instrument was completed in one visit and followed by obturation with warm vertical compaction technique. After two months of observation, there are no clinical symptoms and radiographic appearance showed healing of periapical lesion.

**Abstract 386**

**Management of separated endodontic instrument in middle-third distobuccal root canal of first maxillary molar with bypass technique under dental operating microscope visualization: A case report**

**DERYANA AVIDHIANITA, ANGGRAINI MARGONO**

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Instrument separation is a common complication during endodontic treatments. Fragment retrieval success rate is high, but also has a higher risk of removing sound dentin, leading to root perforation and vertical root fracture. Success rate of fragment retrieval and bypassing is approximately two times greater if the fragment was visible. A clinical case of a separated endodontic instrument and treatment using bypass technique under dental operating microscope visualization are presented in this report. A 21 years old woman was referred by an endodontist at a private practice due to lack of facilities. Around one year ago patient had an uncomplete root canal therapy by a general practitioner. Patient had been complaining about chewing discomfort on right upper molar since a month ago. Clinical findings showed a temporary filled tooth with sensitivity to percussion and unsensitivity to cold test and palpation. Preoperative radiographs showed a separated endodontic instrument in the middle third of distobuccal canal and periodontal ligament widening. Based on clinical and radiographic findings the

diagnosis obtained was chronic apical periodontitis et causa pulp necrosis and a separated instrument. Therefore, a conventional root canal therapy with bypass technique was done. The result showed hermetically obturated root canals. Post treatment evaluation was carried out two weeks after root canal treatment. All symptoms had disappeared, and the tooth was finally restored with fiber post and Ceramage crown.

**Abstract 387**

**Nonsurgical endodontic treatment for mandibular second molar with vertucci type II configuration: A case report**

**ELBERT DWI SUMA PUTRA, DENNY NURDIN**

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Root canal treatment for second molar tooth is little bit tricky because type IV and type II Vertucci are the most common types found in mesial roots, while type I Vertucci in distal roots. Therefore, it is necessary to do a proper investigation so that the dentist can determine the root canal configuration before treatment to make successful treatment. This case report discusses the non-surgical root canal treatment of a right lower back tooth with a Vertucci type II configuration with follow-up using a composite overlay and using CBCT to support this treatment.

**Abstract 388**

**Retrieval of multiple pulp stones and management of calcified root canals: An endodontic treatment challenge**

**MELIA HEPTANIA, WANDANIA FARAHANNY,  
TRIMURNI ABIDIN**

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Currently canal calcifications is an interesting and challenging case for endodontists. The goal of endodontic treatment is to eliminate microorganisms and their by-products from the root canal system. Calcifications within the pulp may lead to poorer outcome of a root canal procedure, as they can block access to the root canal and hinder cleaning and shaping. Errors in treatment can result in iatrogenic errors that will lead to failure of endodontic treatment. This article describes a case report of a 19-years-old woman with multiple pulp stones in pulp chamber and calcified root canals located in mesio-lingual and mesio-buccal of the left mandibular first molar. Endodontic treatment was performed because the patient had asymptomatic irreversible pulpitis. Several challenges were encountered in this case. The initial challenge encountered was determining the position of the pulp stone in the pulp chamber, which had to be done using radiographs taken from various angles, as well as direct observation of the cavity during access preparation. The pulp stone in this case is of the embedded type, which is retrieved by grinding it using an ultrasonic tips. In addition, another challenge is to avoid perforating the pulp chamber floor when removing the pulp stone, identifying the location of the orifice. Success is achieved with clinical knowledge, magnification aids and ultrasonic tips.

### Abstract 389

#### Endodontic treatment on second molar mandibular with periapical lesion: A case report

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The current concept and rationale of endodontic treatment of periapical lesion are centered on stopping the bacterial stimulation of the host response at the apical foramen that would allow healing of the lesions. Some clinical studies have confirmed that simple non-surgical treatment with proper infection control can promote healing of periapical lesions. Up to 85% treatment success has been reported for periapical lesions after non-surgical endodontic therapy which implies that most periapical lesions including abscesses respond to non-surgical endodontic therapy. The success of endodontic treatment in cases of periapical lesions was assessed based on clinical and radiographic criteria. This case report discusses the endodontic treatment of a mandibular second molar with apical abscess.

### Abstract 390

#### Endodontic treatment of maxillary lateral incisor with periapical lesion: A case report

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Periapical lesions are generally a continuation of untreated teeth with caries and pulp necrosis. Residual pulp tissue and microbial infection in the root canals are the cause of inflammation of the periapical tissues and form periapical lesions. Periapical lesions can be categorized into dental granulomas, periradicular cysts or periapical abscesses. The main goal of root canal treatment is to restore the infected tooth and the decayed tooth to a healthy state and normal function. Conservative nonsurgical treatment is the first choice in treating periapical lesions. Surgical treatment is recommended if the odds are met with failure. This case report describes root canal treatment of maxillary lateral incisor with periapical lesion. A 37-year-old male patient was referred from the prosthodontis to the Department of Conservative Dentistry and Endodontics of Padjadjaran University, with the chief complaint of frequent toothache and pus coming out of the gums. The tooth had been filled several years ago. Clinical examination revealed secondary caries on maxillary left lateral incisor and a fistula in the buccal mucosa of the tooth. Radiographically, overhanging restoration and periapical radiolucency involving half of the root was seen. Treatment was started with removing the previous restoration and performing root canal drainage. The treatment was continued by root canal preparation using a rotary file (Protaper Next ; Dentsply, USA) with crown down technique. Root canal irrigation using sodium hypochlorite (5,25%), EDTA solution (17%) and distilled water. Calcium hydroxide (Calcipex II ; Nishika, Japan) was used as an intracanal medicament for 10 weeks with 6 cycle of applications. Obturation of the root canal was perform after periapical lesion has shrunk, decrease in size and periapical bone started to repair. Obturation was done using gutta-percha points (Protaper Next GP ; Dentsply/Maillefer, Switzerland) and AH

plus sealer (Dentsply DE Trey, Konstanz, Germany). Cleaning, shaping and microbial control through irrigation and root canal medication determine success in the treatment of periapical lesions.

### Abstract 391

#### Endodontic treatment of mandibular first premolar with curved canals: A case report

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The curved canals in the posterior teeth often present a major challenge to the clinicians during the endodontic treatments. Periapical radiographs are the most appropriate way to diagnose the presence of curved canals. Careful and meticulous technique will yield a safe and sufficient enlargement of the curved canals. This case report describes the endodontic management of mandibular first premolar with curved canals. A 28 year old female patient came to the Conservative Dentistry Department, RSGM UNPAD with a complaint of fracture in right lower tooth since six months. Clinical examination revealed that tooth 44 had a fracture involving the pulp on the disto-occlusal surface. Vitality, percussion and palpation testing of tooth 44 was non-responsive. The radiographic examination revealed normal periapical region. The diagnosis of tooth 44 was previously initiated therapy with normal apical tissues. The treatment plan was endodontic treatment and full-coverage final restoration. The treatment began with informed consent followed by determination of root canal curvature with Schneider method. Access preparation was done under rubber dam isolation. The canals were instrumented by precurved hand files with balanced force technique and canal preparation using ProTaper Gold instrument with crown-down technique under irrigation with 5.25% sodium hypochlorite. Calcium hydroxide was used as an intracanal medicament. Obturation was performed on the next visit using gutta-percha and AH plus sealer. The tooth was restored using full-coverage restoration (lithium disilicate) with fiber post. Early diagnosis and proper instrumentation techniques would minimize the procedural errors and help to achieve a successful outcome of the endodontic treatment for curved canals.

### Abstract 392

#### Endodontic treatment of lower right second molar with severely curved canal: A case report

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Endodontic treatment of curved canals in posterior teeth often present a major challenge for the clinicians. Improper instrumentation may develop ledges and fracture instruments which further complicate the endodontic treatment. Knowledge of the root canal morphology and the degree of canal curvature are required for successful therapy. The objective of this case report was to describe the endodontic treatment of lower right second molar with severely curved canal. A 24 year old female patient was referred to Conservative Dentistry Clinic, RSGM Universitas Padjadjaran

Abstract

for endodontic treatment on lower right second molar. Clinical examination revealed large cavity with pulp exposure. Periapical radiographic examination showed a 60 degree curvature in mesial root and a periapical lesion with periapical index score 4 in the distal root. This tooth was diagnosed as pulp necrosis with chronic apical abscess according to American Association of Endodontists. The treatment stages were access opening, root canal negotiation using precurved file (D FINDER, Mani), root canal preparation with rotary file (HiFlex CM, Coltene), calcium hydroxide as interappointment medicament, obturation with lateral condensation technique and resin based sealer (AH26, Dentsply) and composite overlay as final restoration. Preoperative assessment of the curved canal and proper instrumentation technique was necessary to avoid procedural errors and successfully treat this case.

**Abstract 393**

**Intentional endodontic treatment of dens invaginatus Type II in maxillary lateral incisor for orthodontic and aesthetic considerations: A case report**

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Dens invaginatus (DI) is a developmental anomaly of a tooth attributed by epithelial invagination in a developing tooth crown and/or the root surface before mineralization. In type II DI, the epithelium invaginates into the root and affects the anatomy of the crown, with high incidence in lateral maxillary incisor. The crown is rather wider and often contributes to anterior teeth shifting and aesthetically disturbed. Orthodontic appliance in conjunction with anatomical correction of tooth with DI can be done to gain anterior space. This case report aims to describe the intentionally root canal treated type II DI of a 25 year old female with midline shifted maxillary anterior teeth. CBCT was taken to capture the anatomy of root canal system. Endodontic treatment was planned with a decision to preserve the dens invaginatus in order to maintain structural strength of the root. The treatment initiated with access opening; four orifices were found, one orifice of the invagination was located in the middle, and three other orifices namely palatal, distal and mesial were located in form of a symmetrical triangle. Subsequently, root canals were cleaned and shaped with step back technique using K-file stainless steel hand instrument (Dentsply), and obturated with warm vertical compaction technique (SybronEndo). Finally, the tooth was coronally sealed with SDR (Dentsply), followed by bulkfill resin composite (3M). The anatomy of the tooth was corrected afterwards, with palatal, mesial and distal tooth reduction to mimic the shape of lateral incisor and to gain space for ideal anterior teeth alignment. Difficulties were encountered during endodontic treatment due to the complexity of root canal anatomy, therefore understanding the tooth anatomy, 3D imaging evaluation using CBCT and working under magnification were essential for successful treatment.

**Abstract 394**

**Preendodontic evaluation of mandibular premolars: Need of the hour**

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Mandibular premolars typically present with a single root and a single canal. However complex anatomical abnormalities have been described in mandibular premolars, rendering them one of the most challenging teeth to treat endodontically. Canal configurations in mandibular premolars may vary significantly with respect to ethnicity, race and sex. Recent imaging techniques and population-based evaluations have provided more information about mandibular premolar architecture and its intrinsic variability. Possible anatomic variations in mandibular premolars are bifurcation of canals (23–30%) terminating in multiple apical foramina (15–20%), as compared to second premolars, second premolars with multiple canals in Caucasian, Indian, and Middle Eastern populations, a deep mesial radicular invagination of first premolars, prevalent type 1 canal configurations in first premolars and association between ethnicity, root canal morphology across population groups in first and second premolars. Fusion or gemination, fusion with adjacent or supernumerary teeth, dens invaginatus, dens evaginatus, taurodontism, C-shaped canals, and supernumerary premolars are some of the other developmental anatomic variants of mandibular premolars. Prior to actually starting root canal therapy, every clinician consults the blueprint of tooth anatomy. The large amount of data on tooth anatomy available to researchers allows for a better knowledge of the internal anatomy of the tooth and its many variants. Thorough preoperative clinical assessment, meticulous observation of the coronal and radicular anatomy and landmarks, accurate straight and angled preoperative radiographs, use of three dimensional imaging for complex root canal anatomies, preparation of a buccolingually directed oval access cavity if a second canal (or bifurcation) is suspected, coronal enlargement, enhanced illumination, and magnification for detecting variations in the morphology are the various aids for a successful endodontic procedure in premolars. Hence to ensure endodontic success, a detailed understanding of normal anatomy and common deviations is essential.

**Abstract 395**

**A comparative evaluation of cyclic fatigue resistance of hyflex EDM, Plex V and Superendo files in continuous rotary motion : An *in vitro* study**

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**Aim:** The purpose of this study was to evaluate the resistance to cyclic fatigue of Hyflex EDM, Plex V and Superendo files in continuous motion.

**Subjects and Methods:** A total of 5 new size 25.06 taper Hyflex Edm files, Plex V 25.06 taper files and Superendo 25.06 taper files

each were selected. A cyclic fatigue testing device with stainless steel canal with a 90° angle of curvature and 3 mm width; curvature starting at 6 mm from the tip was used. All instruments were rotated till fracture occurred and time till fracture of each instrument was recorded in seconds.

**Statistical Analysis Used:** Data were analyzed using ANOVA.

**Results:** All the files showed superior resistance to cyclic fatigue in continuous motion. Hyflex EDM primary files displayed maximum resistance to cyclic fatigue both in continuous motion. Followed by Superendo and Plex V files exhibiting least resistance.

**Conclusion:** Hyflex EDM files showed better cyclic fatigue resistance at apical curvature compared to other files.

### Abstract 396

#### Endodontic micro: Robot

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Endodontic therapy which is known as the Root Canal Treatment is a process to remove the damaged pulp tissue from the root canal space of the tooth and sealing the root canal to prevent from being a source of infection. The treatment success rate is almost 60-65% by general dentists and 90% by the specialists. The treatment is also time consuming and highly prone to human errors (or) mishaps. The Use of modern machining technology can remove human factors from this process and increase the success quotient through the accuracy inherent in modern machining. This computer controlled machine can be mounted on the tooth of interest within the patient's oral cavity. The help of Online monitoring and intelligent control, this micro machine will be subjected to perform automated probing, drilling, shaping and filling of the root canal. Thus a micro robot has been built. Here, a two dimensional X-rays of tooth can be converted to a Three dimensional (3D) of a root canal path. Built in micro sensors are placed to monitor the actions of the micro – robot. Computer Numerical Code (CNC) code is generated by the CAD/CAM software from these images. This code can then be fed into a CNC code interpreter to drive the micro robot and prepare the root canal. An Endodontic Micro – Robot has to be built mainly for reducing the reliance on the skills of the dentist, minimizing the human errors and thereby offering a method for precise diagnosis and treatment. Three Design concepts were suggested and compared to determine the best efficient working model of an Endodontic Micro – robot. This review paper mainly describes about the Design process, Manufacturing process, assembly and testing. Ultimately, also discusses about Scheduling and the approximate Budget of an Endodontic Micro – Robot. Though this micro – robot has a steep learning curve, there is no doubt that it is going to be the biggest revolution in the field of Endodontics.

### Abstract 397

#### Efficacy of 70% ethanol in removal of two types of calcium hydroxide intracanal medicament with and without passive ultrasonic irrigation: An *in-vitro* stereomicroscopic study

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**Introduction:** Calcium hydroxide is often used as intracanal medicament, however, its complete removal from root canal system poses a challenge even today. Studies using 70% alcohol, a known surface tension depressant, with the aim to remove calcium hydroxide from root canals are lacking. Hence, purpose of this study was to assess cleanliness of root canal walls after attempting to remove two types of calcium hydroxide: aqueous-based (Ultracal) and oil-based (Metapex) using 70% ethanol with and without passive ultrasonic irrigation (PUI).

**Materials and Methods:** 48 single rooted teeth were sectioned to uniform length of 15mm. After root canal instrumentation, tooth samples were divided into 2 groups (n=24) and filled with either Ultracal or Metapex inserted upto 3mm from working length using a Lentulospiral. Samples were incubated at 37°C and 100% humidity for 7 days. The root canal was initially irrigated with 10mL saline solution and reinstrumented with master apical file to remove bulk of placed calcium hydroxide. Samples in each group were then randomly assigned into 2 subgroups (n=12) for irrigation using 70% ethanol with and without PUI. A final flush with 5mL saline solution was performed. The tooth samples were sectioned longitudinally by diamond disk and chisel without entering root canals. Stereomicroscope images at 4.5X magnification were obtained and cleanliness of root canal walls was scored according to the scoring system given by Kuga et al (2010). The data were statistically analyzed by Kruskal–Wallis test, Mann–Whitney U test, Friedman's test and Wilcoxon tests, with significance level set at 5%.

**Results:** 70% ethanol effectively removed Ultracal from root canals. No significant differences were observed with non-activated or PUI protocols (P<0.05). In Metapex group, 70% ethanol irrigation with PUI showed significantly better cleaning efficiency than non-activated irrigation (P<0.05).

**Conclusions:** Use of 70% ethanol for removal of aqueous-based calcium hydroxide showed good cleaning efficacy in all thirds of the root canal regardless of irrigant activation. Moderate amount of remnants of oil-based calcium hydroxide were present with non-activated 70% ethanol irrigation but better cleanliness was seen with PUI. Removal of oil-based calcium hydroxide from root canal system is enhanced with 70% ethanol with PUI.

### Abstract 398

#### Dynamic navigation: Transforming the concept of minimal invasive endodontics

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With the great growing of digitalization in dentistry, digital technologies have become very common and fundamental in Endodontics. With advancements in computer technology and imaging, the guided surgical procedures are becoming choice with its edge. Essentially there are two types of guidance: static and

Abstract

dynamic. Static guidance refers to utilization of a fixed surgical stent, while Dynamic navigation integrates surgical instrumentation and radiologic images using an optical positioning device controlled by a dedicated computerized interface. A clinical real-time interface displays and guides users to drill into the targeted position through the prefixed trace according to the output of the preoperative planning software. The ideal drill position is planned virtually by the surgeon using the CBCT data set uploaded into the planning software. Sensors attached to the surgical handpiece and the patient's head or teeth transfer 3-dimensional spatial information to a stereotracker. It has been used in number of areas in medicine, in craniofacial surgery and implant dentistry. Dynamic navigation systems (DNSs) were originally introduced in dentistry in the US in 2000 to facilitate insertion of dental implants. High accuracy of dynamic navigation minimizes the potential risk of damage to critical anatomical structure. In endodontics, computer-aided guided navigation systems have demonstrated their potential for clinical practice. Guided endodontics for access cavity preparation and canal location in endodontics has focused on use of guides. DNS is more accurate and more efficient in locating canals in calcified human teeth as compared to free hand technique. This novel system results in significantly less tooth structure removal and a shorter operation time. The dynamic navigation system allows operator to precisely perform a minimally invasive osteotomy and root end resection during endodontic surgery. Dynamic navigation is a promising technology aiming at facilitating enhanced accuracy while performing surgical procedures and reducing the risk of iatrogenic errors. Minimal invasive protocols are the stepping stones to the future of endodontics. Although not much worked upon, DNS is a promising digital alternative management strategy.

**Abstract 399**

**A review cone beam computed tomography study of root canal morphology of permanent mandibular incisors in Indian population**

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Comprehension of the root canal system anatomy is an essential prerequisite for endodontic treatment. The lack of knowledge regarding morphological and anatomical variations of the root canal system can result in failure to identify all root canals and lead to inadequate instrumentations and consequent failure of endodontic treatment. The root canal anatomy of each tooth has certain commonly occurring characteristics as well as numerous atypical ones, understanding of which can be the road map to successful endodontics. The root canal morphology of permanent mandibular incisors is not simple, as it may be complicated by the presence of a second canal, lateral canals, and apical delta. Ideally, internal anatomical complexities, such as the number of canals, their shapes, and trajectories, including the presence of confluences and bifurcation should be assessed before undertaking instrumentation. The expected root canal anatomy dictates the location of the initial entry of access, dictates the size of the first file to be used, and

contributes to a rational approach in solving the problems that arise during therapy. The external and internal morphological features of roots are complex, and several classifications have been proposed to define the various types of canal configuration that occur commonly. Amongst the various methods for assessing root canal morphology, CBCT has recently become the most valuable tool as it reconstructs the projection data to provide the interrelational images in three orthogonal planes (axial, sagittal, and coronal). The aim of this review paper is to evaluate the different root canal morphology and configuration seen in permanent mandibular incisors in the Indian population based on the data collected from the year 2011 - 2021 published results.

**Abstract 400**

**Dental wings: The butterfly effect**

**SIMRANJIT KAUR**

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The butterfly effect is an optical phenomenon that occurs in transverse sections of roots as different shades of dentin. It is observed for endodontic reasons to measure the density of dentinal tubules. It has been attributed to dentinal tubular sclerosis that causes the light to refract and scatter. In sclerotic dentin, the tubules are occluded with calcified material, as a result the density of dentinal tubules is decreased that causes less light to scatter. Certain cross sections of root exhibit butterfly effect when observed under polarised microscopy because of dentinal translucency. Thus it is one of the significant parameters used for dental age estimation. Root translucency increases with age which signifies that butterfly effect is thus age related. The significance of the direction of butterfly effect correlates with root fracture following root resection and ultrasonic root end preparation. This may explain the prevalence of vertical root fracture that run buccolingually. Dentinal hypersensitivity is directly related to the number of dentinal tubules. The greater number of dentinal tubules in buccolingual surface of teeth makes them more susceptible to hypersensitivity. The presence of butterfly effect also impact sealer penetration into dentinal tubules. Additionally, dentin microhardness value decreases after treatment with calcium hydroxide and antibiotic paste over time intervals. Therefore antibiotic paste should be used with caution in endodontic treatment in teeth exhibiting butterfly effect. This review article thus describes that root sections with butterfly effect have lower density of tubules and thus have much clinical significance in Endodontics. Evaluation of butterfly effect could also be an important additional parameter while estimating adult age.

**Abstract 401**

**Anaesthetic efficacy of lidocaine as intra ligamentary injection in patients with irreversible pulpitis of mandibular teeth undergoing root canal therapy: A systematic review and meta-analysis**

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V PRABHAKAR, ANIRUDHAN SUBHA**

## Abstract

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**Aim:** To evaluate the efficacy of Lidocaine as Intraligamentary Injection compared to other supplementary anaesthetic methods and solutions in patients with Irreversible Pulpitis of mandibular teeth undergoing Root Canal Therapy.

**Methods:** A Protocol and search strategy were prepared based on the PICO question.

P- Patients reporting with irreversible pulpitis undergoing root canal therapy of mandibular teeth

I- Intraligamentary Injection with Lidocaine

C-Any other supplementary anaesthetic method

O-Anaesthetic efficacy of the method used

Records were identified through data bases like PubMed/MEDLINE, CTRI, LILACS, clinicaltrials.gov and Cochrane. The quality of the studies was assessed using the revised Cochrane risk of bias tool-2 (RoB 2). Meta-analysis and Forest-Plot of pooled data were conducted for eligible studies.

**Results:** 667 citations and 9 citations were identified through database search and manual search respectively. After removing duplicates and going through abstracts, 19 full-text articles were chosen and 13 articles met the inclusion criteria. Risk of bias analysis revealed 1 study had some concerns of bias, 4 study had high risk of bias and 8 studies had low risk of bias. Meta-analysis revealed pooled estimate of 0.77 with 95% Confidence Interval of 0-.31-1.91. I square value revealed moderate heterogeneity of the studies included in Meta-analysis.

**Conclusion:** Within the limitations of the study, it was observed that Lidocaine Intraligamentary Injection was more effective in achieving pulpal anaesthesia for patients with Irreversible Pulpitis undergoing Root Canal Therapy compared to other supplementary anaesthetic methods and solutions. However, there is a need to conduct more Randomized controlled trials to assess the efficacy of Lidocaine Intraligamentary injection compared to other methods.

### Abstract 402

**Biological restoration: To reincarnate or emanate?**

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Coronal fracture by trauma is the most frequent type of dental injury in permanent dentition. Most affected teeth are upper incisors due to anterior position and protrusion caused by the eruptive process. The tooth fragments can be obtained from the patient's own teeth or from the tooth bank. The restorations using these teeth are termed Biological restoration. The use of biological restoration with natural crown resulted in clinical success as well as recovered the proper functional anatomy of the tooth. Fragment reattachment using natural teeth provides excellent results regarding surface smoothness and the maintenance of the incisal guide in dental structures that cause physiological wear. Interdental posts of human dentin or "Biopins" are one possible option for permanent anterior vital teeth that require additional retention. Biopins provide a greater level of retention and stability in fractured vital teeth.

Extrusion of root filling materials into the periapical tissue causes inflammation, including foreign body reaction, and contributes to poor prognosis. Apical dentin chip plugs used root canal obturation and also in perforation, pulp regeneration, it acts as a reservoir of growth factor in regenerative endodontics. Post and core is the only satisfactory treatment option when more than half of coronal structure loss. Biological or dentinal post made of human extracted tooth provides resilience comparable to the natural tooth. It also provides good adhesion to the tooth structure by composite resin. A biological post is a feasible option for the strengthening of the root canal, because it reduces radicular dentin stress, biocompatible, preserves the internal dentin walls, adapts to canal configuration. This paper is a systemic review of the literature on biological restoration in endodontics.

### Abstract 403

**Retrieval of iatrogenic and self-introduced foreign bodies from the root canal: A case series**

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The diagnosis of foreign bodies lodged inside the root canal and the periapical region is usually accidental. These objects get implanted into the canal when the chamber is exposed due to a large carious lesion, traumatic injury, or in root canals left open for draining. These foreign objects may act as a potential source of pain and infection. The following case series illustrates the successful retrieval of both iatrogenic and self-introduced foreign bodies in order to facilitate non-surgical root canal treatment. The items retrieved from the canal were a metal wire, a stapler pin, pencil lead and an iatrogenically introduced diamond point. Endodontic treatment was successfully completed in all the four cases after the removal of the obstructions.

### Abstract 404

**Endodontic management of mandibular premolar with two roots**

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Successful endodontic treatment depends on thorough knowledge in root canal morphology, appropriate assessment of pulp chamber floor, critical interpretation of radiograph, and on biomechanical preparation followed by three dimensional obturation of root canal system. The possibility of additional root /canal should be considered even in teeth a low frequency of abnormal root canal anatomy. Mandibular premolars usually have single root with single root canal system. However numerous studies related to anatomic variations of mandibular premolar have been reported. The clinician should be aware of the configuration of the pulp system for the successful endodontic treatment. The incidence of two roots in these teeth are quite rare. This report presents the clinical management of mandibular premolar having two roots bifurcated at the midroot level.

## Abstract 405 Proresolving mediators in endodontics: A review

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The success of endodontic treatment is related to the prevention and healing of Apical Periodontitis, an inflammatory disease triggered by microorganisms infecting the root canal system after pulpal damage. A delay in the healing of Apical Periodontitis may be because of an imbalance of the cytokines and inflammatory processes. During the inflammatory response, once the clearance of the pathogenic noxa has been achieved, tissue hemostasis is restored by a switch in the biosynthesis of lipid mediators toward the release of immunoresolvent molecules. Proresolving mediators are specialized molecules (SPMs) involved in active resolution of the inflammatory process by regulating tissue homeostasis. SPMs are derived from polyunsaturated fatty acids (PUFAs) of arachidonic acid and omega-3 fatty acids. Their primary mechanism of action is through the resolution of inflammatory pathosis without predisposing the host to an increased vulnerability to infections. They do not block the inflammatory process; instead they regulate inflammatory homeostasis. SPMs attenuate the production of proinflammatory cytokines such as Tumor Necrosis Factor alpha and interferon gamma and inhibit polymorphonuclear neutrophil and T-cell adhesion, infiltration and chemotaxis. The aim of this review is to bring evidence of the future potential application of Proresolving mediators in the prevention and treatment of endodontic disease. This will open the doors for new therapeutics as an adjunct to endodontic treatment.

## Abstract 406 Patients perception of quality of life post endodontic therapy and rehabilitation: A cross sectional study

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**Objective:** To assess the patient's perception of quality of life post endodontic therapy and rehabilitation. Description of the experimental design and materials and method- 232 adult, patients who underwent endodontic treatment were requested to fill a feedback form. The feedback form had 21 questions, for the patient seeking to assess their experience before, during, and after the endodontic treatment.

**Results:** The feedback form was filled by 55% females and 45% male patients. 64% of the patients had chief complain of pain, and 30% had swelling before the root canal treatment. 75% of patients had their root canal treatment done in the posterior region and 18% had a root canal treated tooth in the anterior region. 60% of the patients got their root canal treatment done by an endodontist and 30% of patients got it done by a general dentist. 56% of the patients

said that they did not experience any pain during the root canal treatment, also almost 80% of the patients were relieved of pain after the endodontic therapy. 95% of patients said that the current status of their root canal-treated tooth is healthy and satisfactory. Only 17% of patients had difficulty in mastication after the root canal treatment and only 12% of patients had difficulty in cleaning their teeth. Others faced no problem in their daily oral functions. 81% of patients think there is a notable improvement in their daily routine and normal oral functions after restoring a tooth/teeth with root canal treatment. 94% of people said that they would recommend their kins to restore their tooth with endodontic treatment instead of extracting it.

**Conclusion:** It is very apparent that endodontic therapy relieved pain and restored the function of the tooth, thus it improved the quality of life of patients. Patients who experienced pain, swelling, and pus discharge before the endodontic treatment were relieved of the symptoms after the treatment. Thus, we can conclude that patients who underwent endodontic treatment and restored their teeth are satisfied and have a better quality of life.

## Abstract 407 Evaluation and comparison of sealer penetrability and gap formation of ah plus, bioroot rcs and sealapex sealers to root dentin by scanning electron microscope analysis: An *in vitro* study

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**Aim:** To evaluate and compare the sealer penetrability and gap formation of root canal sealer to root dentin filled with sealers - AH Plus (Epoxy), Sealapex (Calcium Hydroxide) and BioRoot RCS (Bioceramic).

**Materials and Methods:** Twenty-seven mandibular second premolars were selected and radiographed at two angulations. The teeth were stored in labelled plastic vials containing artificial saliva and then randomly assigned to 3 groups based on the sealers:

Group 1- AH Plus, n = 9

Group 2- Sealapex, n = 9

Group 3- BioRoot RCS n = 9

Teeth were decoronated and conventional root canal therapy was done with Protaper universal rotary files. The three groups were filled using AH Plus, Sealapex, BioRoot RCS along with single cone technique. 1 mm sections at apical, middle and cervical 3rds were taken using water cooled low speed saw. All specimens were evaluated using Scanning Electron Microscopy.

**Statistical Analysis:** Statistical analysis was performed using Three Way ANOVA and Post Hoc test. Statistical Analysis was done with the help of SPSS software (version 16.0) for windows.

**Results:**

- Sealer penetrability - AH Plus(Group 1) > BioRoot RCS(Group 3) > Sealapex(Group 2).
- Gap formation - BioRoot RCS(Group 3) < AH Plus(Group 1) < Sealapex(Group 2).

**Conclusion:**

- Best Sealer penetration was seen in AH Plus followed by

Abstract

BioRoot RCS and finally by Sealapex.

- Penetration for AH Plus and Sealapex was seen at the coronal third than the middle third while BioRoot RCS sealer showed better penetration at the apical third.
- Minimum gap formation was observed with BioRoot RCS sealers when compared with the other 2 sealers.

#### Abstract 408

##### A review of *in vitro* and clinical studies for evidence based approach to treat C-shaped mandibular second molars

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C shaped canal, a common root canal variation in mandibular molar are often seen in root canal form having an elongated ribbon shaped arc (C shape). These canals are mostly seen in mandibular second molars as an extensive complex root canal system with the presence of fins or webs that connects individual mesial and distal canals. And hence, these canals presents a challenge in diagnosis, debridement and obturation. Diagnosis of C-shaped canal configuration before treatment can facilitate effective management, which will prevent irreparable damage that may put the tooth in severe jeopardy. For proper diagnosis a clinician must have a thorough knowledge of the anatomy of C-shaped canal and their radiographic interpretations to know which diagnostic tool is effective in diagnosing C-shaped canal. C-shaped canals has extensive canal complexities with the presence of fins and webs, which can pose a challenge for any file systems to instrument all the canal surface effectively, based on the evidence of micro-CT studies evaluating the percentage of un-instrumented areas in C-shaped canal by various file systems will help to discuss the efficacy of these file systems in instrumenting C-shaped canals. Complex anatomy of C-shaped canal makes a complete 3-D obturation very challenging. Based on the evidences of micro-CT, stereomicroscopic and cross-sectional digital photographic studies performed to evaluate the percentages of canal area occupied by gutta-percha, sealers, voids and time taken for filling by various obturation techniques will help to discuss their efficacy in obturating C-shaped canals. Hence, the aim of this review paper will focus on evidences available for diagnosing, instrumenting and obturation of the C-shaped mandibular second molar which would give an insight to the clinicians in their management.

#### Abstract 409

##### Antibacterial efficacy of calcium hydroxide alone and combinations of calcium hydroxide, chitosan and nisin as an intracanal medicament against *Enterococcus faecialis*: An *in vitro* study

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**Objective:** The purpose of this study was to evaluate and compare the antibacterial efficacy of Calcium hydroxide alone and

combinations of calcium hydroxide, chitosan and nisin as intracanal medicament against *Enterococcus faecalis*.

**Materials and Methods:** Intracanal dressings: Group 1 –Calcium Hydroxide , Group 2 – Chitosan +Nisin (1:1),Group 3- Calcium hydroxide ,Chitosan,Nisin (1:1:1) were taken on a culture plate inoculated with *E.faecalis*. After 24 h of incubation the bacterial colonies were isolated and suspended in 5 ml of infusion broth followed by incubation at 37°C for 4 h. 0.5 McFarland of the bacterial suspension was prepared and then cultured on Mueller–Hinton agar culture medium with the help of a sterile swab. In each culture plate, five wells were created with a sterile pipette for placement of the samples. Antibacterial activity was assessed using Agar diffusion test and results were noted as diameter of growth inhibition zone.

**Results:** Student-t test is done to analyse the results.Statistically significant difference of combination of calcium hydroxide,chitosan and nisin was observed as compared to the other groups. Antibacterial activity of calcium hydroxide,chitosan and nisin (Group C) ( $P < 0.001$ ) in combination was more efficacious as compared to calcium hydroxide (Group A) ( $P < 0.001$ )alone . Chitosan and nisin (Group B) ( $P < 0.001$ ) was least capable in elimination of *E. Faecialis*.  
**Conclusion:** In this present *in vitro* study , Intracanal dressing with combination of all the three intracanal medicaments calcium hydroxide,chitosan and nisin (1:1:1) showed better results as compared to calcium hydroxide alone followed by chitosan and nisin. Hence it can be estimated that the combination of conventional and newer medicament gives predictable outcome.

#### Abstract 410

##### Assessment of knowledge and practice about management of avulsed teeth with splinting among dentists in central India

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**Objective:** The aim of the study was to assess the knowledge and practice about the management of avulsed teeth with splinting among dentists in central India.

**Methodology:** A self-administered web-based close-ended questionnaire was conducted among the dentists in central India. The participants comprised of total 219 Dental Health Care Professionals (DHCPs) including General Dental Practitioners (GDPs), Post Graduate Students (PGs), and Specialists. The data were statistically analyzed by the Chi-Square test.

**Results:** In this survey, among all the participants (61.5%) of GDPs, (87.9%) of PGs, and (95.5%) of Specialists who have knowledge about IADT guidelines regarding the management of avulsed teeth. PGs and Specialists have significantly ( $p < 0.001$ ) better practice for the management of avulsed teeth with splinting than GDPs as they have more traumatic injury cases in practice.

**Conclusion:** The knowledge level on the management of avulsed teeth with splinting among general dental practitioners in central India needs to be improved. The utilization of International Association of Dental Traumatology guidelines for the management of dental traumatic injury should be recommended to increase the

Abstract

knowledge level and to ensure good treatment outcomes.

### Abstract 411

#### Cryotherapy: A new paradigm of treatment in endodontics

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Cryotherapy has been frequently applied in medicine and other fields of dentistry. It refers to decreasing the tissue temperature for therapeutic purposes. The concept of cryotherapy actually does not imply cooling the target tissue but rather extracting heat from the tissue of higher temperature to the subject of lower temperature. It has been primarily used for pain relief in sports injuries, tendonitis, sprains and lower back pain. However, in dentistry, cryotherapy has been used after intraoral excisional surgical procedures, periodontal surgery, and after extractions and implant placement and was found to be effective in reducing swelling and pain. In the field of endodontics, cryotherapy has been reported to be used after periradicular surgeries and during root canal treatment to minimize postoperative pain and inflammation. One important implementation of cryotherapy in endodontics is deep cryotherapy of nickel-titanium (NiTi) endodontic files, which offered enhanced cyclic fatigue resistance, reducing potential file separation. More recently, cryotherapy was successfully tried as a useful adjunct for hemostasis in vital pulp cryotherapy in conjunction with bioceramic materials. The concept of cryotherapy, its mechanism and physiological effect, and different applications of cryotherapy in endodontics are discussed in this review.

### Abstract 412

#### Assessment of C-reactive protein levels in acute apical abscess due to root canal infection

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Acute apical abscess is the most common form of dental abscess and is caused by infection of the root canal of the tooth. Apical abscess may contribute to low grade systemic inflammation associated with a generalized increase in systemic inflammatory mediators such as C-reactive protein (CRP), interleukin (IL)-1, IL-2, IL-6 and Immunoglobulin (IgA, IgG and IgM) levels. Recent studies indicate that apical periodontitis, acute alveolar abscess, and periodontal diseases are associated with elevation of CRP; however, the relationship between periapical abscess and CRP elevation, various treatment modalities and reduction in extra and intra oral swelling, reduction in pain and CRP level are unclear. Objective Aim of this study is to evaluate the serum levels of CRP in patients with acute Periapical abscess before and after Root canal treatment, reduction in extra and intra oral swelling and reduction in pain. Methodology In patients with acute apical abscess C –reactive proteins were evaluated before and after root canal treatment. Incision and drainage was done in whichever case necessary. Intracanal medication was placed. Protaper Gold file was used for

biomechanical preparation. PAI score of the corresponding tooth was noted. Pain and swelling reduction after RCT was assessed. Pain was evaluated using visual analogue scale (VAS), regarding swelling reduction patient was asked to evaluate subjectively whether the patient profile has returned to normal after the treatment and they were asked how many days it took for the swelling to resolve completely. Statistical analysis The Normality of variables was derived using Shapiro-Wilks test. As the variables were skewed, Wilcoxon signed rank test was applied to compare mean values between baseline and postoperative CRP levels. Results The present study concluded significant reduction in postoperative CRP levels compared to preop CRP levels after root canal treatment for patients with acute periapical abscess.

### Abstract 413

#### Current trends in the use of irrigant activation techniques among endodontist and general dentists in central India: A knowledge and practice based survey

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**Objective:** The objective of this study was to assess the knowledge and practice of Irrigant Activation Techniques among Endodontist and General Dentists in Central India.

**Methodology:** In this online survey a questionnaire consisting of 14 closed ended questions was distributed among Dental Health Care Professionals including Endodontists and General Dentists. Total 202 Responses were collected through google forms. The questionnaire included questions that are focused on Irrigation activation technique based on the knowledge and practice. Chi square test of proportion was done to assess the difference in proportion of the responses and “unpaired t test” was done to compare between the groups. All statistical analysis was doing using Statistical Packages of Social Science SPSS version 21 and p value less the 0.05 was considered statistically significant.

**Results:** The usage of irrigation activation technique was more in Endodontists as compared to general dentist. Our data indicated that most of the respondents use sodium hypochlorite (NaOCl) as the primary endodontic irrigant. Most commonly used irrigation activation technique use by participants is manual dynamic agitation. The mean knowledge score was significantly high among Endodontists as compared to the General dentists. ( $p < 0.05$ )

**Conclusion:** Irrigation activation techniques improve intracanal cleanliness, has better antimicrobial capacity, tissue dissolving property and smear layer removal therefore, their use is recommended throughout root canal preparation. Vast majority of the Endodontist in Central India use some form of Irrigation activation technique to improve the efficacy of irrigation. Various irrigation devices have been developed to give the effective cleaning and superior debris removal to replace the older needle irrigation method.

#### Abstract 414

### Caries proportion among diabetic patients under insulin therapy and oral hypoglycemic drugs

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**Aim:** To compare and evaluate caries proportion among diabetic patients under insulin therapy and oral hypoglycemic drugs.

**Materials and Methods:** A comparative cross sectional study was conducted in the General Medicine out patient division of Government Medical College, Kottayam among 35 – 65 year old adult patients with sample size of 240. 120 non diabetic patients were taken as control group; the type II diabetes mellitus group included 60 diabetic patients under insulin therapy and 60 patients under oral hypoglycemic drug therapy. Glycemic status of nondiabetic patients were assessed with glucometer, when no recent reports were available. After getting informed consent, data collection was done using a questionnaire. The dental examination was done using a standard mouth mirror, probe and DMFT score was calculated on each patient; oral hygiene status recorded using OHI-S. Statistical analysis was done by Chi-square test, Independent t-test and ANOVA (one way) test.

**Results:** Among diabetic patients, patients taking oral hypoglycemic drugs are more caries prone compared to patients under insulin therapy (p-value < 0.05).

**Conclusion:** Present study results indicate that diabetic patients under oral hypoglycemic drug therapy are at high risk of dental caries. So regular dental visits for diabetic patients under drug therapy are necessary for early detection of dental caries.

#### Abstract 415

### Guided endodontics – A pocket friendly approach: A case series

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Pulp canal obliteration (PCO) is the deposition of hard tissue within the root canal space. It is commonly associated with teeth having a history of trauma. In such cases, if root canal treatment is indicated, the treatment is more challenging compared to a tooth with a patent canal. The access cavity will be difficult to align correctly with loss of pericemental dentin. On the other hand, accessing the apical third of the root during periapical surgery can also be challenging, as it requires precision to reach the apical target without damaging the neighbouring anatomical structures. In cases of calcified canals and endodontic microsurgery, Guided endodontics can deliver more predictable treatment outcomes compared to conventional treatment strategies. It may avoid unnecessary removal of tissue, avoiding complications and therefore, improving the prognosis of treatment. Additive manufacturing, which is more colloquially referred to as 3D printing, is quickly approaching mainstream adoption as a highly flexible processing technique that can be applied to plastic, metal, ceramic, concrete and other building materials. This technology is

used in dentistry to make 3D models from the data obtained from CBCT. This presentation of three cases discusses about the use of guided endodontics in the management of pulp canal obliteration in maxillary central incisors and endodontic microsurgeries in an economical way.

#### Abstract 416

### Confocal laser scanning microscopic evaluation of tubular penetration of MTA fillapex and endosequence bioceramic sealer: An *in vitro* study

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**Aim:** To evaluate and compare the depth of sealer penetration of AH Plus, MTA Fillapex and Endosequence Bioceramic sealer by confocal laser scanning microscopic investigation.

**Materials and Methods:** 30 maxillary or mandibular single rooted, sound teeth were selected. Samples were decoronated at cemento-enamel junction to achieve a standardized root length of 14mm. Access opening and biomechanical preparation was done till #F3. Samples were divided into 3 groups for obturation using following sealers as, Group 1- AH Plus sealer, Group 2 – MTA Fillapex, Group 3- Endosequence Bioceramic sealer. Each tooth was sectioned perpendicular to its long axis in 1-mm-thick sections using a slow-speed handpiece at three different points measuring from the root apex 3, 6, and 9 mm. So three sections were obtained - coronal, middle and apical third of the samples. The depth of sealer penetration into dentinal tubules was calculated using confocal laser scanning microscope.

**Statistical Analysis:** Was done by using descriptive and inferential statistics using student's unpaired t test, one way ANOVA and Multiple Comparison: Tukey test and software used in the analysis were SPSS 24.0 version and GraphPad Prism 7.0 version and  $p < 0.05$  is considered as level of significance.

**Results:** Significant difference was found in mean depth of penetration between group 1 and group 3 ( $t=3.05, p=0.007$ ) and no significant difference was found between group 1 and group 2 ( $t=0.2, p=0.7$ ).

**Conclusion:** The depth of dentinal tubule penetration of sealer appears to be influenced by the chemical and physical characteristics of the materials. Endosequence Bioceramic sealers displayed deeper and more consistent penetration. MTA Fillapex showed comparable sealer penetration with AH Plus sealer. All the groups showed maximum penetration at coronal third, followed by the middle and apical third.

#### Abstract 417

### A drop of ink may make a million think!!

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The mechanical and biological functions of the body are geometrically controlled by the natural and intricate 3D features

## Abstract

of dental and craniofacial tissues. Despite the great need for regenerative strategies, the biomanufacturing methods that are primarily devoted to addressing the regeneration of various dental structures are very limited. For instance, current procedures exclusively rely on evoked bleeding and, the body's own ability to remodel the blood clot in the root canal. The few biofabrication-inspired methods that have been recently proposed are not yet close to being a clinical reality. Conventional biofabrication techniques possess limited reproducibility and versatility in their fabrication procedures because of complex anatomical geometries. Lately, novel 3D bioprinting endowed by the automated deposition process offers high reproducibility and significantly improved control over the architecture of the fabricated tissue constructs. Essentially, bioinks i.e., pre-programmed structures and geometries containing biomaterials and/or living cells, has tremendous potential to address this critical need in regenerative endodontics. These technologies are able to deposit living cells in a layer-by-layer fashion into a desired shape or pattern to produce complex tissue architectures. Recently, the 5D printing technique has been introduced which incorporates 3D printing data with local control composition of the biomimetic materials, and particles distributions to reproduce the real organ response during the physiology studies. Thus, bioprinting strategies have significant potential to improve the efficiency of translating tissue engineering applications into clinical practice. Various 3D printing technologies including microextrusion, inkjet, magnetic levitation, as well as laser and light lithography have been utilized for deposition and patterning of cell-laden bioinks, for precise positioning of cellularized scaffolds on-demand, either embedded in hydrogels or free from scaffold support. Hence, through this review, we aim to gather and share in-depth insights on the bioinks currently employed for regenerative endodontics. In addition, the paper outlines our views on how it impacts future innovations.

### Abstract 418

#### Rewalling: "Ars clavem" for successful endodontics

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**Aim:** The aim of the study was to assess the knowledge, attitude and practice about Pre-Endodontic Buildup among Postgraduates, Academicians and Practitioners who perform root canal treatment in India.

**Materials and Methods:** A cross sectional online survey was conducted among Postgraduates, Academicians and Private Practitioners who perform root canal treatment in India. About 160 participants enrolled anonymously and their consent was obtained. The information was collected from each participant through structured questionnaires (19 in number) containing answers in the form of multiple choices.

**Statistical Analysis:** Chi Square Goodness of Fit test was used to compare the distribution in the responses for the study questionnaire by the study participants. The level of significance was set at  $P < 0.05$ .

**Results:** The following was inferred from this study:

I. Overall knowledge score towards Pre-endodontic buildup was about 66.3%

II. Knowledge scores significantly differed among Endodontists (89.3%) and Non-endodontists (46.4%)

III. Lower Practice scores among Endodontists and Non endodontists were associated with lack of time while insufficient knowledge was mostly associated with Non endodontists.

**Conclusion:** The findings of this study suggests that efforts should be made to increase the awareness of Pre-endodontic buildup among Endodontists and Non endodontists to improve their practices and thereby enhance the success of treatment.

### Abstract 419

#### External cervical resorption: An overview

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External cervical resorption (ECR) is an aggressive form of dental hard tissue destruction initiating at the cervical aspect of the root surface, extending apicocoronally and circumferentially inside the dentin. It has an unclear etiology, despite the various case reports and clinical studies that have been conducted so far, exploring ECR. It is relatively uncommon and often misdiagnosed leading to improper management and undesirable outcomes eventually resulting in tooth loss. Over the past two decades, ECR has attracted increased interest. It is partly due to the combination of recent advancements in clinical assessment measures, such as improved radiographic detection with cone-beam computed tomographic imaging, novel micro-CT and histopathological assessment of ECR. This has helped providing additional insights into the nature of the lesion thereby facilitating development and improvement in the existing treatment methods for the condition. This review paper provides an overview of the recent developments pertaining to the etiology, histopathology, predisposing factors, diagnosis and treatment of External Cervical Resorption.

### Abstract 420

#### Lasers in endodontics: A review

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A laser (Light Amplification by Stimulated Emission of Radiation) is a device which transforms light of various frequencies into a chromatic radiation in the visible, infrared and ultraviolet regions with all the waves in phase capable of mobilizing immense heat and power when focused at close range. Use of lasers within scope of endodontic practice and research has increased significantly in past few years. The frequently used lasers in endodontics are Nd:YAG, Diode laser, Er:YAG, Er Cr:YSGG, He:Ne laser. Laser have been used as coadjuvant treatment in endodontic therapy to improve clinical procedures success rate. The purpose of this review is to summarize the laser application in endodontics such as their use in pulp diagnosis, laser

Abstract

doppler flowmetry, dentinal hypersensitivity, pulp capping, pulpotomy, disinfection of root canals through laser activated irrigation and surgical endodontics. The advantages of laser over currently used conventional methods and techniques are improved disinfection efficacy, more effective root canal cleaning, reduction of permeability, reduction of microleakage and elimination of need to use toxic solvents.

#### Abstract 421

### Lesions mimicking endodontic radiolucencies of non-endodontic origin

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Apical periodontitis lesions generally have an aetiology that is associated with necrosis and infection of the root canal system that manifests itself as the host defense response to microbial challenge. Such lesions are usually identified as radiolucency located at the apex of the teeth on radiographic examinations. These lesions could be chronic (eg, radicular cysts, granulomas, and chronic abscesses) or acute (eg, periradicular abscess or cellulitis) and represent approximately 90% of all periapical lesions. There are lesions of neoplastic sources such as cystic lesions of non-endodontic origin like nasopalatine duct cysts and anatomic variations such as a Stafne bone cavity (SBC) that when located in the periapical area of the teeth might radiographically and clinically mimic lesions of endodontic origin, especially when associated with teeth with pulp necrosis or that were previously treated endodontically, leading to misdiagnosis and an ineffective therapeutic protocol. Hence, clinical and radiological aspects as well as analysis of the patients' medical history, pulp vitality tests, and aspiration are essential tools to develop a correct diagnosis of endodontic lesions. This narrative review aims to analyse the cases and literature in relation to the lesions located in apical area of teeth with a non-endodontic source mimicking endodontic radiolucencies.

#### Abstract 422

### Comparative evaluation of degree of post endodontic pain following obturation with cold lateral condensation and thermoplasticized gutta-percha technique: A randomized clinical trial

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**Aim:** Comparative evaluation of degree of pain post endodontic pain following obturation with cold lateral condensation and thermoplasticized gutta-percha technique.

**Materials and Methods:** In the present study, thirty molars were included. Case history was recorded. Maxillary and mandibular arch anesthesia was given with 2% lignocaine with 1:80,000 epinephrine local anesthesia. Access cavities were made, Canal orifices were located and canal patency checked with #10 K-file. Coronal and middle third were enlarged with S-X Protaper files. Canal orifices were enlarged with the help of Gates-Glidden drills G1-G3. Determination of working length were made with apex locator and with radiographs. Canals were prepared and shaped using crown

down techniques with both manual and rotary instrumentation. During whole instrumentation RC Prep was used as canal lubricant and 2.5% NaOCl as irrigant followed by 17% EDTA and final flush with saline. The canals orifices were protected with sterile dry cotton pellet and the access cavities were sealed temporarily with cavit. After one week patients was recalled and the canals were re-opened, and obturation was performed. The root canal fillings were divided into two groups. Group A (n=15) obturation with cold lateral condensation Group B (n=15) obturation with thermoplasticized gutta percha with help of VDW befill 2 in 1 system. 10-cm visual analogue scale (VAS) was used to record postoperative pain.

**Results:** The result of visual analogue scale showed that there was more post endodontic pain (PEP) in Cold lateral obturation technique than Thermoplastized GP obturation technique. At 6 hrs Group A had mean value 2.86 whereas Group B had 2.13 which was not significant, but there was significant change ( $p < 0.05$ ) at 12 hrs.

**Conclusion:** Within the limitation of the study, more post endodontic pain was seen with cold lateral obturation than thermoplasticized obturation. It was seen that females had more PEP than males, symptomatic teeth, teeth diagnosed with apical periodontitis and vital teeth had more PEP.

#### Abstract 423

### A broad review on arginine and its application in dentistry

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Caries is one of the most common childhood diseases. The disease arises as the result of a complex interaction of many factors. All tooth surfaces are covered with a thin biofilm to which bacteria adhere and mature. As well as substrate in the saliva, the biofilm bacteria may also utilize dietary sugars as a substrate, producing acid, mainly lactic acid. Bacterial activity leads to a drop in the pH, which eventually leads to the dissolution of the hydroxyapatite crystals of the enamel. Arginine is an amino acid that occurs naturally in a range of food products and in the saliva. It is metabolized by arginolytic bacteria which produce ammonia-like substance, which leads to an increase in the pH in the oral biofilm. This thereby counteracts the acidic environment conducive to the growth of acid-resistant bacteria. The ammonia produced by the ADS (Arginine Deiminase System) pathway from arginine helps in reducing caries externally present in saliva. Clinical studies have shown that external supplements of arginine have a profound impact on both non-caries and active caries individuals through ADS activity. Ammonia production from this pathway protects bacteria from lethal acidification, and ATP production provides a source of energy for the cells. The purpose of this literature review is to evaluate the evidence supporting the significance of arginine and its associated mechanism of action, To check its Potential to promote remineralization and decrease dentinal hypersensitivity and to Provide oral health professionals with recommendations for using arginine in clinical practice.

### Abstract 424

#### Therapeutic effects of curcumin in root canal procedure: A review

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Endodontic infections are biofilm mediated pathosis. Elimination of this biofilm is essential for successful root canal therapy. But, due to complex structure of the biofilm and anatomic complexities in the root canal, bacteria are resistant to conventional disinfection therapy by sodium hypochlorite. Also, sodium hypochlorite has shown to be cytotoxic and its inability to completely remove the smear layer requires an additional irrigant. Hence, there is a need for a newer irrigant with potential antimicrobial activity and reduced cytotoxicity. Herbal plants and their extracts are considered safe in comparison to synthetic compounds as they lack major side-effects. In this regard, there is relatively little focus on natural medicinal plant extracts. Curcumin, a phytochemical obtained from rhizomes of *Curcuma longa* shows broad spectrum antimicrobial activity. It is a commonly used spice, colouring and flavouring agent used in South Asian countries. Over the last decade, Curcumin is becoming popular in Endodontics due to its multifunctional effects like antimicrobial, antifungal, antiviral, antiseptic and anti-oxidant properties. Curcumin, a natural photosensitizer also has improved photophysical properties, provides targeted therapy, less cytotoxicity and cost-effective. Several invitro studies are performed which shows Photoactivated curcumin, Curcumin-modified fibers and Nano-curcumin particles to be an effective adjunct in root canal disinfection against resistant gram-positive bacterial species. Recently, Curcumin complexes are proven effective against *Candida* present in conjugation with these bacterial species in the root canal system. Also, adjunctive Photodynamic therapy with curcumin did not have an impact on the bond strength values of certain sealers to the root dentin. Thus, the aim of this study is to perform a review on the existing literature about Curcumin and its varied applications for root canal therapy.

### Abstract 425

#### A comparative study on healing outcome in chronic apical periodontitis obturated using bioceramic and zinc oxide eugenol based sealers

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**Objective:** The objective of this study was to compare the incidence of crack formation on root dentin after shaping with four shaping files based on offset shape in cross section, thermal treatment, variable cross - section and slim NiTi wire design.

**Materials and Methods:** Forty freshly extracted permanent mandibular first premolar teeth were selected. Samples were divided into four groups (n = 10), Group 1 – One-curve (Micro-Mega) Group 2 – TruNatomy (Dentsply Sirona) Group 3 – ProTaper Gold (Dentsply Sirona) Group 4 –. ProTaper Next (Dentsply Sirona) Shaping of pulp space were done for all specimens in each group [Group 1 – with One-Curve, Group 2 -TruNatomy PRIME, Group 3 - up to ProTaper

Gold F2, Group 4 – up to ProTaper Next X2] Roots were sectioned horizontally of length 4mm, from coronal, middle and apical third using diamond disc. All slices were then viewed under CBCT.

**Statistical Analysis:** Chi-square test.

**Results:** TruNatomy files inflicted less dentinal cracks, followed by one curve, ProTaper Next and ProTaper Gold. Crack formation were more in the apical third when compared to middle and coronal thirds.

**Conclusion:** All shaping files might inflict dentinal cracks. In this study, single file system induced less dentinal cracks in coronal, middle and apical third of the pulp space than multiple file system.

### Abstract 426

#### Reattachment of fractured anterior tooth segment: A case report

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Crown fractures are the most common consequences of traumatic injuries that mainly occur in the anterior teeth, especially maxillary incisors. One of the options for managing coronal tooth fractures when the fragment is available with no or minimal violation of the biological width, is the reattachment of the dental fragment. As the dental bonding technology advances, it is now possible to achieve excellent results with reattachment of dislocated tooth fragments. Furthermore, the use of natural tooth substance eliminates the problems of differential restorative material wear, mismatched shades and difficulty in reproduction of texture and contour. This paper reports a case of a Maxillary Central Incisor with an Ellis Class III fracture, with a mobile tooth fragment. After Endodontic and Periodontic evaluation, the tooth was immediately endodontically treated, and obturation was carried out. This was followed by insertion of pre-fabricated fibre post. Reattachment of the fractured fragment, that was in sound condition, was done using a resin based cement. Final finishing and polishing was carried out of the entire crown structure. A specialized interdisciplinary treatment plan led to the restoration of the original tooth form, function and esthetics.

### Abstract 427

#### Evaluation of postoperative pain following reciprocating and continuous rotary heat-treated NiTi instrumentation of root canals: A randomized clinical trial

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**Aim:** To evaluate post-operative pain following continuous vs reciprocating rotary motion in maxillary premolars with acute irreversible pulpitis.

**Materials and Methods:** A total of 180 patients were shown to be sufficient for detecting statistically significant difference with G\*Power software 3.1.9.2 (Universtät Kiel, Germany) (effect size-0.3,  $\alpha$  error prob – 0.05 and power0.95). After obtaining the institutional ethical committee clearance and registered with ClinicalTrials.gov

Abstract

(NCT04655105) the patient recruitment was initiated. Patient were randomly assigned into four groups, group 1) Truanatomy,2) Hyflex EDM 3) Edge endo (reciprocating motion),4) Protaper gold. Pre-treatment pain were categorized on a 10-point visual analog scale (VAS) with 1- 3 as mild; 4-7 – moderate; and 8-10 – severe pain. Root canal treatment was completed in single appointment, sodium hypochlorite 3% was used as irrigant and irrigant activation was done with manual dynamic agitation, obturation was done with zoe sealer using single cone obturation technique and GIC entrance filling was given in same appointment. The post-operative pain levels and the need for analgesics were recorded after 24, 48 hrs and 7 days by telephoning each patient to question them. Post-operative pain triggering mechanism was ascertained whether it was spontaneous, or stimulus based. The post-operative pain was evaluated with same 10-point VAS used earlier.

**Statistical Analysis:** normality of variables was assessed, and pre-op & post-op pain was compared using Kruskal wallis test.

**Results:** post-operative pain reduction was near significant in reciprocation mode (edge endo file) when compared to other continuous file rotation groups. Regarding post-operative analgesic intake there is significant difference between Tru-anatomy and Edge-Endo group regarding number of dose and need for analgesic intake with least post-operative analgesic intake in the latter.

#### Abstract 428

##### Cyclic fatigue testing of three different NiTi endodontic instruments in simulated curved canals: *In vitro* study

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**Aim:** Present study was to evaluate and compare the cyclic fatigue resistance of three different types of nickel titanium endodontic (NiTi) rotary files ( Hyflex CM, Hyflex EDM, ProTaper Gold) in simulated Curved (abrupt) canals and Double curved (S-shaped) canals.

**Materials and Methods:** Sixty rotary nickel titanium instruments were used for analysis in this study. They divided into three groups based on the different cross sections. Three groups were further divided into two sub groups based on radius of curvatures. Ten files were tested in each sub-group. Continuous rotation motion using a X-SMART PLUS motor set at continuous rotation mode with recommended torque control setting and at a constant speed of 500 rpm, 400rpm, 300rpm and 2.5 N.cm torque to obtain the number of cycles to fracture (NCF) for each instrument.

**Results:** One Way ANOVA and Post Hoc Tukey Analysis to find the difference between the groups. Comparing the cyclic fatigue resistance of three different types of nickel titanium endodontic (NiTi) rotary files Hyflex CM (Group A), Hyflex EDM (Group B), ProTaper Gold (Group C), in single curvature, Hyflex EDM (Group B) is having highest mean +/- SD of  $10238.51 \pm 556.56$  followed by Hyflex CM (Group A) with mean +/-SD of  $7689.99 \pm 769.41$  and ProTaper Gold (Group C)with the mean +/-SD of  $3047 \pm 2384.15$  whereas in double curvature, Hyflex EDM (Group B) is having highest mean and SD of  $6148.84 \pm 920.48$  followed by Hyflex CM (Group A) with  $1896.86 \pm 339.18$  and ProTaper Gold (Group C) with the mean  $\pm$  SD

of  $1086.21 \pm 1491.30$ .

**Conclusion:** Hyflex EDM (Group B) exhibited highest cyclic fatigue resistance followed by Hyflex CM (Group A) and ProTaper gold (Group C) NiTi rotary files in both single curvature and double curvature.

#### Abstract 429

##### Current trends and future prospective of vital pulp therapy: A literature review

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Dental pulp is a unique connective tissue and is enclosed within mineralized structures of tooth. Embryologically, histologically and functionally the dentin and the pulp are the same, hence referred as “the dentin-pulp complex”. As pulp tissue is enclosed within hard tissues, it has low compliance against trauma such as dental caries, bacteria, restorative materials, which results in frequent removal of pulp for endodontic therapy. Loss of pulp tissue frequently leads to fragility of tooth and eventually deterioration in patient's quality of life. Vital pulp therapy aims in maintaining the vitality of dental pulp and also to stimulate the remaining pulp to regenerate the dentin- pulp complex. Currently the bio-ceramic cements with better biocompatibility and sealing properties, has the ability to chemically stimulate dental pulp for dentinogenesis, and has made vital pulp therapy more predictable. Also, with the advances in pulp biology, novel ideas for preservation and regeneration of dental pulp using new biomaterials which can naturally induce the process of dentinogenesis has been proposed in the literature. Repair of human dental pulp is a complicated cellular and molecular process and various growth factors such as transforming growth factor beta (TGF- $\beta$ ), bone morphogenic proteins (BMPs), insulin-like growth factors, fibroblast growth factor, and platelet derived growth factors, may take part in these processes. Transforming growth factor beta-1 (TGF- $\beta$ 1) is an important factor involved in dental pulp tissue repair by stimulating cell proliferation, cell migration, and type I collagen synthesis, as well as mineralization. Current direct pulp capping is the reaction of dental pulp to the chemical stimulation. But ideal direct pulp capping materials/agents which induce dentinogenesis similar to natural biological process in pulp, can be effective strategies in future. Additionally application of anti-stimuli and/or anti-inflammatory agents i.e., pre-treatment agents in combination with direct pulp capping materials/agents may also be required along with strategies which uses biological markers, has considerable promise in dentin regeneration. This review will focus on current treatment strategies and potential approach for dental pulp preservation.

#### Abstract 430

##### The review of antibiotics during course of endodontic treatment by dentists in India: A comprehensive survey

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**Aim:** To describe an overview of prescribing antibiotics during

Abstract

endodontic treatment based on reports of Indian dentists.

**Materials and Methods:** A link for an online questionnaire consisting of two parts; the first part including personal information like name, age, designation of endodontic practice; the second part containing the questions related to decision about antibiotic while treating endodontic infections, was sent to dentists through google form. The data was analysed by applying appropriate statistical tests using SPSS v21.0 software.

**Results:** A total of 124 members responded to the questionnaire so far. The majority of the participants were general dentists (56.5%) while 4.8% were Endodontists. Majority of respondents (50%) reported duration of antibiotics prescription for 5 days followed by 3 days prescription (41%). Amoxicillin + Clavulanic acid was the first choice of antibiotic for 90.3% of the respondents. For patients allergic to penicillin, 38.7% of respondents prescribed Erythromycin followed by prescription of Cephalosporins by 23.5% of respondents. From the analysis, 30.6% respondents prescribed antibiotics to control spread of infections, and 4.8% respondents for swelling and pain. Study further revealed that dentists (39%) prescribed antibiotics for condition such as pulpitis where it was not indicated.

**Conclusion:** From this findings, antibiotics are overprescribed for the endodontic infections treatment, reinforcing the need for education regarding the use of antibiotics.

#### Abstract 431

##### Genotoxicity of root canal sealers

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Root canal sealers are widely used in endodontics to prevent reinfection and growth of surviving microorganisms. Genotoxicity is defined as toxicity that affects DNA structure, causing DNA lesions. Not all genotoxins act directly on the DNA molecule. Some genotoxins interact with DNA repair proteins, increasing mutation rate, or mitotic spindle proteins, leading to chromosomal misaggregation or even with proteins involved in the cell cycle, increasing the proliferation rate. Genotoxicity is a critical issue in determining the safety of agents that might contact biological structures and should be considered within a biological risk assessment process. Mutagens or genotoxic substances induce DNA damage directly or indirectly through inactivation of enzymes involved in the maintenance of genome integrity. The potential health risks of genetic damage is intimately linked to diseases such as cancer. Dental materials persist in the oral cavity for long periods which imply that risk assessment is required to ensure the safety profile of such materials. Due to the current demand of enhanced clinical performance of dental materials, the number of commercial products is continuously increasing. Physical properties, biocompatibility, sealing ability, adhesion, solubility, and antibacterial efficacy results are abundant for root canal sealers. However, genotoxic stress as a reaction to endodontic sealers is also an important parameter to be assessed to validate the safety of biomaterials in clinical practice.

#### Abstract 432

##### Rise in post covid complications and role of a dentist: A review

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The COVID-19 pandemic has hit the world in 2019 and since then the global population is widely affected. Changing trends and the unpredictable nature of the coronavirus have made it essential for the health care workers to give attention to the occurrence of newer manifestations for a longer duration of time, post-recovery. Post-Covid complications continue to trouble many, even days after recovering from COVID-19. The available data regarding the short-term and long-term consequences is still insufficient. This review article aims to provide information about the occurrence of newer signs and symptoms, aggravation of pre-existing oral conditions post-recovery, oral manifestations of coexisting systemic complications for early recognition and prevention of severity of the condition. These include serious opportunistic fungal infections such as COVID-19 associated mucormycosis (CAMCR), candidiasis, xerostomia, taste dysfunctions, Herpetic infections, vasculitis, hyperinflammatory response, aphthae like lesions/ulcers and erosions, white/red plaque, erythematous lesions, angina bullosa like lesions. That might be attributed to occur as a consequence of disease, pre-existing systemic conditions, steroid therapy, multidrug-resistant infections, intensive care therapy, overuse of antibiotics, and other invasive and non-invasive protocols for treatment of COVID-19. A dentist's prime role is to look for these manifestations to provide early diagnosis and dental care with a multidisciplinary approach, leading to serious complications if not watched out for.

#### Abstract 433

##### Bond strength and microleakage of nanocomposites: A systematic review

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**Objective:** For resin–dentin bonding, the depth of demineralization and completeness of monomer infiltration into this calcium-depleted zone are two important factors believed to affect the quality of dentin bond. The present review aims to establish a systematic review to describe the Bond strength and microleakage of Nanocomposite materials to enamel and dentine.

**Methods:** An electronic search was conducted in PubMed, Scopus, and Google scholar database. The MeSH terms were “nanocomposites”, “bond strength”, “microleakage”, “enamel”, “dentin”, “polymerisation shrinkage”. The database extracted was limited to the studies published between 2015-2020 and only human extracted teeth in-vitro studies were included. The PRISMA 2010 checklist was used to analyze the studies which were included in the systematic review.

**Results:** A total of 350 articles were retrieved through an electronic

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database, out of which 150 were excluded based on its title and abstract. After evaluating the article for its full-text articles, 12 studies were included in the systematic review, these articles were then assessed for its risk of bias according to the modified Cochrane risk of bias tool.

**Conclusion:** It could be concluded that the mechanical properties of nanocomposite are superior to those of traditional composites, nanofiller particles are radically different from filler particles in standard composites may be the explanation for this. In traditional composites, the primary particles tend to assemble into fibrous, low-density structures. Traditional composites' fibrous structure restricts filler loading and causes poor handling. The filler loading in nanocomposites is more consistent and have more compact filler particles, which allows for a greater volume of resin to be added. As a result, the mechanical properties of nanocomposites are found to be superior to those of traditional composites.

#### Abstract 434

##### A novel bio-ceramic healing material for endodontic management: A review

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The review investigated a new bio-ceramic repair material, Bio-C Repair (Angelus, Londrina, PR, Brazil), silicate-based hydraulic cement that is available in a ready-for-use format that does not need to be manipulated, with several clinical applications. Some of the advantages of Bio-C Repair material include its good physical properties and its ability to stimulate tissue regeneration as well as good pulpal response. According to the manufacturer, it exhibits excellent consistency that is easy to be applied, acts as a barrier against microorganisms, stimulates tissue healing, and does not contribute to discoloration. Bio C Repair has cytocompatibility, good biocompatibility, and a bio-mineralization potential that is comparable to Mineral Trioxide Aggregate. This review discusses the availability, composition, properties, and clinical applications of Bio-C Repair Material in Endodontic practice.

#### Abstract 435

##### Redox potential of saliva in dental caries: A systematic review

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Antioxidants play a vital role in our everyday life. They help in neutralizing or destroying ROS (Reactive Oxygen Species), RNS (Reactive Nitrogen Species) which cause oxidative stress. Oxidative stress is a state in which the free radicals in our body outnumber our antioxidant defences. This oxidative stress can affect the initiation and progression of many inflammatory and infectious diseases including dental caries. Saliva acts as the first-line defence against dental caries. The role of salivary antioxidants has been studied, and it was identified that an imbalance between free radicals and antioxidants

in saliva might play a significant role in the onset and progression of dental caries. This paper elaborates on the action of salivary Total Antioxidant Capacity and vitamin C and their levels in dental caries.

#### Abstract 436

##### Influence of irrigation systems on dentinal tubule penetration of bioceramic sealers: A review

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Bioceramic sealers gained popularity in the field of endodontics since 2009. Since then, the classic endodontic triad of Clean, Shape and Pack has been strongly accompanied by an additional factor encompassing the sealer material used to obturate the root canal. Bioceramic sealers act by diffusing the sealer particles in to the dentinal tubules to produce mechanical interlocking bonds, establishing a mineral infiltration zone by virtue of their alkalinity through collagen denaturation, formation of Hydroxyapatite along this mineral infiltration zone. The mechanism of action signifies the importance of dentinal tubule penetration of calcium silicate-based materials. On a parallel track, irrigation systems have been improved constantly in order to ensure complete disinfection of the deeper and inaccessible areas of the root canal. Various techniques like the positive pressure and negative pressure irrigation systems have been employed in the field to achieve better disinfection. The current study aims to review the literature available to measure the influence of irrigation systems on the depth of penetration of different bioceramic sealer materials.

#### Abstract 437

##### Ozonated water as an irrigant in disinfecting root canal systems: A systematic review

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**Objective:** To evaluate the efficacy of ozonated water as an irrigant in the disinfection of the root canal system.

**Materials and Methods:** The search was carried out on electronic databases PubMed and Google Scholar, ScienceDirect within the last 15 years. The systematic review was conducted according to PRISMA guidelines and methodological studies was assessed through the Cochrane risk of bias tools.

**Results:** Pinherio et al, ozonated water reduced microbial count by 98.02%. Recai zan et al, aqueous ozone 10ml/min for 4 and 5 mins showed no statistical difference while aqueous ozone 10ml/min for 3 and 5 mins showed the most statistical difference. SEM analysis indicated intertwined bacteria in the dentinal tubules and with 5 mins exposure to aqueous ozone showed fewer bacteria and intertubular surface showed roughness. Zeynep Goztas et al, there was no difference between 2.5% NaOCl and aqueous ozone. Estrella C et al, out of all the groups none of the Irrigants produced any antibacterial effect on E. faecalis over 20 mins contact time within infected root

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canals. Huth et al, Ozonated water eliminated nearly all *E. faecalis*, *C. albicans* as compared to gaseous ozone however none of the irrigants offered complete elimination of the microbial species as compared to NaOCl. Cardoso et al, first sampling revealed ozonated water reduced CFU of *E. faecalis* and *C. albicans* when compared to the control group. However, on second sampling, number of microorganisms had increased, also ozonated water had no effect in the neutralization of endotoxins. Hubbezoglu et al, manual irrigation with NaOCl offered 100% reduction of CFU while ozonated water reduced only 91.4% of the CFU however on ultrasonic activation, the CFU reduced by 100% with both NaOCl and ozonated water.

**Conclusion:** It could be concluded that ozonated water is not a better disinfecting irrigants than sodium hypochlorite and chlorhexidine in the disinfection of the root canal system, however it had almost comparable level of disinfection.

### Abstract 438

#### Applications of curcuma longa – The golden spice in endodontics: A narrative review

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Curcuma longa or Turmeric, popularly known as Golden Spice, belonging to the ginger family Zingiberaceae, has a long history of its therapeutic usage dating back nearly 4000 years. Apart from its use in various industries like food, cosmetics, and the medical field as a traditional remedy, it's even used in the dental field owing to its medicinal benefits. This article aims to highlight the various applications of Curcuma longa in the field of Endodontics.

### Abstract 439

#### Revascularization of immature permanent teeth with necrotic pulp and periapical pathology: Case series

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Necrotic immature teeth with periapical pathology present a challenge to dentists because the techniques used in apexification makes the tooth susceptible to fracture, since the root does not continue to grow in length and the canal walls are thin and fragile. However, revascularization allows the continued development of roots, enables the apical closure and thickening of dentinal walls. Two clinically and radiographically diagnosed necrotic immature permanent teeth were treated using revascularization procedure. Follow up has been done at 1st, 3rd, 6th and 12th month. This case series discusses the alternative treatment strategy for necrotic immature permanent tooth.

### Abstract 440

#### Root end surgery: The current facets: An overview

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Root end surgery is an endodontic surgical procedure that requires high precision. Outright indications for endodontic surgery can be, extremely calcified canals with periapical pathology, double curved roots where canal negotiation is difficult, blunderbuss shaped apex, external root resorption, combination of external and internal root resorption etc. It is often the last resort to maintain a tooth with periapical lesion that cannot be managed with conventional endodontic treatment. The foremost objective of root end surgery is to avert microbial leakage from the root canal system into the periradicular tissues by placing a fluid free seal. Thorough analysis of articles from 2015 to 2021 were done and conclusions were made. Clinicians are recommended to employ a microsurgical technique aided by magnification and illumination, to perform root end surgery with favourable outcomes. There has been changes in the surgical approach in root end surgery over the past decades. Gentle flap reflection, thereby reducing bleeding and post surgical scar formation, minimal osteotomy with elimination of bevel angle procedures are preferred over traditional ostectomy approach. Use of ultrasonic retro-tips for root end cavity preparation decreases the risk of perforation by its enhanced canal centering ability and minimizing the dentinal micro fractures. Ultra sonically prepared root end cavity preparation must be filled with a material that guarantees a hermetic seal. Studies have suggested that MTA exhibits properties of an ideal root end filling material. Magnification of 10X -16X is recommended for cavity preparation and higher magnification (20-25X) for final inspection of root end restoration. Application of endodontic surgery is not advised in posterior teeth because of the possible paresthesia in the mandibular arch and sinus infringement in the maxillary arch. A major step in apical surgery is to recognize possible seepage areas at the resected root face and successively guarantee adequate bacteria free root end filling. Only an adhesive and persistent root end obturation will permit periapical healing with upright long term prognosis.

### Abstract 441

#### Dissecting endodontics at the nano level

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India

Nanotechnology is defined as the study of manipulating matter on an atomic and molecular level. The use of nanotechnology in endodontics in the form of nanomaterials and Nano robots has gained quiet interest and it seems as the material of choice of near future. Nanomaterials are natural or manufactured materials which contain particles in an unbound state and tend to have unique physicochemical properties, such as large surface, ultra-small size, and increased chemical reactivity. In the field of endodontics, various inorganic, organic and bioactive nanomaterials are used as irrigants, as intracanal medicaments using different carriers or as endodontic sealers. This article reviews the effectiveness of different nanoparticles used in endodontics for

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better understanding their ability against the root canal flora. A major challenge encountered in root canal treatment is the inability, of the current cleaning and shaping procedures to totally eliminate bacterial biofilms surviving within the anatomic complexities. Since incorporation of nanoparticles is the present and future of endodontics, it is vital to know their merits and demerits when used during the root canal procedure. Improvements in the antimicrobial properties and mechanical properties of these materials, judicious and cautious use of these materials in regeneration of previously diseased tissue remains the main focus of nanomaterials in endodontics.

**Abstract 442**  
**Comparative evaluation of tensile bond strength of endodontic sealers to dentin and gutta percha: An *in-vitro* study**

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**Introduction:** Gutta percha when used in conjunction with endodontic sealer helps achieve three dimensional seal in root canals. Various compositions of endodontic sealers are available, that can be used along with gold standard gutta percha obturating material to attain this seal.

**Aim:** This study was done to evaluate the tensile bond strength of three different endodontic sealers to dentin and gutta percha.

**Materials and Methods:** 30 teeth were collected for the study and stored in isotonic saline solution. Flat root dentin sections, 4mm diameter were obtained by cutting in bucco-lingual direction at right angle to tooth's long axis, using diamond disc. Heat-softened gutta-percha cylinders of dimension 4mm were prepared. Based on sealers used, dentin sections and gutta percha cylinders were then divided into three groups, Group1(n=10)-AH Plus, Group2(n=10)-MTA, Group3(n=10)-GuttaFlow. Each group was further subdivided into Subgroup A (n=5)-Dentin and Subgroup B (n=5)-Gutta Percha. All the samples were then placed separately on Plexiglas, then aluminium cylinders were stabilized on individual substrates with small amounts of wax and then filled with respective sealer in each group and placed in 100% humidity at 37 degrees for 24 hours. Later these were subjected to the universal testing machine to assess the tensile bond strength.

**Statistical Analysis:** Two-way ANOVA (materials versus substrates) and Student-Newman-Keuls test.

**Results:** According to the results of the present study, the highest bond strength was observed in AH Plus. There was a significant difference between all the 3 groups of sealer with AH Plus showing highest bond strength to both dentin and gutta percha when compared to MTA Fillapex and GuttaFlow. Also GuttaFlow showed the least bond strength amongst the three sealers used in the present study.

**Conclusion:** Though adhesive strength is only one aspect of root canal sealers, it is considered one of the most important quality. All the sealers tested showed measurable adhesion to dentine and gutta percha. Although MTA Fillapex and GuttaFlow bioseal showed

lower tensile bond strength compared to that of AH Plus sealer, both presented acceptable resistance to dislodgement. Hence, use of these sealers with gutta percha for root canal treatment produce better results in endodontic treatment.

**Abstract 443**  
**Influence of different irrigant activation methods on apical debris extrusion and bacterial elimination from infected root canals**

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**Aim:** The study aimed to determine the amount of debris extruded apically and the microbial elimination from infected root canals after using 4 different irrigant activation methods.

**Materials and Methods:** 40 freshly extracted human mandibular premolars were selected and randomly assigned to 4 groups(n=10). All the teeth were mechanically prepared,sterilized and inoculated with E.faecalis for 1 week. The root canals were then irrigated and activated with 3% sodium hypochlorite using different activation methods- conventional syringe irrigation (Group 1),Manual Dynamic Agitation-MDA (Group 2),Passive Ultrasonic Irrigation-PUI- Ultra X (Group 3),Sonic Irrigation-SI- Endoactivator (Group4) and the extruded debris were collected in a previously described model by Myers and Montgomery. The microbial samples were taken from the irrigated canals using sterile paper points and the samples were cultured on blood agar medium and recorded as colony forming units. The Eppendorf tubes with debris were then stored in an incubator at 37° for 10 days. The amount of extruded debris were then measured by subtracting the weight from the initial weight of the tube. STATISTICAL ANALYSIS – Kruskal Wallis test followed by Mann Whitney's post hoc analysis was performed . The level of significance was set at P<0.05.

**Results:** I. The test results showed that Group 3 showed significantly least Apical Debris Extrusion as compared to Group 1, 2 & 4 at P<0.05 followed by group 2 & 1 and highest with group 4. II. The test results showed that Group 3 showed the least CFUs / ml, followed by group 4 and finally group 2 showing significantly lesser mean CFUs / ml as compared to group 1 at P<0.05.

**Conclusion:** I. All the irrigation activation methods were associated with apical extrusion of debris, with PUI system extruding significantly least amount of debris as compared to the other groups. II. Irrigation activation techniques were beneficial in reducing the microbial load from the infected canals with PUI system showing complete elimination of the microbes followed by SI and MDA.

**Abstract 444**  
**Revascularization of immature permanent tooth with apical periodontitis**

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## Abstract

Tissue engineering is a growing field. In the near future, it will probably be possible to generate a complete vital tooth from a single stem cell. Pulp revascularization is dependent on the ability of residual pulp and apical and periodontal stem cells to differentiate. These cells have the ability to generate a highly vascularized and a conjunctive rich living tissue that colonize the available pulp space. Revascularization is a new treatment method for immature necrotic permanent teeth. Up to now, apexification procedures were applied for these teeth, using calcium hydroxide or MTA to produce an artificial apical barrier. However, the pulp revascularization allows the stimulation of the apical development and the root maturation of immature teeth. This is a case report of successful revascularization of a nonvital upper front tooth of a 12 year old boy who visited the dental office with a chief complaint of fractured upper front tooth with a history of trauma 5 years back. On clinical testing and radiographic evaluation the tooth is found to be non vital with a radiolucent lesion at the apex. Triple antibiotic paste has placed in the non instrumented canal at the first visit for a period of 3 weeks. On second visit a sterile prick had made on the periapical tissue to induce bleeding, created a blood clot 4 mm apical to cemento enamel junction. On follow up visit over a period of 6 months, continued root end development has observed with evident dentinal wall thickening along with the attainment of root length. On 1 year follow up visit, the tooth has found to be functional, asymptomatic, and radiograph showed complete resolution of periapical radiolucency.

### Abstract 445

**Comparative evaluation of shear bond strength of MTA and a newer bioceramic material- 'Meta Bonemedik', with a dual cure composite resin- 'Multilink Speed' in regeneration**

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**Aim:** To compare and evaluate the shear bond strength of MTA and a newer bioceramic material - 'Meta Bonemedik', with a dual cure composite resin- 'Multilink Speed' in regenerative procedures. **MATERIALS AND METHODS:** Twenty wells in acrylic blocks were filled with bioceramic materials representing 2 groups (n=10): Angelus MTA (Angelus, Londrina, Brazil) and Meta bonemedik (Meta Bio Med Co. Ltd, South Korea). After allowing the samples to set according to the manufacturers instructions, exposed surfaces of the bioceramic materials were restored with Multilink Speed (Ivoclar Vivadent) composite resin. The samples were then allowed to set for 7 days at 37°C and 100% humidity to ensure absolute setting of the bioceramic material. Each block was then placed in a universal testing machine to test the shear bond strength and the crosshead was advanced at 0.5 mm/min until fracture.

**Statistical Analysis:** Independent Student t test results demonstrates that the mean shear bond strength of Angelus MTA was significantly higher ( $27.29 \pm 2.16$ ) as compared to Meta bonemedik ( $18.67 \pm 1.71$ ) with a mean difference of 8.62 MPa (95% CI 6.79 to 10.45 MPa) at  $P < 0.001$ .

**Results:** The mean shear bond strengths between Multilink Speed and Angelus MTA was 27.29 MPa and Multilink Speed and Meta

bonemedik was 18.67 MPa, therefore Angelus MTA showed higher bond strength than Meta bonemedik.

**Conclusion:** Within the limitations of this study, the shear bond strength was significantly higher in Angelus MTA than Meta bonemedik when used with a dual-cure composite resin. Higher bond strength indicates potentially decreased surface area susceptible to microleakage and thus reduces the probability of subsequent contamination of the pulp space in regenerative procedures.

### Abstract 446

**In vitro comparison of accuracy of three different apex locator in stimulated environmental conditions**

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Purpose of this in vitro study was to evaluate and compare the accuracy of RootZX mini, Apex ID and CANAL PRO Apex locators in determining working length in three different stimulated clinical conditions- 1. With irrigant (Naocl). 2. In open apex. 3. With blood and pulpal tissue. **MATERIALS AND METHODS-** Sample preparation-30 premolars divided in 3 groups. GROUP1-Samples containing 5% sodium hypochloride (n=10). GROUP 2-Samples with open apex (n=10) GROUP 3-Samples containing blood and pulpal tissue (n=10) All samples were embedded till CEJ in a plastic container containing alginate to stimulate periodontium. For electronic measurement size 15 K file was connected to the electronic apex locator used with lip electrode inserted in alginate model. Measurements are obtained using all three apex locators CANAL PRO, APEX ID, ROOT ZX MINI. **ACTUAL LENGTH DETERMINATION-** A 15K file is inserted to canal until file just became visible at the level of apical foramen seen through magnifying glass file is then measured with a digital caliper and from this 0.5 mm is subtracted this is the actual length. Mean value of these measurements was recorded for each samples and for each EAL the recorded AL is compared with values obtained with EAL. Working length obtained by each method was subjected to statistical analysis. **RESULTS OF DATA AND STATISTICAL ANALYSIS** With Naocl all apex locators showed 100% accuracy when subjected to Pearsons bivariate test. GROUP2-(Open apex) accuracy Canal pro-90%, Apex ID-80%, Root ZX min -60% with statistically significant difference ( $r < 0.01$ ). GROUP 3-(With blood and pulp)- accuracy Canal pro-90%, Apex ID(90%), Root ZX min (80%) with statistically significant difference ( $r < 0.01$ ). **CONCLUSION-** Root ZX mini showed 100%, 60%, 80% accuracy with irrigant, open apex and pulp tissue stimulated environment respectively within + or -0.5 mm from actual length. Apex ID showed 100%, 80%, 90% accuracy with irrigant, open apex and pulp tissue respectively within + or -0.5 mm of actual length. Canal pro showed 100%, 90%, 90% accuracy with irrigant, open apex and pulp tissue respectively within + or - 0.5 mm of actual length.

### Abstract 447

**Herbal extracts as intracanal medicament: A review**

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Abstract

The main purpose of root canal treatment is to eliminate the bacteria, and their toxins from the pulp space. The cleaning and shaping of the root canal reduces the microbial content to great extent, however the root canal anatomy provides area in which bacteria can persist and thrive. Therefore, there is a need of use of intracanal medicament in some cases to prevent weeping canals, reduce inflammation of periapical tissues in addition to the irrigants. Many herbal plants such as propolis, curcumin, aloe vera are used as phytomedicines in dentistry as they possess varying degree of biological and antibacterial effects. In endodontics, these are used as intracanal medicaments to overcome the potential side effects caused by chemical agents. This paper aims to provide a comprehensive review of various herbal endodontic medicaments evaluated for their effectiveness in the disinfection of root canal system.

**Abstract 448**

**Healodontics with MTA and PRF: A case series**

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The success of endodontic therapy depends on complete periapical repair and regeneration. Most of the time teeth with periapical lesions heal satisfactorily after non-surgical endodontic intervention. Abramovitz et al. discussed the guidelines of case selection for apical surgery and non-surgical retreatment. They reported that treatment of 24.5% of the cases was impossible without surgical therapy. Endodontic surgery includes the curettage of all periapical soft tissues and sometimes application of different biomaterials to enhance the new bone formation in the defect site. Currently, bioceramics like MTA is used as a retrograde filling material to overcome the shortcomings of earlier available alternatives. Bioceramics are biocompatible and support periradicular tissue regeneration. They also restrict the free flow of microbes and their toxins into the periapical tissues by providing a tight apical seal in the canal. The healing of hard and soft tissue is mediated by wide range of intra and extracellular events that are regulated by signalling proteins. Platelets play a crucial role not only in hemostasis, but also in wound healing process. Platelet rich fibrin is an autologous material comprising of platelets, leukocytes and growth factors enmeshed within a dense fibrous matrix. It is non-cytotoxic, can be obtained easily, does not dissolve freely, require minimal to no modifications before use and can stimulate regeneration of tissues. Recently, studies have demonstrated that the PRF membrane has a very significant slow sustained release of many key Growth Factors for at least 1 week and up to 28 days thereby helping in the healing process. The following case series depicts the healing after the endodontic microsurgeries using MTA as a retrograde filling material with or without the Platelet Rich Fibrin.

**Abstract 449**

**Orthograde retreatment after failed non-surgical and surgical endodontics: A case report**

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Endodontic failure may arise mainly from persistent intra-radicular infection from residual bacteria in the root canal. As a result, retreatment is the most appropriate way of dealing with failed cases. Many clinicians choose to perform periapical surgery, on the grounds that it has immediate results. Healing of refractory cases may be prevented by bacteria colonizing the root apex and surrounding periapical tissues. With failure of orthograde endodontic retreatment, periapical surgery may be indicated, but without elimination of bacteria from the root canal system, complete healing following apical surgery is unlikely. This report describes a case of mandibular incisors where, following the failure of endodontic treatment and apicoectomy, an orthograde retreatment procedure, using a long-term intra canal calcium hydroxide as an antimicrobial agent, was performed. This was followed by the formation of apical mineral trioxide aggregate (MTA) plug to promote root-end closure of the resected apex, and the periapical radiolucency eventually disappeared. MTA seems to be an effective root end filling material. Orthograde retreatment can be an efficient therapeutic option in case of failed peri-radicular surgery, provoked by remaining intra-canal microorganisms. Nevertheless, careful case selection should take place before the final decision.

**Abstract 450**

**An *in-vitro* fracture strength assessment of surgical endodontically treated teeth with different root-end filling materials**

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**Objective:** To assess and compare the fracture strength of surgical endodontically treated teeth when the retrograde preparations were restored either with Biodentine or Endosequence bioceramic root repair material (BC RRM) Fast set putty or Geristore.

**Methods:** One hundred and twenty human mandibular premolars were used and allocated into five groups randomly. Following conventional root canal treatment and resection of 3 mm of the root end, retrograde cavities of 3mm deep were prepared with ultrasonic tips. The teeth were divided into five groups (n=24 each): Group 1 (intact, sound teeth), Group 2 (without root-end filling), Group 3, 4, 5 retrocavities were filled with Biodentine, Endosequence bioceramic root repair material putty and Geristore, respectively. Thermo-mechanical cyclic loading (TMC) was performed for one section of samples (n=12 each) and the immediate and after TMC fracture resistance was evaluated using the Instron machine. To analyze the data statistically, a one-way ANOVA followed by Tukey's multiple post-hoc procedure was used.

**Results:** Intact teeth had shown the highest fracture strength values than all other four groups with significant differences statistically ( $P < 0.05$ ). Fracture strength values were not different among Endosequence and Biodentine group samples both immediately and after thermo-mechanical cyclic loading ( $P = 0.5987$  and  $0.9999$  respectively). The fracture strength was not different statistically between Geristore and without root-end filling groups.

Abstract

**Conclusion:** Endodontically treated teeth with Endosequence BCRRM or Biodentine root-end filled teeth had shown better fracture resistance. Retrofilling with Geristore was not able to improve fracture strength of root canal-treated teeth.

**Abstract 451**

**Effect of various irrigants on root dentin microhardness and smear layer removal**

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**Aim:** The objective of this study is to investigate the ability of smear layer removal by Fumaric acid and Etidronic acid in comparison with EDTA and their influence on root dentin microhardness using scanning electron microscopy.

**Materials and Methods:** Non-carious, single-rooted mandibular premolar teeth (n=108) were collected. For 96 teeth, conventional access cavity preparations were done and canals were prepared using the ProTaper rotary system upto file F3 (#30/09) using 2 ml of 3% sodium hypochlorite irrigation after each instrumentation. Later these teeth were divided into 2 groups (n=48 each) for evaluation of smear layer removal efficacy and root dentin microhardness. For smear removal, the canals were irrigated with 1 ml of test irrigants for 3 minutes i.e; normal saline (group I), 17% EDTA (group II), 18% Etidronic acid (group III) and 0.7% Fumaric acid (group IV). The roots were sectioned longitudinally and examined under the scanning electron microscope for evaluating the remnants of smear layer at different root regions. For evaluations of root dentin microhardness, teeth samples (n=48) were prepared using a similar irrigation protocol used for smear layer evaluation of samples. All the sample teeth along with control teeth (n=12) were sectioned in a mesio – distal direction and among the two halves, the most evident part was selected for root dentin microhardness evaluation.

**Results:** Irrigation with 0.7% fumaric acid resulted in effective smear layer removal at various levels of the root canal. However, it showed a significant reduction in root dentin microhardness when compared to other test irrigants. All the irrigants effectively removed smear in the coronal third of root canal and has shown least efficacy in apical thirds.

**Conclusion:** All the test irrigants were efficient in removing the smear layer, the most efficient being 0.7% fumaric acid. All the test irrigants altered root dentin hardness, but the least reduction was exhibited by 18% Etidronic acid and the highest reduction was observed with 0.7% fumaric acid.

**Abstract 452**

**Biomimetics in endodontics: A review**

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Biomimetics is defined as the study of the formation, structure, or function of biologically produced substances and materials and biological mechanisms and processes especially for the purpose of

synthesizing similar products by artificial mechanisms which mimic natural ones. (kottor 2013). As teeth do not have natural method of repair, biomimetic principles should be used to artificially repair tooth to its natural function and aesthetics. In biomimetic dentistry there are two aspects. One, the lost or missing dental tissue is restored, leading to the full return of the function and aesthetics to the teeth. Or the material used can regenerate, replicate or mimic the missing dental tissue. This article highlights on the past achievements, current developments and future prospects of tissue engineering and regenerative therapy in the field of endodontics.

**Abstract 453**

**Guided endodontics: Review**

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Guided endodontics- a new boon to endodontist in managing difficult case scenarios, in a better predictable and high success rates. The introduction of modern technologies in dentistry, like Cone Beam Computed Tomography (CBCT), 3-dimensional (3D) printing technology and a 3D surgical guide designed with computer-aided software have led way to this method of approach. This guided endodontic treatment deemed to be helpful in Accessing anterior teeth with calcified canals, morphologically anomalous teeth, apical surgery (Targeted Endodontic Microsurgery- TEMS), fibre post removal and more to be studied. They may use Static or Dynamic navigation to achieve a failproof access. The main advantage of this innovation its extremely detailed planning, relatively fast and safe execution technique, preserving the healthy tooth structure by conservative approach with minimal procedural errors, calculative approach thus preventing damage to the adjacent nerves and vessels during endodontic surgical procedures. This review brings to light the various application of this valuable tool in endodontic treatment plan.

**Abstract 454**

**Comparative evaluation of mechanical properties of graphene coated gutta-percha with conventional gutta-percha**

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**Introduction:** Various materials like Resin, glass ionomer cement, Bioceramic materials, Silver nanoparticles have been coated onto gutta-percha to enhance its mechanical properties. Significantly higher tensile strength have been recorded in chitosan coated gutta-percha as compared to conventional. Addition of graphene in composites and Glass ionomer cements have led to increase in their mechanical and antibacterial properties.

**Aims and Objectives:** This study aimed to evaluate and compare the ultimate tensile strength and percentage elongation of graphene coated gutta-percha (GCCGP) with conventional gutta-percha (CGP)

**Materials and Methods:** Experimental graphene oxide dispersion in organic solvent was prepared by mixing 2mg of graphene

## Abstract

oxide powder in 20ml of isopropanol solution and stirred with a mechanical stirrer. This solution was placed inside the bath sonicator for 20 minutes. The grey colored dispersion was left to stand for 1 hour to allow any unstable aggregates to form. A small level of sedimentation was observed at the end. 44 gutta-percha cones of ISO size 80 (0.80)2% taper (Sure Dent, Korea) were randomly distributed into two groups with 22 specimens each (n=22), as the graphene coated (GCGP) or non-coated gutta-percha (CGP). 22 CGP cones were used in the control group. The Gutta-percha cones of the experimental group (n=22), were swished in the graphene oxide dispersion once and kept to dry for 5 minutes. Ultimate tensile strength testing was carried on the specimens using a compressive load at a crosshead speed of 1.0 mm /min in an Instron Universal testing machine. Percentage elongation was calculated by dividing the elongation at the moment of rupture by the initial gauge length and multiplying by 100. Results were tabulated and subjected to unpaired t-test with the level of significance ( $p < 0.05$ ).

**Results:** The ultimate tensile strength was significantly higher for the GCGP ( $14.13 \pm 1.69$ ) when compared to CGP ( $11.15 \pm 0.90$ ). There was a significant difference in percentage elongation between CGP (92.63%) and GCGP (22.09%), ( $p < 0.001$ ).

**Conclusion:** Within the limits of this study, addition of graphene oxide significantly increased the ultimate tensile strength and reduced the percentage elongation of Gutta-percha.

### Abstract 455

#### Effect of irrigating solutions infused with chitosan nanoparticles on micro-hardness of root canal dentin: An *in-vitro* study

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**Aim:** To evaluate and compare the effect of endodontic irrigation solutions infused with chitosan nanoparticles on the micro-hardness of root canal dentin.

**Materials and Methods:** Fifty freshly extracted, single rooted mandibular premolars were selected and randomly divided into five groups (n=10). The irrigating solutions used are 0.2% Chitosan Nanoparticles (CNPs), 5.25% Sodium Hypochlorite (NaOCl) and 2% Chlorhexidine Gluconate (CHX). After instrumentation and biomechanical preparations the samples were irrigated with irrigating solutions respectively- Group I: with Saline (control), Group II: with NaOCl, Group III: with NaOCl-CNPs, Group IV: with CHX and Group V: CHX-CNPs, followed by final irrigation with distilled water. Specimens were cut into half then embedded in acrylic resin and evaluated for micro-hardness using Vickers hardness tester. Data obtained were analysed using one-way ANOVA with Tukey's Post-Hoc test.

**Results:** Micro hardness of root canal treated with different irrigating solution was found highest in Group IV (CHX) followed by Group V (CHX-CNPs), Group I (Saline), Group III (NaOCl-CNPs) and least microhardness was observed in Group II (NaOCl). Specimen irrigated with chitosan nanoparticle infused irrigating solution (Group III)

showed a significant increase in Vickers hardness number (VHN) value ( $p < 0.05$ ).

**Conclusion:** Teeth treated with irrigants (NaOCl) infused with chitosan nanoparticles showed higher microhardness values as compared to the irrigants without them. Teeth treated with 2% Chlorhexidine solution showed highest microhardness values. Thus, seems to be appropriate and ideal irrigating solution (because of its harmless effect on the microhardness).

### Abstract 456

#### Communication of endodontic mishaps and failures

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*Mishaps and failures have been a heartbreaking moment for every dentist. It is hard to admit one has failed and to retreat that case without any cost or referring to an experienced specialist.*

Doctor patient communication is of great importance in health care. The main goal of communication with patient is building a good rapport and create a trust towards doctor. This makes patient more comfortable during treatment. If a patient suffer pain even after endodontic treatment, in such scenario "trust" has a crucial role. If it loses, the patient will argue or complain about the quality of treatment. Failure to communicate with the patient is the main challenge to endodontist especially in failure cases. Around 90% of endodontic treatments are successful. However sometimes due to some procedural errors like instrument separation, unnoticed root canal, perforation, apical extrusion of debris etc may cause failure of root canal therapy. Endodontic procedures are usually performed as an emergency treatment. Patient visits our clinic majorly with pain and anxiety. These types of people are generally poor listeners. This is the main barrier for communication with patient. To minimize patient anxieties endodontist should explain the outcome, risk and complications that may occur during or even after the completion of the treatment. Any mishaps like instrument separation, perforation etc may occur during treatment and we should inform the patient about the same before he or she leaves the clinic. Also, endodontist should explain the potential complications that may occur and what can be done to solve such situations. The main cause of root canal failure is not placing proper post endodontic restoration at correct time. We should explain the need of these restorations before starting the treatment. Some patients may have reaction to the treatment like swelling, fever etc. Generally, patients blame his endodontist for such reactions. So, to avoid this the endodontist should explain that "every person has different type of immune responses towards treatment" before starting the procedure.

### Abstract 457

#### Dentin microhardness following use of different combinations of intracanal medicaments and vehicles in regenerative endodontics: An *in-vitro* study

Abstract

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**Aim:** To evaluate and compare the microhardness of dentin after use of intracanal medicaments calcium hypochlorite, triple antibiotic paste and calcium hydroxide, with propylene glycol and chitosan vehicles.

**Materials and Methods:** Thirty-nine freshly extracted single rooted mandibular premolars were selected and divided into seven groups. Teeth were decoronated at the cemento-enamel junction. Instrumentation and irrigation were performed. Then the following intracanal medicaments were placed.

Group 1 (C1)- Ca(OCl)<sub>2</sub> + chitosan

Group 2 (C2)- TAP + chitosan

Group 3 (C3)- Ca(OH)<sub>2</sub> + chitosan

Group 4 (P1)- Ca(OCl)<sub>2</sub> + propylene glycol

Group 5 (P2)- TAP + propylene glycol

Group 6 (P3)- Ca(OH)<sub>2</sub> + propylene glycol

Group 7 (S)- no medicament (irrigation using saline)

Specimens were then cut into two halves vertically. Specimens were then embedded in acrylic resin and then subjected to microhardness test using Vickers hardness tester.

The teeth were analysed statistically using One-way analysis of variance (ANOVA) and the comparison of means was conducted using Tukey's Post hoc test.

**Results:** There were significant differences in mean microhardness value between Group C3 and other groups except group C1. ( $P < .05$ ). The mean microhardness was found to be highest in C3, followed with C1, P3, C2, P2, P1 and lowest in S.

$C3 > C1 > P3 > C2 > P2 > P1 > S$

**Conclusion:** All the intracanal medicaments reduced the microhardness of dentin after 1 week. Calcium hypochlorite can be used as a novel intracanal medicament as it resulted in higher microhardness value. Chitosan as a vehicle along with calcium hydroxide and calcium hypochlorite resulted in higher microhardness values as compared to other groups containing propylene glycol vehicle.

#### Abstract 458

##### Artificial intelligence in endodontics: A review

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Artificial Intelligence (AI) is a relatively newer concept, which stands for the idea of machines being capable of performing human tasks. To be able to function in the same way as the intelligence of the human being and to be able to replace the intellect of the person, a necessary premise is required. The premise is that, human intelligence has a structure and this can be digitized purely in computing. Complex endodontic scenarios can be effectively diagnosed with the help of artificial

intelligence by coupling advanced tools like CBCT, digital radiography etc. Today Artificial Intelligence has come into a reality and their applications has been common in almost all areas of modern human life. In modern medicine and dentistry, also, this technology has brought tremendous impact. For diagnosing a disease, a medical/dental professional has to analyze the symptoms of the patient, lab results, diagnostic images and many more factors. They are always vulnerable to the clinician's imperfect memory and cognitive bias. In such a situation, the Artificial Intelligence can replace the intellectual power of a highly specialized expert in diagnosing the condition.

New researches are still active to find a true autonomous system to mimic human intellectual power. Currently, the virtual components of AI, known as software type of algorithms is the main component used in dentistry. Massive data in the form of radiographic images, photographs, spectral images, electronic medical records, experimental parameters, treatment records, murmurs of patients, sounds of handpiece etc. will be analyzed by this software type algorithms and help to interpret the diagnosis more accurately and effectively. They also help for treatment through visualized anatomic guidelines and to expect possible outcomes of treatment and the prognosis status. This review paper analyzes the possible influence of growing artificial intelligence technology in vast area of dental science especially in endodontics, their possible limitations, ethical considerations and possible impact on dentists.

#### Abstract 459

##### Cryotherapy: An emerging trend in the field of endodontics

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**Introduction:** Cryotherapy is a minimally invasive therapy refers to decreasing the tissue temperature for therapeutic purposes. Root canal treatment is more frequently associated with severe postoperative pain and swelling. Therefore, management of postoperative pain & swelling is crucial in endodontic practice. Control of pulpal hemorrhage in direct pulp capping is important for successful vital pulp therapy. The separation of rotary instruments during instrumentation without warning is a major hindrance for the success of root canal treatment. Various studies shows that Cryotherapy is a simple and cheap supplementary method for minimizing postoperative pain in cases of apical periodontitis and for controlling pulpal hemorrhage during vital pulp therapy. Cryotherapy is effective in reducing swelling and pain in endodontic surgery. Cryogenic treatment of metal during manufacture has been advocated for improving the surface hardness and thermal stability and deep cryotherapy of NiTi endodontic files, which offered enhanced cyclic fatigue resistance, reducing potential file separation. **Objective:** The objective of this systematic review is to describes the concept of cryotherapy, its mechanism, physiological effects

Abstract

and its different application in the field of endodontics with their possible limitation.

**Methods:** The screening of articles was based on electronic search of the following data base: PubMed, Google Scholar, Scopus, web of science. The selected articles were limited to those published in the English language using following key words cryotherapy, physiological effect of cryotherapy, Cryotherapy in endodontic treatment, cryotherapy and vital pulp therapy, pain and temperature. Risk of bias assessed using the Cochrane criteria.

**Results:** Out of 41 studies included, 23 studies addressed the physiological effect of cryotherapy including postoperative pain, swelling, inflammation, mucositis, carcinoma, tissue metabolism. 8 focused on illustrating the role of cryotherapy in vital pulp treatment and 10 were concerned with the effect of cryogenic treatment in endodontic instruments.

**Conclusion:** It can be concluded that cryotherapy is effective in post endodontic pain and swelling. Cryotherapy is applied for the control of pulpal hemorrhage in direct pulp capping. Dry deep cryotherapy treatment increases the cyclic fatigue resistance, releases internal stress and reduces potential file separation of super elastic NiTi files.

**Abstract 460**  
**Photodynamic therapy**

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The persistence of microorganisms in the root canal system is one of the leading causes of root canal treatment failure. The complexity of the root canal system with its isthmuses, ramifications, and dentinal tubules makes complete debridement of bacteria almost impossible, even when conventional methods of endodontic instrumentation and irrigation are performed to the highest technical standards. Antimicrobial photodynamic therapy is an adjunctive, conservative, non-selective method to eradicate the bacteria. It is a promising approach to prevent reinfection without inducing bacterial resistance and is based on the concept that non-toxic photosensitizers can be preferentially localized in certain tissues and subsequently activated by light of the appropriate wavelength to generate singlet oxygen and free radicals that are cytotoxic to cells of the target tissue. In photodynamic therapy, nanoparticle-based photosensitizers are used which have higher reactive oxygen species production, reduced antimicrobial resistance, higher stability with possibility of controlled release of reactive oxygen species after photo activation. This review paper highlights the significance of antimicrobial photodynamic therapy as a novel adjunct in endodontic disinfection.

**Abstract 461**  
**The effect of apical preparation size on the removal of smear layer and organic debris from root canal wall: An in-vitro scanning electron microscopic study**

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**Aim:** To compare the effect of apical preparation size on the removal of smear layer and organic debris from root canal wall.

**Materials and Methods:** Thirty freshly extracted single-rooted teeth with comparable root canal morphology were selected. Standardized access cavity preparation and working length determination was done. Chemomechanical Preparation of root canals were done upto 20/.02 with hand K files. Samples were then randomly divided into 3 groups of 10 specimens each. Group A (Control Group): Without further chemomechanical preparation. Group B: Final chemomechanical preparation with rotary NiTi files upto 25/.04. Group C: Final chemomechanical preparation with rotary NiTi files upto 30/.04. Copious irrigation was done with 17% EDTA and 5.25% NaOCl. All the root canals were dried with paper points and coronal orifices were sealed with the temporary cement. Each tooth was sectioned into two halves. Samples were then dehydrated in a graded series of ethanol solution (30–100%) and gold coated for evaluation under a Scanning Electron Microscope. Data was analyzed via the Mann-Whitney U test with the help of SPSS 17 statistical software.

**Results:** Significant reduction of Smear layer and Organic Debris was determined when prepared with rotary NiTi files to final apical size of 30/.04 as compared to the final apical size of 25/.04 in the apical third ( $p < 0.05$ ).

**Conclusion:** Under the conditions of this study, an increase in the apical preparation size (30/.04) has significantly enhanced root.

**Abstract 462**  
**An in vitro study of the interaction of sodium hypochlorite and octenidine dihydrochloride: optical observation, mass spectrometry and H<sup>1</sup> nuclear magnetic resonance based observational analysis**

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Sodium hypochlorite (NaOCl) is the most common irrigant during root canal therapy. Despite its excellent antimicrobial activity and tissue solubility, sodium hypochlorite lacks some important properties such as substantivity and smear layer removal. To overcome this drawback, chlorhexidine (CHX) has been used as an irrigant with sustained antimicrobial properties. However, the combination of NaOCl and CHX results in an orange-brown precipitate and the formation of parachloroaniline (PCA) which has been found to be potentially carcinogenic. Octenidine dihydrochloride (OCT) is a new positively charged bipyridine antimicrobial compound proposed as a root canal irrigant. This contains 0.1% Octenidine dihydrochloride with broad spectrum antibacterial, antifungal and some antiviral property. However, Octenidine has also shown to interact with NaOCl. The aim of this study is first to identify the colour changes of the precipitation formed by interaction between OCT and NaOCl & the analysis of residue obtained utilising mass spectrometric (MS) analysis and proton nuclear magnetic resonance (H<sup>1</sup> NMR) to know the origin and nature of the precipitate.

**Abstract 463**  
**Robotics: The future of endodontics**

Abstract

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As the abridgement between technology and dentistry seems to be shortened, the world of robotics has seldom been explored by clinicians for the increased precision of work in the field of endodontics. Since their advent in 1967, the possibility that their usage could eventually ergonomically ease the job of a dentist has been believed to be crucial and the most potential solution to fundamentally decrease the chances of making mistakes when performing a procedure on a patient. This could also be used as an adjunct to digital dentistry/ teledentistry which is the main means of communication between the dentist and the patient in times of a COVID-19 pandemic hit world. In conservative dentistry and endodontics, the work of tooth preparation, root canal treatments etc. often require an estimated level of perfection and it has been proven by researches on previously manufactured robots with greater degree of freedom in movement that such a technique could be used in clinical situations to achieve the desired result. Such systems include tooth-arrangement multi-finger hand (TAMFH) which is based on the MOTOMAN UP6 robot etc. while these systems may require tedious kinematic planning and analytic techniques for accurate procedure to be performed, they give an added advantage of shorter appointment durations and lesser aerosol production. Another benefit that seems to have attracted many clinicians all over the world is their efficacy to disrupt/destroy root canal biofilms and a possibility that the magnification achieved with its aide would increase the overall success of endodontic therapy. The branch of robotics as an accompanied tool in dentistry has been explored much time and again and still needs research to be applicable in clinics on a day to day basis. This review elaborates their usage, technical aspects and the science behind it.

**Abstract 464**

**Management of a partially inflamed pulp of a permanent molar by pulpotomy using platelet-rich fibrin and mineral trioxide aggregate: A biological approach**

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The aim of vital pulp therapy is to maintain the health of pulp tissue by eliminating bacteria from the dentin pulp complex. A 19-year-old female patient reported to the Department of Conservative Dentistry and Endodontics with an established pulpitis in tooth # 46. The tooth had a carious pulp exposure, with a history of lingering pain. Patient was diagnosed with symptomatic irreversible pulpitis with closed apices and was managed using conservative treatment modalities such as vital pulpotomy with a regenerative approach. After isolation under rubber dam, caries excavation, pulp exposure and pulpotomy

were performed. Platelet - Rich Fibrin (PRF) was used, as a pulpotomy medicament and was followed by Mineral Trioxide Aggregate (MTA) placement. Finally, composite resin restoration was done immediately. At the first recall, i.e., after 24 hours, no postoperative pain was reported. Further, recall evaluations were planned clinically and radiographically after 1, 3, 6 and 12 months. After 3 months period, on radiographic examination, it revealed a normal periodontal ligament space and the tooth responded positively to pulp sensibility tests. A longer recall period is required as planned, to justify the use of this approach for the treatment of pulpitis in human permanent molars.

**Abstract 465**

**Comparative evaluation of the antimicrobial efficacy of chlorhexidine, octenidine and novel silver citrate solution against *Enterococcus faecalis*: An in-vitro study**

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*Enterococcus faecalis* is a gram positive facultative anaerobe which is rarely present in primary endodontic infections, but is the most common cause of secondary endodontic infections. Chlorhexidine gluconate is used at a concentration of 2% to 6% as a root canal irrigant. It has a broad spectrum anti-bacterial action, substantively low toxicity, lack of foul smell and bad taste. Due to these properties, it has been recommended as a potent root canal irrigant. Chlorhexidine has shown to be more effective against gram positive organisms than gram negative organisms. Octenidine hydrochloride (OCT) Octenidine, is a bispyridine derivative, that is, N, N- [1,10-decanediyl-di-1 (4H)-pyridinyl-4pyridene] bis (1-octanamine) dihydrochloride. It has been demonstrated that OCT appears to be more effective than chlorhexidine as a means for prolonged bacterial anti-adhesive activity. OCT has been suggested as an endodontic irrigant based on its antimicrobial effects and lower cytotoxicity. Citric acid is a weak organic acid with strong chelating properties, has been employed as endodontic irrigants with a concentration between 25% and 50%. A novel metabolic substrate based on silver citrate was tested as an innovative endodontic irrigation solution, (pH ~ 1.7). While citric acid possesses the aforementioned activities that make it an interesting active principle for an endodontic irrigant formulation, it can also be very effective as a capping agent for silver ions and nanoparticles, thus stabilizing the formulation. The following study compares the antimicrobial efficacy of 0.2% Octenidine, 2% Chlorhexidine Digluconate, and Novel Silver Citrate solution using the Minimum Inhibitory.

**Abstract 466**

**Evaluation of pain incidence in patients treated with syringe irrigation and diode laser activation irrigation: A randomized clinical trial**

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India

Abstract

**Aim:** To compare the post-operative pain in patients treated with syringe irrigation (SI) and laser activated (LA) irrigation using diode laser.

**Materials and Methods:** This is a randomized clinical trial with a parallel study design. Patients aged from 20-65 years with symptomatic necrosed teeth of singled rooted teeth needing a primary endodontic treatment having periapical radiolucency not more than 2 mm were eligible for the study. The control group was SI and the intervention was LA. In the first appointment, access cavity opening was done followed by cleaning shaping, after which 3% NaOCl was used as an irrigant for SI and LA. Calcium hydroxide was placed in the canal and the teeth were temporized. The patients were enquired telephonically for post-operative pain at 24 hours, 48 hours and 7 days and was recorded using NRS pain scale. The null hypothesis is: There is no difference in the post operative pain using LA irrigation. The primary outcome of this study was to assess the post-operative pain. Simple randomization of the patients was done through a lottery system by two operators. The trial was single masked as the patients were blinded of the intervention, by using the diode laser in the SI group but was not activated.

**Results:** Of the data and statistical analysis: The total sample consisted of 56 participants, of which SI and LA were each allocated 28 participants using convenience sampling. In the SI group, out of 27 participants, 20 participants experienced pain. Whereas, in the LA group, out 28 participants, 8 participants reported post-operative pain. In the 56 participants who underwent the trial, a statistical significant difference was observed between SI and LA group at 24 hours ( $p=0.14$ ) and at 48 hours ( $p=0.042$ ) using Chi-square test (Significance at  $p<0.05$ ). No adverse effects of the intervention was observed.

**Conclusions:** The incidence of post-operative pain was significantly reduced in the LA group at 24 hours and 48 hours. There was no significant change of post-operative pain after 7 days between LA and SI groups.

#### Abstract 467

#### Pulp capping materials: Contemporary to futuristic approach

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The foundation of restorative dentistry relies primarily on the principle that the preservation of a healthy and functional pulp-dentine complex which would result in the successful healing of the exposed pulp. Emphasis has shifted from the “doomed” organ concept of an exposed pulp to at least one of hope and recovery. Due to the emerging need for regenerative dentistry, concentration on the development of an ideal scaffold is necessary. Different materials are introduced in literature so as to seal and induce tertiary dentine regeneration. Novel introduced materials

aim at sealing the exposure site while inducing odontogenesis therefore increasing the success rate of vital pulp therapy. However, the most important governing factor in the success of vital pulp therapy is the correct diagnosis of reversibility of pulpal inflammation and the extent of pulp infection. Also implementing latest techniques in caries excavation for vital pulp therapy cases could improve success rates of such cases. Modernist materials range from different synthetic materials such as Bioceramics to the new biologically proposed scaffolds. A wide range of materials are suggested within the literature to be used as pulp capping protective dressing materials that varies from ready-made synthetic materials to biological based scaffolds and composites. Newly evolved biological based scaffolds show promising results in dentine regeneration therefore strengthening the tooth structure and overcoming potential drawbacks of use of currently available recommended materials.

#### Abstract 468

#### Review of effects of restorative and endodontic material on diagnostic parameter of magnetic resonance imaging

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Magnetic resonance imaging (MRI) has become a common and important life-saving diagnostic tool in recent times for diseases of the head and neck region. It's a diagnostic tool that uses a powerful magnetic field, radio waves, and a computer, to create images of tissues and organs throughout the body. There are a number of reasons why MRI technology is becoming more frequently utilized internationally, including increased accessibility, the absence of ionizing radiation, and superior soft-tissue resolution compared to other imaging modalities. MRI of the head and neck region is vital in contemporary diagnosis for numerous indications. Dental materials have important implications for the use of MRI as a diagnostic imaging modality. Unfortunately, the magnetic field and radiofrequency pulses generated within the magnetic resonance image interact unfavorably with dental materials that have magnetic properties. This leads to unwanted effects such as artifact formation, heat generation, and mechanical displacement. This presentation is to highlight and assimilate the present understanding of the effects of restorative and endodontic materials on magnetic resonance imaging. Dentists should be aware of the interactions of various restorative and endodontic dental materials and different technical factors that interplay with diagnosis by an MRI scanning machine. An understanding of the basic physics involved in magnetic resonance is required to appreciate the relevance of dental materials in an MRI scanner. It is imperative that modern dentists have an innate understanding of the multitude of factors that governs the interaction between contemporary dental materials and MRI imaging capability.

#### Abstract 469

#### Internal root resorption and it's management

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## Abstract

Root resorption of permanent teeth does not occur naturally and is invariably inflammatory in nature. Internal resorption is a rare insidious process that begins in the root canal and destroys surrounding dental hard tissues. Odontoclastic multinuclear cells are responsible for the resorption, which can grow to perforate the root if untreated. The process is initiated by a variety of stimuli such as trauma, pulpotomy, extreme heat produced during cutting of dentin, chronic inflammation of the pulp following caries perpetuated by bacterial factors, cracked tooth, tooth transplantation, and orthodontic treatment. Internal root resorption are relatively rarely observed in clinical practice, because they are mostly asymptomatic and are usually diagnosed just by chance during routine radiographic examination. Proper patient history, early diagnosis, and appropriate treatment at the correct time prevent tooth loss. To date, root canal treatment remains the only treatment of choice with teeth diagnosed with internal root resorption as it removes the granulation tissue and blood supply of the clastic cells. Treatment is by arresting the cellular activity accounting for the resorptive process. Various therapeutic options include orthograde or retrograde fillings of the root canal resorption area. Delayed treatment can lead to progressive internal resorption. Prognosis of treatment depends on the extent or the size of lesion. Prognosis of small lesions of internal root resorption is very good. Sodium hypochlorite, ultrasonic instrumentation and calcium hydroxide are the cornerstones of treatment of internal inflammatory root resorption. MTA is a highly biocompatible material which has been shown to be effective in repairing furcation perforations and lateral root perforation that can occur due to internal resorption. Care should be taken to distinguish internal resorption from other types of tooth resorption for appropriate management.

### Abstract 470

**Assessment of awareness among dental practitioners regarding the management of dental traumatic injuries, based on the IADT guidelines 2020: A cross-sectional questionnaire survey**

**ANJAL SHAH, SUPARNA GANGULY SAHA,  
ANUJ BHARDWAJ, MAINAK KANTI SAHA,  
PRASHANSA VIJAYWARGIYA, SHIKHA JAIN**

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**Aim:** The aim of this study was to assess the knowledge of dental practitioners in Central Indian region, regarding the treatment and management of dental traumatic injuries, using the International Association of Dental Traumatology (IADT) Guidelines 2020 as a reference.

**Materials and Methods:** A total of 514 dental practitioners across Central India participated in a cross-sectional study by means of virtual survey. A two part electronic questionnaire was created using google forms, investigating 7 profession based questions and 16 trauma based questions and were sent to all the dentists registered with Dental Council of India in Central India. The responses were analysed to evaluate the awareness among dental practitioners regarding the management of dental traumatic injuries.

**Statistical Analysis:** Descriptive statistics was performed by using the proportional or frequency distribution of the parameters. The respondents were then grouped according to the branch of speciality if any and the data was evaluated by the one-way ANOVA with post-hoc, with p value <0.005.

**Results:** In the present study, out of a total score of 20, the mean knowledge score for dental practitioners was 8.20 (only 54.86 % of the 20 questions were answered correctly) and 282 participants out of 514 had an average level of knowledge.

**Conclusion:** The overall level of knowledge of dentists from Central India region of the revised IADT guidelines is average.

### Abstract 471

**Guided endodontics**

**SALONI VIJAYWARGIYA, HARSHIT SRIVASTAVA,  
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SHREYA DADHICH, PRAGYA SINGHAL**

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Endodontic access to calcified root canals is a great challenge. There are quite frequent chances of technical failures including alterations of root canal geometry and extensive loss of dental hard tissue, which may cause weakening of tooth or root perforation may occur. Currently management of obliterated canals includes various instruments such as burs, orifice openers etc., all are used under magnification. In addition to traditional armamentarium for access opening a newer approach has eased the finding and negotiating such canals. A novel approach such as "Guided endodontics," for the preparation of apically extended access cavities, was introduced. Guided endodontics provides an accurate technique for the minimally invasive preparation of access cavities. This technique enables the accuracy and reliability of digital data and its potential to be used clinically to obtain predictable results in short duration. The chairside time is highly reduced, compared to the conventional approach, thus making it more acceptable to the patient as well as there is clinician's comfort. The cost involved appears to be more, with the requirement of additional facilities. However, in retrospection, the value might not be an excessive amount of considering the iatrogenic risks avoided and chairside time saved. Ceaseless advancements in techniques, instruments, and materials have established modern endodontic microsurgery as a state-of-the-art treatment method. The purpose of this approach was to introduce a new surgical endodontic technique by using a three-dimensional printed template for various surgical procedures.

### Abstract 472

**Novel concentrated growth factors therapy and its application in endodontics**

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Introduction and development of new family of platelet concentrates called Concentrated Growth Factors (CGFs) as a biomaterial has set an

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exciting and promising era in the field of regenerative endodontics. Healing and regeneration require the mutual interaction between a scaffold (fibrin matrix), platelets, growth factors, leukocytes, and stem cells. These key elements are all active components of CGF, hence making this material a suitable candidate for regeneration-based therapies. It not only provides matrix or scaffold permitting cell migration into the defect area, but also provides the wound with crucial biological signals or growth factors like platelet-derived growth factors (PDGFs), transforming growth factors (TGFs), vascular endothelial growth factor (VEGF), and insulin-like growth factor (IGF) that can accelerate the wound-healing and regeneration process. Moreover, the 3D architecture of the fibrin matrix provides the CGF membrane with great density, elasticity and strength that are excellently suited for handling and manipulation. This review paper is intended to provide an insight into various prospects of CGF and to summarize its various therapeutic applications in endodontics.

**Abstract 473**

**Endodontic biofilms: An updated review**

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DEEPAK RAISINGANI, HARSHIT SRIVASTAVA,  
PRACHI MITAL, DEEKSHA KHURANA, RIMJHIM JAIN,  
AARUSHI CHOPRA**

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Rajasthan, India

Preservation of teeth by endodontic therapy has gained lot of recognition, the rationale for this being the complete understanding of endodontic pathology and our ability to combat same. Endodontic infections are essentially biofilm mediated with broader bacterial diversity than previously anticipated. Biofilm mode of growth is advantageous for microorganisms, as they form three-dimensional structured communities which besides facilitating survival in tough environmental condition also help in trapping nutrients, facilitating metabolic cooperation among resident bacteria of the same or different species. Virtually all areas of root canal system including main canal, isthmuses, ramifications harbors these consortium of bacteria. Evolving methods to examine biofilms have improved our understanding for same. Removal of endodontic bacterial biofilms and preventing recontamination of the root canal after treatment are the essential elements for successful outcomes of endodontic treatment. Therefore the aim of this review is to provide an overview of diverse aspects of biofilms including their essential role in endodontic infections, techniques to identify biofilms, mechanisms of antimicrobial resistance, with special emphasis on methods to eradicate biofilms from root canal.

**Abstract 474**

**Irrigant agitation: A tsunami**

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The aim of endodontic treatment is to disinfect root canal system including the isthmus, furcation and apical delta. Since the anatomies

are highly variable, it is impossible to mechanically prepare the entire system, reaching the untouched areas of root canal systems is a challenge itself, which is where irrigation plays an important role. Conventional irrigation with needle deliver irrigants via positive pressure, and it is proved that irrigant is able to reach only 1mm deeper than the tip of the needle in a closed canal system. This results in apical debris left behind in the apical gas pocket created during instrumentation from the hydrolysis of intracanal organic material and sodium hypochlorite. This is called the vapor lock effect which prevents effective irrigant delivery in the apical third of the root canal. Effective agitation and irrigant delivery is a prerequisite for total debridement of microorganisms in root canal systems. Recent advances in irrigant agitation techniques help deliver irrigants using negative pressure and prevent extrusion of debris beyond the periodontium. This review article highlights the use of various irrigant agitation techniques used.

**Abstract 475**

**Pulpal anaesthetic failures: Enigma to endodontists**

**ANJU RETNAKARAN, FAISAL MA GAFFOOR,  
ANOOP SAMUEL, RETHY GOPAKUMAR,  
C SABARI GIREESH, S SONISHA**

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The critical factors which determine the success rate of endodontic procedures depend upon the proper diagnosis. The successful management of pain is the key goal of endodontic practice. Attaining adequate anaesthesia is another critical factor for doing a smooth procedure in patients, this will not only help the patient to overcome their fears towards the treatment but also creates a stress-free environment for the endodontists to do the procedure on the patient. For a proper diagnosis and successful anaesthesia, one should know the neurophysiology of dental pulp in a thorough manner. This paper describes the various causes of pulpal anaesthetic failures.

**Abstract 476**

**Variations in the internal anatomy of permanent maxillary second molar teeth: A review with case series**

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LV VIJAYSHANKAR, PR PRADEEP**

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Karnataka, India

A review with case series of permanent maxillary second molar teeth with variations in the internal anatomy. The maxillary second molar teeth have usually three roots and three canals (Mesio buccal, Disto buccal and palatal canal). Digital technology such as CBCT helps in Improving diagnosis and radiographic interpretations. It is important to visualize and to have knowledge of internal anatomy of teeth before undertaking endodontic therapy. This review paper describes the challenges posed upon diagnosing, and treating the endodontic patient with variations in the root canal system morphology of maxillary second molar

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teeth. This case series serves to remind clinicians that such anatomical variations should be taken into account during endodontic treatment.

**Abstract 477**

**Comparative evaluation of smear layer removal and chelating efficacy of three different irrigating solutions: An *in vitro* study**

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**Aim:** The purpose of this study is to compare smear layer removal and chelating efficacy of three different irrigating solutions.

**Materials and Methods:** Forty Five single rooted teeth will be decoronated, instrumented to a standard working length using single file system and ultrasonic agitation. All the samples will be then randomly divided into 3 groups (n = 15) depending on the final irrigating solutions; Group I: 17% Ethylenediaminetetra acetic acid (EDTA), Group II: HybenX, and Group III: 0.2% Chitosan nanoparticles. All the samples will be sectioned longitudinally and divided into two halves. One half of the sample will be subjected to EDX analysis to check the calcium/phosphate (Ca/P) ratio. The second half of the sample will be subjected to Scanning electron microscopy to evaluate the smear layer removal at various levels of root canal.

**Results:** Results will be statistically analysed.

**Abstract 478**

**Reattachment of fractured coronal tooth fragment of maxillary lateral incisor with fiber post: A case report**

**C ANJANA DAS, KP POOJA**

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Dental trauma is usually sudden, circumstantial, unexpected, accidental occurrence and often requires emergency attention. Children and adolescents are the more vulnerable population for dental injuries. Maxillary incisors are most vulnerable to trauma because of its position in the dental arch. A 16 year old girl was referred with a traumatized permanent maxillary right lateral incisor with complicated sub gingival crown fracture. History of fall on the previous day. An oblique fracture of maxillary right lateral incisor with a fracture line extending 1mm subgingival and 2mm supragingival in palatal and buccal aspects respectively was present. Fractured segment was mobile, partially detached from the radicular portion and was tender on palpation. Radiographic investigation revealed a horizontal fracture line 2mm coronal to the cemento-enamel junction Reattachment of fractured coronal segment with resin cement was planned. To improve the tooth resistance and expand the bonding areas involved in the adhesive reattachment technique, placement of a translucent glass fiber post was also planned. Coronal tooth fragment reattachment is one of the simple conservative, esthetic, and cost effective treatment options when the tooth fragment is available and there is minimal violation of the biological width.

**Abstract 479**

**Diagnosis, treatment planning using cone beam computed tomography of dens invaginatus associated with through and through periapical bone defect and its surgical management adopting unique regenerative approach**

**CM ARPITHA**

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Through and through periapical defects bone defects involves loss of lingual/palatal cortical plates with or without concomitant loss of buccal cortical plate due to the pathological process or creation of the access window. Dens-invaginatus is an anatomical abnormality occurs due to ingrowth of inner enamel organ into dental papilla prior calcification. The diagnosis and treatment planning of such cases can be made using 3 dimensional imaging technique. CBCT helps in presurgical assessment and to plan out advanced treatment options that provides hope for teeth that could not be saved before. This presentation consists two cases of dens-invaginatus (I and III) associated with through and through periapical lesion confirmed with CBCT and planned for endodontic microsurgery. Regenerative approach using combination of demineralized bone matrix (pure collagen particles), autologous platelet concentrates and collagen membrane was applied to the post surgical periapical bone defects to enhance wound healing. The cases were followed up clinically and radiographically. 2D and 3D radiographic assessment was done using molven's criteria and modified PENN criteria respectively which showed favorable healing and successful result.

**Abstract 480**

**Neuromodulation: A new avenue for combating pulpitis and preserving pulp vitality**

**LALITHA SRI ROJA NALLAMILI,  
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Andhra Pradesh, India

Neurogenic inflammation has been described as a component of inflammation caused by an external stimulus, when applied to the peripheral neurons. This stimulation will release neurotrophic factors like Nerve growth factor (NGF), secondary to the release of inflammatory cytokines such as Interleukin – 1 and Tumor necrosis factor alpha at the injured site. Effects on pain signaling are modulated by binding of NGF to receptors on the various cells of pulp. This will release various inflammatory mediators like neuropeptides, including Substance P, Calcitonin gene – Related peptide (CGRP), Glutamate, etc. This suggests that dental nerves, apart from the transmission of pain impulses, are also involved in the modulation of various aspects of pulpal inflammation. Therefore by manipulating dental nerve activity, it is expected to improve treatment outcomes and prognosis of vital pulp therapy especially in the early stages of pulpitis. This can dampen the local inflammatory responses of pulp tissue directly beneath the sites of injury, thereby contributing to the preservation of its vitality and integrity. At present, there are three potential approaches for neuromodulation that include, i) Targeting the Nerve growth factor pathway, ii) Administration of various receptor

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antagonists against neuropeptides like Glutamate and Substance P to suppress the inflammatory response. iii) Administration of receptor agonists to activate immunosuppressants like CGRP. The aim of this review is to demonstrate the pivotal role of dental nerves mediating pulpitis, which goes far beyond the traditional concept and the use of potential novel pharmacological approaches to combat neurogenic inflammation. This may fill the current gap of knowledge, open new therapeutic challenges in endodontics, and helps in the refinement and reclamation of endodontic treatments.

#### Abstract 481

##### Digital fabrication technology from 3D to 5D printing: An overview

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Technology has always been amazing us with its beautiful innovations, making human life simpler to a greater extent. 3D printing technology is one such ingenious technological invention that has contributed greatly to the manufacturing industry, along with various applications in engineering, medicine/dentistry etc. This process is described as additive manufacturing, with its main drawback being that, it is very time consuming. To overcome this challenge, 4D printing was introduced, which involves addition of the 4th dimension, which uses smart printing materials to print objects faster, saving 90% of time and material. Printing curved surface objects with 3D and 4D technologies presented a great challenge which has been overcome by 5D printing. This involves printing in various axes/angles unlike in 3D printing where it prints in a single direction. Multi-dimensional printed models show great promise in the future of dentistry. It has been observed in restorative dentistry, that the common cause of failure of materials is the dimensional changes at the margins which lead to instability or total loss of dental restorations. This can be overcome by creating printed smart restorative materials with continuous self folding adjustments, maximum adaptations with minimum overhangs, materials capable of moving towards the periphery, thus avoiding microleakage. In endodontics, printed directional guides are used in the preparation of endodontic access cavities, in case of pulp canal obliteration, developmental abnormalities etc. In periapical surgery, it is used to determine the osteotomy site and the correct level of root resection in complex cases with matched CBCT and optical scan data. The convergence of haptic and virtual reality technology with its integration with 3D imaging data has resulted in the emergence of haptic simulators that can create virtual oral anatomy, primarily used in dental education for 3D virtual planning. In regenerative dentistry printers are used to print bone tissue, tailored to form biomimetic scaffold which can act as a stable medium for optimal growth of stem cells. It also has varied applications in prosthodontics, implant dentistry, orthodontics, oral and maxillofacial surgery and periodontics. This review focuses on the current applications of 3D, 4D and 5D printing in dental practice.

#### Abstract 482

##### Clinical applications of bioceramics in endodontics: A review

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Bioceramics are materials which include Alumina, Zirconia, Bioactive glass, Glass-ceramics, Hydroxyapatite, and resorbable Calcium Phosphates. They exhibit excellent biocompatibility properties due to their similarity with biological hydroxyapatite. They have the ability to induce a regenerative response in the organism and also have antibacterial properties as a result of precipitation in situ after the material's setting time, a phenomenon that leads to bacterial sequestration. They form porous powders containing nanocrystals with diameters of 1-3nm, which prevent bacterial adhesion. They can be obtained both in situ and in vivo, by various chemical processes. They are classified into three categories- Bio inert, Bioactive, and Biodegradable. The most common bioactive materials used in endodontics are based on tricalcium and dicalcium silicate. They are the material of choice in regenerative endodontics, conservative pulp therapy, and pair radicular surgery due to their higher clinical success rate. This review paper discusses the various clinical applications of bioceramics i.e role in the retrograde filling, repair of furcation perforations/ lateral perforations, internal resorption, pulp capping, retreatment in endodontics.

#### Abstract 483

##### Efficacy of endoactivator and battery powered flosser in removal of debris from canals – Confocal laser microscopy study

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**Aim:** Efficacy of Endoactivator and Battery powered flosser in removal of debris from canals on intratubular penetration with endodontic sealer using confocal laser microscopy.

**Methods:** Forty five single-rooted human teeth were instrumented and randomly divided into 2 Experimental group and 1 Control groups: Group 1 [Endoactivator group (EA)]; Group 2 [Battery powered flosser]; Group 3 [Control (Manual irrigation)]. Obturation of all teeth was done with gutta-percha and AH plus sealer labelled with Rhodamine B dye. Transverse sections at 2 mm and 5 mm from the root apex was examined by using confocal laser scanning microscopy. The percentages of dentinal sealer penetration segments of canal was analysed.

**Results:** Results are awaited.

#### Abstract 484

##### Deep margin elevation: A review

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Restoring the posterior teeth with deep subgingival cavities is always a challenge for dentists in day-to-day life. Crown lengthening and orthodontic tooth extrusion are treatment options to increase the

## Abstract

height of the subgingival restorative margin. Crown lengthening is an invasive procedure and causes sensitivity due to cementum exposure to the oral environment. In orthodontic extrusion, due to root anatomical convexities, attaining the proper emergence profile is difficult and takes a longer time duration. Because of these disadvantages, a minimally invasive procedure, 'Deep Margin Elevation'(DME) has been explored. Deep margin elevation is a technique that increases the restorative margins to an equigingival or supragingival location by placing a composite resin or GIC. This technique prepares the tooth to receive direct and indirect restorations without subtractive procedures like crown lengthening. By this technique, the periodontium is preserved as healthy as possible. Not only the preservation but also provides great retention and support for indirect restorations. Various studies were done to access the effect of DME on marginal leakage, marginal adaptation, and fracture strength of indirect restoration. Nowadays, CAD-CAM indirect restoration is also placed above the elevated margins by this technique. This review will discuss the deep margin elevation technique, advantages, limitations, and recent advances.

### Abstract 485

#### Stepwise intervention: A minimally invasive and a maximally congruous attempt, precursive to endodontics – A case series

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Dental caries has been the very prevalent oral malady, calling for numerous conventional and contemporary measures to combat. In the management of deep carious lesions, traditional attempts have endowed upon complete removal of the cariogenic flora, attempts ranging altogether from pulp capping, pulpectomy, root canal treatment, towards the end with extraction. Regenerative endodontics is an incipient yet a radical breakthrough aiming at attaining back the pulp vitality. Likewise, stepwise removal of deep carious lesion, is a form of vital pulp therapy, which envisions the removal of infected dentin, leaving behind the affected dentin with a scope of remineralization, thereby embarking the advantage of maintaining the sound tooth structure (viable dentin and vital dental pulp), monitoring the proximity of the preparation to dental pulp and aggrandize the longevity of the restoration. It has emerged as an alternative being in favour with the current concept of 'Minimally Invasive' procedures, which is a significant breakthrough, catapulting every attempt of preserving the nature gifted. This paper aims at reporting a series of clinical cases fostering the significance of Stepwise caries removal as a valuable treatment modality, amplifying the motive of minimally invasive endodontic and restorative procedures and at the same time providing magnificently accoutred clinical outcome.

### Abstract 486

#### The comparison of effects of short-term application of RC Cal and NEO Cal on the strength of dentin: An *in-vitro* study

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**Aim:** To compare the compressive strength of dentin with and without application of RC Cal and NEO Cal.

**Materials and Methods:** 15 human extracted single rooted disease-free permanent mandibular premolars were chosen. The root canals were prepared using rotary instrument and divided into three groups at random. In one group, the root canals were filled with RC Cal and in another group the root canals were filled with NEO Cal. Canals of teeth in the control group were left empty. All teeth were stored in normal saline for 14 days and then dentin cylinders were created from coronal third of root by cutting the coronal and apical portions of the teeth. The compressive forces required to shatter the dentin cylinders were measured using an Instron machine (UNIVERSAL TESTING MACHINE), and the data was analysed using the Anova test.

**Results:** The NEO Cal filled teeth required a considerably lowest mean compressive force than the RC Cal filled teeth and the control teeth to shatter the dentin cylinders. The control teeth had highest mean compressive strength than NEO Cal and RC Cal filled teeth ( $P < 0.005$ ).

**Conclusion:** Teeth that had been exposed to calcium hydroxide for 14 days needed less compressive force to shatter root dentin cylinders. Further research is needed to see if impact testing will provide similar results.

### Abstract 487

#### The application of vital pulp therapy in teeth with irreversible pulpitis, and apical periodontitis: A review of literature

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Vital pulp therapy (VPT) is a biological approach to minimally invasive endodontics. Traditionally, such procedures were restricted to teeth showing signs of reversible pulpitis only, and were contraindicated in teeth with irreversible pulpitis and apical periodontitis. However, based on histological and clinical evidence, some recent studies show that carious exposed pulps with established irreversible pulpitis maintain their healing potential. Endodontic literature supports a direct relationship between pulpal inflammation and periapical lesion, hence inflammatory processes may result in the start of apical periodontitis. Therefore, when bacterial contamination is removed from the dentin-pulp complex, and further bacterial recontamination is prevented with a tight coronal seal, the inflamed pulp has a chance to return to a healthy and functional status. This paper aims to present a review of evidence based literature for the biologic rationale, indications, treatment planning and treatment outcomes when vital pulp therapy is carried out in teeth with irreversible pulpitis, and with apical periodontitis.

### Abstract 488

#### Accuracy of presurgical cone-beam computed tomography in detection of alveolar bone defects: A clinical study

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**Aim:** To determine the accuracy of presurgical Cone-beam computed tomography (CBCT) in detection of alveolar bone defects using the gold standard of direct surgical visualization.

**Materials and Methods:** Seventy-four patients (112 teeth) with post treatment apical periodontitis requiring periapical surgery with age range of 18–57 years received preoperative CBCT. Radiographic images were evaluated by three blinded observers (an oral and maxillofacial radiologist and two endodontists) to determine the status of buccal and palatal cortical bone as intact, dehiscence or fenestration, presence of apicomarginal bone defects (AMD) and through and through (T & T) bone defects. All patients underwent endodontic microsurgery and the intraoperative status of buccal cortical plate was recorded and confirmed by 2 consultants. The radiographic findings were compared with the findings of direct visualization serving as a gold standard reference. Sensitivity, specificity, predictive values, and overall accuracy of CBCT were calculated.

**Results:** CBCT correctly revealed the status of the buccal bone in 17 out of 19 teeth with an intact buccal cortex, 34 out of 37 teeth with buccal bone fenestration and 60 out of 63 teeth with buccal bone dehiscence. The overall accuracy of CBCT varied from 91% to 96%. The sensitivity and specificity values of CBCT for T & T defects were 100%. For AMD, CBCT showed sensitivity of 67% and 100% specificity, positive predictive value of 100 and negative predictive value of 82.7.

**Conclusion:** CBCT was associated with significantly greater diagnostic accuracy for detection of through and through bone defects. CBCT failed to diagnose apicomarginal bone defects in 33% teeth. When evaluating the status of buccal cortical plate from CBCT images, observers could detect absence of bone better than its presence as implied from the high sensitivity values for fenestration and dehiscence. Limited FOV CBCT is beneficial as a presurgical tool for diagnosis and treatment planning of teeth with alveolar bone defects for the employment of regenerative techniques.

### Abstract 489

#### Restore to success - Conservative management of dental trauma

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Traumatic dental injuries (TDI) account up to 5% of all injuries for which people seek treatment, with anterior permanent teeth being the most affected. Complicated crown fractures which involve the enamel, dentin and pulp occur in 0.9%-13% of all reported dental injuries. Such cases require immediate aesthetic and functional intervention. Preservation of the pulp vitality is of paramount importance, as is the need to seal the dentine and recreate esthetics. Natural tooth fragment reattachment combined with advanced biomimetic materials allow us to achieve all these objectives in a

simple and reliable way. It offers the advantage of natural tooth colour and surface texture, as well as immediate dentine sealing which prevents further pulpal trauma, and has a survival rate of close to 80%. A 22-year-old female patient presented to our department with a chief complaint of fractured upper anterior tooth. History revealed trauma to the tooth 12 hours prior and patient had retrieved the fractured segment. On examination, an Elli's class III fracture was present in relation to 11, with clinical pulp involvement. Patient experienced pain upon stimulus and the exposed pulp was bright red in color. Tooth responded normally to electric pulp testing and to cold test. The pulp was treated with partial pulpotomy, and esthetics restored by reattaching the fragment using flowable composite. The patient was recalled for follow up after 3 months. The tooth was examined clinically and corroborated with radiographic analysis to assess the treatment outcome.

### Abstract 490

#### Root resorption as an endodontic treatment challenge: A case series

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Resorption is the combination of either physiological or pathological factors that results in the loss of dentin, cementum, and the alveolar bone of tooth structure due to the action of polymorphonuclear giant cells. Such pathologies are often inaccurately diagnosed by routine X-rays. The use of CBCT helps in correct interpretation and decision making for the management of such cases. The most frequent causative factor for resorption includes dental trauma, orthodontic treatment, bleaching and occasionally accompanies periodontal disease. Although the mechanism of resorption process is studied in detail, its etiology is not fully understood. They can be classified as internal, that is when root canal is involved and external, when periodontal ligament is involved. Internal root resorption is a process with progressive destruction of intra-radicular dentin and dentinal tubules along middle and apical thirds of the root canal walls as a result of clastic activities. External root resorption is the loss of dental hard tissue and usually begins on the root surface of tooth. The selection of proper treatment is related to stimulation factors. Intra-pulpal infection can be a stimulation factor in internal and external root resorption. Depending on the location and extent of the resorption, the treatment can be root canal therapy or a combination of endodontic treatment and periodontal surgical complementation. The 1st case report highlights external replacement root resorption secondary to trauma managed using flexible splints and root canal therapy with the use of calcium hydroxide with different vehicles as an intracanal medicament, with 1 month, 3 month, 6 months, and 1-year follow-up. The 2nd case highlights internal root resorption secondary to trauma managed with endodontic therapy by removal of granulation tissue and use of MTA with follow-up up to 3 months. For successful treatment outcome of such cases, correct diagnosis and interpretation with the use of advanced radiographic tools, play a key role. The treatment protocols must be carried out in an appropriate manner for a good long-term prognosis.

### Abstract 491

#### Specialized pro-resolving lipid mediators in endodontics

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An acute inflammatory response is self-limiting and host-protective while chronic low-grade inflammation is sustained and detrimental. Resolution of acute inflammation is necessary to prevent development of chronic inflammation. Specialized Pro resolving lipid mediators (SPMs) are novel autocooids that dampen the inflammatory process by promoting anti-inflammatory response. They execute positive effects in decreasing pain, increasing wound healing, promoting tissue regeneration, and enhancing adaptive immunity. Experimental studies on SPMs have shown promising result in various inflammatory diseases, such as renal fibrosis, cerebral ischemia, marginal periodontitis, and cancer. The potential of SPMs in endodontic therapy has recently been explored. The objective of this review is to analyze the potential use of SPMs in endodontic therapies and various pharmacological strategies that would help in effective delivery of SPMs in dental pulp space.

### Abstract 492

#### Comparison of working length determination using cone-beam computed tomography, periapical radiograph and electronic apex locator in teeth with periapical lesion: An *in-vivo* study

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**Aim:** The purpose of this clinical study was to compare the accuracy of working length (WL) determination using cone-beam computed tomography (CBCT), conventional periapical radiograph and electronic apex locator.

**Materials and Methods:** This study was conducted during root canal treatment of 30 patients with a total of 30 single-rooted teeth with the periapical lesion. The radiological WL was calculated preoperatively from CBCT sections. After access preparation, WL was measured with the apex locator under dry conditions and a WL radiograph was taken with the file in the canal. These three measurements were tabulated, compared and the data were analyzed.

**Results:** There was a significant difference between the working length of all the three groups.

**Conclusion:** Working length determination using CBCT images was more precise when compared to the radiographic method and electronic apex locator.

### Abstract 493

#### Computer-aided design-computer-aided manufacturing composites: A new approach for post endodontic restorations

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CAD/CAM technology is used for fabrication of indirect restoration as it is more precise and less unpredictable than the traditional methods for fabrication of conventional crowns and restorations post endodontic treatment. CAD/CAM composites are patient friendly, less time consuming and can be fabricated chair-side. Since the first introduction of CAD/CAM composites in the market, Paradigm MZ100 (3M ESPE) in 2010, the materials have been improved so far in every aspect. They are an attractive choice as they have improved their mechanical properties with an adequate wear resistance, due to a higher degree of conversion and filler content, their chemical stability, biological properties and long-term performance probability. Fillers used in blocks include silica, alumina and zirconia. Composite crowns can be more easily adjusted and polished intraorally than can ceramic materials. The successful prognosis of a resin composite CAD/CAM restoration relies not only on the physico-mechanical properties of the material and correct application but also on the accurate clinical performance of each procedural step, such as proper case selection, abutment tooth preparation, bonding and occlusal adjustment. Very few *in-vivo* studies have been reported with their use and it remains a material of keen interest especially for endodontically treated teeth that require esthetic coverage. Therefore the objective of this review is to analyse CAD-CAM composites as a post endodontic restorative material from a clinical perspective.

### Abstract 494

#### Cytotoxicity comparison of bioceramic root repair materials and mineral trioxide aggregates: A systematic review of *invitro* studies

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**Introduction:** Most endodontic materials have limited contact with living tissues, such as root apex. However, in some procedures, such as pulp capping/pulpotomy, perforation repair, apexification and root-end filling, materials are placed in close proximity to pulp and periodontal tissues. Therefore, biocompatibility is essential in these situations. In addition it would be ideal if the interaction between the material and surrounding tissue created a microenvironment that favours the healing process. Mineral Trioxide Aggregate (MTA) is increasingly recognized as the preferred choice of capping/filling material because of its bioactivity and biocompatibility. Endosequence Root Repair Material (ERRM), a bioceramic material, is seen as a clinically valuable alternative to MTA because of the differences in nanostructure and easier manipulation by dental clinician.

**Objective:** To evaluate the cytocompatibility and interaction of bioceramic materials with human and animal mesenchymal cells

Abstract

and to compare them with mineral trioxide aggregates.

**Materials and Methods:** PubMed/Medline, Scopus and Web of Science searches were conducted to identify studies published in English without restrictions on year of publication using the following key words: "Cytocompatibility", "Viability", "root repair material", "bioceramics". The articles were selected following the PRISMA statement. This review included in vitro studies using human and animal mesenchymal cells, therefore PICO system was adapted. A total of 50 articles were identified in the initial search. However only 12 studies met the inclusion and exclusion criteria.

**Results:** The results showed that in five studies (41.5%) bioceramic root repair materials have low cytotoxicity, promote cell proliferation and adhesion than Mineral Trioxide Aggregate material. Six studies (50%) revealed that both the tested materials are equally biocompatible. Only one study (8.3%) showed that MTA is more biocompatible than bioceramic materials.

**Conclusion:** Both the materials promote cell viability, are cytocompatible with human mesenchymal cells. Therefore choice of bioceramic materials or MTA materials based on biocompatibility should be the professional's.

**Funding:** This research received no external funding.

#### Abstract 495

#### Multi - modality management of traumatized anterior teeth: A case report

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Traumatic injuries in anterior teeth are very common during childhood and adolescence and often results in loss of vitality and tooth discoloration posing a great challenge to a clinician. In general, these injuries take place before root formation is complete and may result in the inflammation or necrosis of the pulp tissue. Loss of vital pulp in immature permanent teeth may result in cessation of root development and compromised apical closure. Consequently, the root canal remains large with thin and fragile walls and the apex remains open. Dental traumatic injuries can also lead to discoloration, increased overjet with protrusion of teeth and inadequate lip coverage. This case report represents discoloured, proclined anterior teeth with spacing following history of trauma. The management of an open apex using mineral trioxide aggregate (MTA) apexification was done as a one step technique followed by non - vital bleaching of discoloured teeth. Since aesthetic consideration should not be neglected and rehabilitation treatment always request priority, both on a functional and psychological level, post endodontic restoration was planned in such a way that complete space closure and correction of the proclination was achieved by all ceramic crowns. This paper details the treatment of traumatized teeth with aesthetic corrections and maximum patient satisfaction.

#### Abstract 496

#### Comparative evaluation of the antibacterial efficacy of graphene oxide nanoparticle incorporated irrigant and

#### etidronic acid irrigant against *Enterococcus faecalis*: An in-vitro study

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Karnataka, India

**Aims:** The aim of this study is to evaluate and compare the antimicrobial efficacy of graphene oxide nanoparticle irrigant and 18% etidronic acid irrigant against *E. faecalis*.

**Materials and Methods:** The agar disc-diffusion test of the endodontic irrigants were studied on BHI agar plate. The *E. faecalis* (ATCC 29212) strain was evaluated against the following irrigants: 18% Etidronic acid irrigant and graphene oxide nanoparticle irrigant. Sterile paper discs were then saturated with each irrigant and then aseptically transferred to the agar plate previously incubated with bacteria. Size of the resulting zones of inhibition were measured (mm) by two observers with sliding callipers and calculated as follows: Size of growth inhibition zone = (Diameter halo) Diameter specimen / 2. The results will be recorded in terms of the average diameter of growth inhibition zone.

**Results:** The study is an ongoing research.

#### Abstract 497

#### Cone-beam computed tomography evaluation of the incidence of C-shaped canals in mandibular premolars and molars of North Indian population and co-relation of taurodontism with C-shaped molars

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**Aim:** The purpose of this scientific research was to investigate the prevalence of C-shaped root canals in the mandibular premolars and molars and the co-relation of taurodontism with C-shaped molars in a North Indian population using cone-beam computed tomography (CBCT) images. The number of canals in the respective teeth were also analyzed.

**Materials and Methods:** CBCT scans of 121 females and 163 males were evaluated which constituted 120 mandibular first molars, 107 mandibular second molars, 115 mandibular first premolars, and 125 mandibular second premolars. The age of the individuals ranged from 18 to 69. Taurodonts were detected according to Shifman and Chanannel's classification. The research was a retrospective study and approved by the Sri Guru Ramdas Institute of Dental Sciences and Research ethics committee.

**Results:** The prevalence of C-shaped canals in mandibular molars and premolars was found out to be 15% and 35% respectively. There was no significant difference in the incidence of C-shaped canals in males and females. Most of the C-shaped mandibular molars were meso-taurodont. The incidence of 4 canals in non C-shaped mandibular molars was found to be 31.3% and of 2 and 3 canals in non C-shaped mandibular premolars was 5% and 2% respectively. The study was statistically analyzed.

Abstract

**Conclusion:** A high correlation was revealed between taurodontism and complicated C-shape canal configurations. North Indian population exhibited a high incidence of C-shaped root canal configuration in mandibular molars and premolars. Endodontists should be very careful while treating taurodontic teeth and their root configuration characteristics to increase the success rate of endodontic treatment.

**Abstract 498**

**Root canal curvature: "A cruel learning curve"**

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Root curvatures are deviation or bend in the linear relationship of a crown of a tooth to its root. Root curvatures are more frequently observed in the apical third of the root in incisors, canines and premolars. In addition, most canals have multiple planes of curvature throughout their length which may lead to procedural errors such as ledges, fractured instruments, canal blockages, zip and elbow creations. Failure to grasp the rationale behind cleaning and shaping concepts can increase the occurrence of needless complications, such as ledges. A ledge is created when the working length can no longer be negotiated and the original pathway of the canal has been lost. This case report includes 4 cases of patients diagnosed with Symptomatic irreversible pulpitis and pulp necrosis. Routine endodontic treatment was initiated and cleaning and shaping was done using hand Ni-Ti files & HYFLEX-CM files. A well prepared Glyde path is the key to success of managing curved canals. Calcium hydroxide dressing was given for 7 days followed by obturation with guttapercha cone and zinc oxide eugenol sealer. Biomechanical instrumentation in severely curved root canals are always a challenge for the clinicians. Thorough clinical and radiographical examinations are very important in managing these conditions. Smart advancement technique (SAT), Tactile controlled activation technique (TCA) will reduce the procedural errors.

**Abstract 499**

**Accuracy of root -end resection in endodontic microsurgery using computer-aided static navigation technique: A systematic review**

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**Aim:** This study evaluates the accuracy of root-end resection using computer aided - static navigation technique in endodontic micro surgery.

**Methods:** The material and method were based on the PRISMA(Preferred Reporting Items for Systematic Reviews and Meta Analyses) guidelines. PubMed, web of sciences, central Cochrane and Scopus were searched up to June 10th, 2021, followed by manual search. The detailed PICOS(Population, Intervention, Comparison and Outcome) principles were followed. An adequate search

strategy was used in each data base using the key words that fulfill the objective of abstract. Detailed eligibility criteria were applied. Inclusion criteria: In vitro studies, randomized clinical trials, clinical trials, case series, case reports. Exclusion criteria: systematic reviews and editorials. A total of 13 articles were included and were selected for the qualitative analysis. Quality assessment was done using modified CONSORT for in vitro studies and CARE for case reports.

**Results:** Within the included manuscripts, there were 8 case reports and 5 experimental studies. For the case reports the mean compliance was 83% with maximum score of 93%(Ye *et al*, Antal *et al*, Popowiz *et al*) and for experimental studies the mean compliance was 65% with maximum score of 87% (Fan *et al*).

**Conclusion:** The endodontic microsurgies using surgical guides show the predictable outcome and lower risk of iatrogenic damage. Minimally invasive and less chair side time. The clinical studies show high precision using computer aided static navigation technique, so this technique is highly recommended to locate the accurate root- apex in endodontic microsurgery.

**Abstract 500**

**Herbal therapy in endodontics**

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From the medieval era, natural products have been widely used as medicine in dentistry. Drugs that are emerged from plants are referred to as herbal medicines and they are used to accomplish a state of well-being in human beings. India is known for its abundant merchandise of medicinal plants. Among many, some herbs are rich in phytochemical content. These phytochemicals are useful in generating phytomedicines that are derived from leaves, root, seeds, and flowers which have effects on the human body. They have been studied and used nowadays for their anti-inflammatory, antioxidant and antimicrobial properties. In Endodontics the recent trend was set to extract biological medication as root canal irrigant and intra canal medicament because of the cytotoxic reactions of root canal irrigant and their inability to eliminate the microorganisms from the dentinal tubules respectively. Medicinal plants are widely used in endodontics due to their easier availability, increased shelf life, lesser cost and toxicity and due to the side effects of synthetic medicines which alter microbiota. This paper aims at a comprehensive overview of natural products used in endodontics and brings to the forefront the unexplored potential of traditional herbs.

**Abstract 501**

**Iatrogenically perforated tooth: Hopeless or repairable? A case report**

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Root perforations are accidental events that may occur during the

Abstract

endodontic treatment. A reason for perforation can be the incorrectly angled introduction of a bur resulting in lateral perforations, mostly at the mesial or distal aspect of the crown. Perforations increase the risk of failure of the affected tooth. The purpose of treating a perforation is to seal the communication between the root canal space and the periradicular tissues. This will prevent damage to the periodontal ligament and alveolar bone resorption. The factors influencing the success of perforation repair depend upon the visualization of the perforation site, the location and the size of the perforation, potential microbial colonization of the endodontic system, the time lapse between the occurrence of the perforation and repair, and the filling material. Magnification provides us with more depth of field, allows us to look deeper into the perforation site, and eases the placement of the osteoinductive material to seal the perforation site. Decontamination at the perforation site and in the remaining root canal system is essential for long-term success. Mineral trioxide aggregate (MTA) is widely used to seal perforations because of its biocompatibility and sealability. Treatment done under an operating microscope with MTA has been suitable for perforation repair and has shown a good prognosis. The use of biocompatible materials to repair perforations is advocated to reduce the incidence of inflammatory reactions in the surrounding tissues. Thus, this case report aims to demonstrate the repair of lateral perforation in a mandibular premolar with Mineral Trioxide Aggregate.

#### Abstract 502

##### Biomimetic reattachment of a subgingivally fractured anterior tooth after endodontic treatment: A case report

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In today's world of biomimetics, natural appearance is considered to be the benchmark for aesthetics in dentistry. Coronal fracture of anterior teeth is a common finding in adolescents and young adults, which adversely affects the aesthetics and consequently, demands a more permanent and aesthetic approach. Though diverse treatment modalities are available, tooth fragment reattachment is generally considered a viable treatment option due to simplicity, natural aesthetics, and functional success. Depending on the extent of fracture, position of the fracture line, root length and esthetic needs, the treatment can have either a surgical or a non-surgical approach. As to the materials used for bonding, different types of adhesive systems (multimode, total-etch or self-etch) and different types of intermediate materials such as conventional or flowable composites, resin cements or resin-modified glass ionomer cements can be used. In a surgical fragment re-attachment technique, which is predominantly involving the pulp, hence endodontic treatment of the affected tooth precedes the surgical flap elevation. In a non-surgical fragment re-attachment technique, it can either be attached using bonding agent or an intermediate material (flowable composite or resin cements). In the case presented in this report, the tooth is endodontically treated, followed by post placement, and flap elevation, to re-attach it using flowable composite. The

tooth was finished and polished, and followed for 6 months to reveal maintenance of aesthetics and function. Tooth fragment reattachment procedure offers ultraconservative, safe, fast and esthetically pleasing results when the fractured fragment is available due to the improvement of adhesive techniques and restorative materials.

#### Abstract 503

##### Assessment of apically extruded debris produced by the self-adjusting file system and ProTaper Universal: An *in-vitro* study

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**Aim:** To evaluate the weight of debris extruded apically from teeth using Self- Adjusting File system and ProTaper Universal.

**Materials and Methods:** Twenty extracted human mandibular premolars with single canals were selected and randomly divided into two groups (n = 20) for instrumentation with two different file systems. Group 1: ProTaper Universal F2 (25.08; Dentsply Maillefer, Ballaigues, Switzerland). Group 2: Self-Adjusting File (SAF, 1.5-mm diameter; Re-Dent Nova, Ra'anana, Israel), and Debris extruding by instrumentation were collected into pre-weighed glass bottles. These bottles were then stored in an incubator at 70°C for 5 days. Bottles with extruded dry debris then weighed to obtain the final weight. Statistical analysis for the debris extruded apically was analysed using one-way analysis of variance and post hoc Tukey's test.

**Results:** The statistical analysis showed a significant difference between two groups tested (P < 0.001). Self -Adjusting File (SAF) exhibited significantly less (P < 0.001) debris extrusion between the two groups tested.

**Conclusion:** Under the conditions of this study, both system caused apical debris extrusion . The Self -Adjusting File (SAF) instrumentation was associated with less debris extrusion compared to ProTaper Universal.

#### Abstract 504

##### Magnification the 3<sup>rd</sup> eye: seeing the unseen

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"You can only treat what you can see." Miniscule anatomy of canal always poses a challenge to Endodontist. As unaided eyes can only see upto the level of canal orifice, higher visual acuity is required in managing intricate cases. Optical magnifications have really broadened the horizons of dentistry. Any device that enhances or improves a clinician's resolving power is extremely beneficial in producing precision dentistry. The application of magnification in Endodontics provides visual enhancement and improved ergonomics. Ambiguity in clinical diagnosis is minimized with enhanced visual ability. Dental loupes and dental operating microscopes ameliorate management of elusive and calcified canals, iatrogenic errors, as well as retreatment cases which were once thought to be impossible

Abstract

to treat. A magnified, clear image can speak more for itself than a thousand words put together. In the foreseeable future, the use of magnification is likely to become the standard of practice, particularly within the discipline of endodontics. This paper will focus on the implication of magnification and illumination to manage surgical and non-surgical endodontic procedures.

**Abstract 505**  
**Hemisection: Conserving by dicing**

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A Condition characterized by the association of periodontal and pulpal disease in the same element is known as Endo-Perio lesion. Pulpal and periodontal problems are responsible for more than half of the tooth mortality. Endo-perio lesion develop due to the intimate anatomic and functional relation between endodontic and periodontal tissues. Both the pulp and periodontium share the same embryologic and anatomic origin. The various pathways connecting them like dentinal tubules, lateral and accessory canals, and the apical foramen, may create complication by adding up micro-organisms, where ultimately interdisciplinary approach is required. Treatment and prognosis of endodontic-periodontal diseases vary, depend on the cause and the correct diagnosis of each specific condition. Root amputation, Hemisection, Bicuspidization, Regenerative periodontal procedures are various treatment options for endo-perio lesions. A 45 year old patient came to hospital with chief complaint of food lodgement in lower right back tooth region since 4-5 months. On clinical examination tooth had distal surface caries with deep periodontal pocket on distal side. Tooth gave negative response on electric pulp testing i.e non-vital. Radiographic examination showed tooth no. 46 having angular bone loss on distal wall and radiolucency involving enamel and dentin on only distal portion of crown. SO Hemisection was planned as treatment option. In this case separation of the tooth was done at the furcation area into two halves with removal of distal half.. This decision was based on the extent and pattern of bony loss, root trunk and root length, ability to eliminate the osseous defect and restorative considerations. After healing prosthesis was given on tooth number 46 & 47. Pt was kept on followup.

**Abstract 506**  
**Artificial Intelligence – A ray of hope in endodontics: Review**

**DIVYA**

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Uttar Pradesh, India

Artificial intelligence has been defined as the idea of machines being capable of performing human tasks. The term was coined in 1950 and at times called as machine intelligence. It comprises of various methodologies such as artificial neural networks (ANN), genetic algorithms (GA) and fuzzy logic. These systems have the capability to solve the complex problems with the help of simple rules providing a clinician a logical reasoning for the fuzzy problem. In the field of endodontics, AI can aid in providing better precision in detection of

diseases a well diagnosis. It is helpful in studying root canal system anatomy, detecting periapical lesions, root fractures, working length determination and many more applications. Thereby reaching the goal of endodontic success .

**Abstract 507**  
**Comparative evaluation of effect of rotary file and lentulo spiral usage at different speeds on apical extrusion of calcium hydroxide: An *in vitro* study**

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**Aim:** To compare apical extrusion of calcium hydroxide using rotary file and lentulo spiral at different speeds.

**Materials and Methods:** 25 human mandibular single rooted premolars were used. Root canals were enlarged till F1 Protaper universal file size. Root canals were irrigated with 5.25% sodium hypochloride, 17% EDTA and saline and then tooth were dried with paper points. Each teeth were placed in glass tubes which were covered with aluminium foil. Specimens were divided into 5 groups (n=5): G1: #30 K file, G2: Protaper universal file at 350rpm, G3: Protaper universal file at 1000rpm, G4: Lentulo spiral at 350rpm, G5: Lentulo spiral at 1000rpm. K-file was used at working length, lentulo spiral and rotary files were used 2mm short of working length. The apices were inspected for extrusion of calcium hydroxide with operating microscope and were scored. Data was analyzed using chi-square test.

**Results:** There was statistically significant differences ( $p < 0.05$ ) among file system and lentulo spiral with different speed, with minimum extrusion in K-File(G1) followed by protaper systems(G2,G3) and highest extrusion in lentulo spiral systems (G4,G5). Apical extrusion was seen found higher ( $p < 0.005$ ) at 1000rpm as compared to 350rpm in both protaper system and lentulo spiral system.

**Conclusion:** Lentulo spirals and rotary files should be used with lower speed in clinical practice to avoid extrusion of calcium hydroxide.

**Abstract 508**  
**Comparative evaluation of incidence of post-operative pain using hand, rotary and reciprocating file systems: An *in-vivo* study**

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SHANTUN MALHOTRA**

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**Aim:** The aim of this study was to evaluate the incidence of post-operative pain after cleaning and shaping with 3 file system using Hand, Rotary and Reciprocation motion in maxillary and mandibular molars.

**Materials and Methods:** A total 60 patients were randomly divided into 3 groups according to the instrumentation technique used. In

## Abstract

group 1 (n=20) teeth were prepared with Hand Protaper file system till F2 size. In group 2 (n=20) teeth were prepared with Primary Wave One Gold (reciprocating motion) and in group 3 (n=20) teeth were prepared with ProTaper Gold file system (rotary motion) till F2 size. The pre and post-operative pain score was noted using Visual Analog Scale at 12, 24, 48 and 72 hours after preparation.

**Results:** All the pre-instrumentation pain values were higher than post-instrumentation. There was a significant difference between the groups with highest post-operative pain value for group 2 wave one gold (reciprocation motion) followed by Hand protaper and Protaper gold rotary files.

**Conclusion:** Post-operative pain was significantly lower in patients treated with Rotary Protaper gold as compared to wave one gold and hand protaper file systems.

### Abstract 509

#### The magic gels in regenerative endodontics: A review

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Preserving the natural dentition in its normal form and function is one of the major goals of endodontic treatment. Clinically, retaining or re-establishing the vitality of pulp tissue damaged by microbial infection, trauma, or developmental defects is quiet challenging. The paradigm shift in the endodontic treatment procedures from repair related approach to regeneration of dentin-pulp complex have shown a promising impact on efforts to retain the natural dental tissues. The biological concept of regenerative endodontic procedures involves the triad of stem cells, scaffold and signaling molecules. The potential regenerative approaches that are widely acknowledged include root-canal revascularization, postnatal stem cell therapy, pulp implant, three-dimensional cell printing, injectable scaffolds, and gene therapy. These approaches aim to regenerate the dentin-pulp complex through stimulating the differentiation of resident or transplanted progenitor stem cells. Currently the use of injectable hydrogel-based scaffolds which mimic the extracellular matrix of the dental pulp have been extensively researched in the field of regenerative endodontics. They are a unique category of three-dimensional polymeric networks that are broadly classified into natural, synthetic or hybrid hydrogels. Natural hydrogel polymers are bioactive, highly biocompatible, and biodegradable. On the other hand, synthetic hydrogel polymers offer superior mechanical properties, thermostability and durability when compared to natural hydrogels. Hybrid hydrogels combine the benefits of both synthetic and natural polymers. These hydrogels can be used as scaffolds or as carriers of therapeutic agents such as drugs, cells, proteins, and bioactive molecules that induce the regeneration of dentin-pulp complex. Thus, the aim of this presentation is to provide an overview of various dental hydrogels tested and their current clinical applications based on scientific evidence.

### Abstract 510

#### Fractured endodontic instrument: The common clinical dilemma – Retrieve, bypass or entomb

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India

Instrument separation during endodontic therapy is a frequent accident with rotary instruments being more likely to separate than manual ones. The treatment of cases with a separated instrument can either be conservative or surgical. A conservative approach involves the following treatment choices: a) removal of the fragment, b) bypass of the fragment, c) instrumentation and obturation coronally to the fragment. Concerning the removal of a separated instrument, a variety of techniques and systems have been developed. Ultrasonics, in combination with the operative microscope constitute the most effective and reliable tools for removing a separated endodontic instrument from a root canal. The likelihood of successful removal depends on a number of factors. To name a few, are: the level of separation (coronal, middle or apical third); location in relation to the root canal curvature; the type of separated instrument; its length; the degree of canal curvature and the tooth type. Several complications may occur during the management of a separated instrument: separation of the ultrasonic tip or file used for bypassing or removing the instrument; further separation of the fragment; perforation; ledge; extrusion of the file into periapical tissues; tooth weakening due to dentin removal. Prognosis for a tooth retaining a separated instrument depends on the presence of a periapical lesion, the microbial load of the root canal during the time of separation and the quality of the obturation which include coronal and apical seal.

### Abstract 511

#### Comparative evaluation of root canal morphology of human mandibular permanent second molar using cone-beam computed tomography and decalcification and dye-penetration technique: An *in vitro* study

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**Objective:** To evaluate the root canal morphology of human mandibular permanent second molar to determine the number of root canals and root canal configurations according to Vertucci's classification of root canal morphology using Cone Beam Computed Tomography (CBCT) and Decalcification with Dye Penetration technique. A comparative study also has been performed to analyse the accuracy of CBCT taking into consideration decalcification technique as the reference standard.

**Materials and Methods:** 100 (n=100) human permanent mandibular 2nd molar teeth, freshly collected were taken and the root canal morphology has been evaluated by CBCT. The teeth were then subjected to decalcification (by HNO<sub>3</sub>) and dye-penetration (Indian Ink) processes for further comparative evaluation of root canal morphology. A comparative analysis between those studies also has been performed to analyse the accuracy of CBCT taking decalcification technique as the reference standard.

**Results:** The present study shows that there is no significant difference between the observed and the expected values of decalcification & dye penetration technique and CBCT respectively, as the p value is more than 0.05. The human permanent mandibular second molars: in mesial root canal have Type II canal predominantly

## Abstract

followed by Type IV root canal; in Distal Root Canal have Type I canal predominantly.

**Conclusion:** Human Permanent Mandibular Second molars usually are two-rooted teeth with three canals; mesial root canal have Type II canal predominantly and in distal root canal have type I canal predominantly. According to our study CBCT can be used effectively and successfully for diagnosis and prognosis of endodontic treatment.

### Abstract 512

#### Functions of root canal sealers: A review

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Successful endodontic therapy depends on several factors. Proper reaming, filing and irrigation of the canal should result in a reduction or elimination of microorganisms. A well-adapted filling with sealer should fill the canal and prevent reinfection and a properly placed coronal restoration should complete the task. The usual canal filling material is gutta-percha in conjunction with a sealer. Because the gutta-percha is impermeable, leakage, if it occurs, can take place at either the gutta-percha sealer interface or the sealer dentinal wall interface. Therefore, some of the physical properties of sealer and the possible effect of a post preparation on sealer become important. Grossman studied the physical properties of sealers and postulated that sealing ability may be related to those physical properties and that manipulation of the material during or after filling could affect the ability to produce a good seal. The root canal sealers have different functions like it has antibacterial property, act as lubricant for core material, increase radio-opacity of core or filling materials. So, meaning of this review is to compile functions of different endodontic sealers.

### Abstract 513

#### Management of different types of root resorption using cone beam computed tomography, ledermix medicament and bioactive cement: A case series

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Root resorption (RR) is the loss of dental hard tissue (i.e., cementum, dentine and/or enamel) as a result of clastic activities within the pulp or periodontium. RR may be physiologic as seen in deciduous teeth where the process is well regulated. Bone also undergoes continuous physiologic remodeling throughout life, whereas RR of permanent teeth does not occur naturally and is invariably inflammatory in nature. Thus, RR in the permanent dentition is a pathologic event and if left untreated, might result in the premature loss of the affected teeth. Based on origin, location, and etiologic factor; RR in permanent teeth can be broadly classified into internal and external resorption, Where External resorption can be further classified as Surface, Replacement, and Inflammatory. Intraoral radiographs are the most common approach used for RR diagnosis, and most clinical studies use the radiographs of an irregular root surface outline at different angles to determine which surface is

affected. Currently, as the limitations of routine dental radiography are widely known, cone-beam computed tomography (CBCT) is gaining popularity, enhancing the diagnosis of resorptive lesions in earlier stages. This case series, presents 3 cases of External Root Resorption, highlighting the importance of using cone-beam computed tomography, ledermix dressings, trichloroacetic acid, and bioactive endodontic cement, like Calcium Enriched mixture and Biodentine in the diagnosis and efficient management of different types of root resorption.

### Abstract 514

#### Developing a proximal contact former and *in vitro* comparative 3D image reconstruction analysis of contacts and contour formed by this device

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S KARTHIK**

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**Aim:** To develop a transparent proximal contact former using resin based material and to assess quantitatively the proximal contour and contact tightness using the new device.

**Materials and Methods:** The experimental device was fabricated using an epoxy resin based material. The dimensions was based on previous studies on proximal contour and contacts of extensive class II composite restorations. All teeth were prepared with MO cavity designed to simulate a condition representing moderate-wide preparation. The mesial contacts of 20 lower right first molars was used for testing. After preparation the 20 samples were restored using the tofflemire matrix system. These samples were further divided into 2 groups of 10 samples each depending on whether the contact former was used or not. Quantitative assessment of contour was done using MEDIT T500 scanner by superimposing method and Siemens NX software. Contact tightness was measured using belt tension tester. Data collected was statistically analysed using ANOVA followed by post-hoc, independent t test & Chi-square test

**Results:** Contact tightness and contour formed is significantly better when using contact former than without using contact former ( $p < 0.05$ ).

**Conclusion:** When using contact former in class II composite restorations more contact tightness and contour is formed than without using contact former.

### Abstract 515

#### Navigating into the future by dynamic navigation system

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India

Endodontic diagnosis and treatment planning are made easy with the use of operating surgical microscope, Ni-Ti revolution for shaping canals and most recently the use of CBCT technique. Recently a new technology known as Dynamic navigation System (DNS) has been introduced. Prior to introduction of this technology

Abstract

a static guide (CAD-CAM) using prefabricated stent based on CBCT scan was manufactured to guide safe placement of implant, negotiating calcified, multiple canals and difficult to locate canals, unusual canal anatomy and in endodontic microsurgery. Small and more accurate access can be made safely using this technology. Conservative access cavities are performed in two different ways.

- I. Manually (Depending on operator's skill.)
- II. Guided (Depending on planning and precision during execution) which shows differences in terms of design and precision. Access cavities with DNS are prepared mostly to minimize tooth weakening and also to reduce instrumentation stress.

DNS uses a stereoscopic tracking camera to dynamically guide the operator's instruments to the correct location for placement of implants and negotiating calcified canals. It is comfortable to patients, more precise, less invasive and safer due to real time control of entire procedure. It is a transition in dental profession. It will facilitate the operator's maneuvers and reduce the risk of iatrogenic errors.

#### Abstract 516

### Successful conservative management of symptomatic irreversible pulpitis with apical periodontitis in vital mature molar by pulpotomy using biodentine: A case series

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Irreversible pulpitis is the most prevalent reason for endodontic therapy in permanent teeth especially when it is associated with periapical pathology. It is an inflammatory disease of the dental pulp that is characterized by spontaneous, lingering pain that lasts for minutes to hours where pulp tissue is incapable of self-healing. Root canal therapy is the routine choice of treatment for irreversible pulpitis with periapical involvement. However, root canal treatment has the drawback of being a non-biologic and non-conservative procedure. It is also costly, time-consuming, technique-dependent, and necessitates meticulous skills. Advancement in the knowledge of regeneration, pulp biology, the healing ability of inflamed pulp, and the development of Bioceramic materials, has shifted the focus of endodontology from root canal treatment towards vital pulp therapy in properly selected cases. Vital pulp therapy is increasingly being regarded as a less invasive alternative to root canal treatment for teeth with inflamed pulp. The occurrence of spontaneous preoperative pain does not always imply that the pulp is irreversibly damaged. Even when periapical radiolucency is present, the pulp tissue can remain vital. This living pulp tissue can return to a healthy and functional state after eliminating caries and bacterial contamination from the dentine-pulp complex and achieving a hermetic coronal seal using bioactive material. Permanent tooth pulpotomy with calcium-silicate-based cement can help preserve the pulp vitality and promote healing and repair of the inflamed pulp. Biodentine has improved properties such as better handling, faster initial setting time, better marginal integrity, no tooth staining with better antimicrobial activity, cytocompatibility,

and bioactivity. It encourages dentine regeneration by inducing odontoblast differentiation from pulp progenitor cells and promote mineralization, resulting in reactionary dentine and a thick dental bridge. This case series presents the successful outcome of vital pulp therapy in vital mandibular molars in symptomatic irreversible pulpitis with periapical involvement by using biodentine, with the help of cone-beam computed tomography (CBCT). The successful outcome of these cases suggests that irreversibly inflamed pulp with periapical involvement has the potential to heal after coronal pulpotomy with biodentine.

#### Abstract 517

### Strontium as an additive in calcium silicate cements for endodontic applications: A narrative review

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The prime purpose of calcium silicate based endodontic cements is to provide perfect sealing of the root canal to prevent re-infection. However, the presence of heavy elements in these cements can lead to tooth discoloration and periapical tissue toxicity. Ideally, the cement components should aid in biomineralization and should be biocompatible, especially in event of any over-extrusion into the periapical region. Currently, mineral trioxide aggregate (MTA), a calcium silicate cement is extensively used in endodontics for various therapeutic purposes. Portland cement and a radiopacifier agent are the actual components present in MTA. However, literature evidence suggests that bismuth oxide present in MTA affects the hydration kinetics of the cement, reducing the precipitation of calcium hydroxide in the hydrated paste that drastically affects the compressive strength and setting reaction. On the other hand, toxicity due to bismuth compounds and arsenic impurities is a major concern regarding MTA safety. Thus, the need arises to develop new compositions of endodontic cements with adequate bioactive as well as radiopaque metallic ions. Strontium (Sr<sup>2+</sup>) containing silicate cements would be an ideal choice due to their enhanced bioactivity and radio-opacity. It has been reported that the incorporation of Sr<sup>2+</sup> ions into the bioactive glass favors regeneration of alveolar bone, root cementum and periodontal ligament. Also, Sr<sup>2+</sup> ions are identified to be non-toxic for human periodontal ligament (PDL) cells. Density and atomic number are the main deciding factors in radio-opacity and hence, Sr<sup>2+</sup> can be used to enhance the radiodensity of conventional calcium silicate cements, thereby avoiding other toxic heavy metals. The low particle size, high radio-contrast, improved bioactivity and cell compatibility warrants the use of strontium in silicate-based endodontic cement formulations. Currently literature studies are available pertaining to the addition of strontium in calcium silicate based cements like MTA, tetracalcium phosphate, orthosilicate etc., This narrative review highlights the various formulations of calcium silicate-based cements containing strontium for applications in endodontics.

### Abstract 518

#### Observation of fracture pattern of WaveOne Gold instruments that fractured during clinical use: A scanning electron microscopic study

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**Aim:** The present study aimed at observation and analysis of the pattern of fracture of rotary WaveOne instruments that had fractured during clinical use.

**Materials and Methods:** Forty five fractured WaveOne Gold were collected from the post graduate clinic of Department of Conservative Dentistry and Endodontics, Dr. Z. A. Dental College, AMU Aligarh. All the files were cleaned in an ultrasonic cleaner for 30 minutes and scheduled for scanning electron microscopic (SEM) observation. All these instruments had an unclear history of clinical use and most of the fractured instruments had usually undergone 08-10 clinical usages. The fractured surface of each instrument was observed under SEM at different magnifications and the pattern of fracture was evaluated.

**Results:** The fracture pattern of almost all the fractured files, generally exhibited substantial ductile character, evidenced by a dimpled rupture fracture surface. Forty three files showed a ductile fracture pattern characterized by a dull dimpled surface and microvoids. Only two files showed evidence of brittle fractures with crack propagation at grain boundaries and cleavage surfaces indicative of transgranular fracture.

**Conclusions:** Within the protocol of the present study it can be concluded that the main mode of fracture of the WaveOne Gold instruments is the ductile fracture. Although the brittle fracture may occur in some instruments where stress propagation along a crack or a manufacturing defect may result in the fracture of the instrument.

### Abstract 519

#### Endodontic microsurgery – A road to salvation for symptomatic tooth after root canal treatment and recurrent endodontic lesions

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Endodontic surgery is a surgical procedure performed to remove or correct the causative agents of radicular and periradicular disease and to restore these tissues to its functional health. There has been a gradual paradigm shift from surgical to nonsurgical treatment over the past few decades. Periradicular surgery should be considered to identify and rectify the cause for the persistence of symptoms in patients even after nonsurgical retreatment. Nonsurgical treatment should have been rendered at least twice in such cases before opting for surgery. Objectives and rationale for surgery are Curettage, Resection and Inspection. A 42 year old female patient reported to the department of Conservative Dentistry and Endodontics, with the chief complaint of pain in her upper front tooth (maxillary central incisors). She gave history of

Road Traffic Accident (RTA). Pulp vitality test was done by using Electric pulp tester. Tooth #11 and 21 were found to be non vital. Root canal treatment (RCT) was done. Pain in tooth #21 subsided, but the patient complained of constant pain in tooth #11. Re-RCT was attempted twice with multiple Calcium hydroxide dressings, but the clinical symptoms did not subside. Moreover, the root end was getting blunted/resorbed which was clearly evident in RVG. The tooth was not mobile. According to Kim's Classification of microsurgical cases Class A, Endodontic surgery was planned. The patient was examined for bleeding time, clotting time, prothrombin time before the surgery. Patient's systemic status was also evaluated, wherein the patient revealed that she recovered from Covid-19, 2 months back. After incision and flap elevation, the tooth showed complete denudation of buccal plate (Kim's Class F). Curettage, root resection and cold burnishing were done. Bone grafts were placed along with Ab – Gel and the flap was sutured. The patient's clinical symptoms subsided within 6 days of surgery. Follow up was done after 2, 6 and 12 months and the root did not resorb further, yielding to a successful outcome.

### Abstract 520

#### Endodontic pharmacotherapy in pregnant women: A review

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Pregnancy is said to be a unique period in a women's life and maternal oral health and diseases is considered to be one of the most significant public health concern. Even though oral health care is considered a key to overall health and wellbeing during pregnancy, a study suggests that odontogenic pain is said to affect about 54.9% of pregnant women. This pain is often related to pulpal and periapical infections which can pose a threat to both the mother and the fetus. Odontogenic infections can compromise oropharyngeal airway as they can rapidly progress into deep space infections. The American Dental Association in collaboration with the American College of Obstetricians and Gynecologists developed a consensus statement in 2012 that was reaffirmed in 2019. The statement signified suitable and timely oral health care as a critical component of a healthy pregnancy which included prevention and management of odontogenic infections. Abuse of analgesics such as consumption of over-the-counter medications to control serious pulpal pain during pregnancy can have deleterious effects on fetus and mother. Additionally, there is anxiety among dentists about prescribing medications during endodontic treatment to pregnant women as there is uncertainty about safe use of medications during pregnancy. This is due to the limited safety data available about the effects of commonly used medications upon the developing fetus. The data that is available is limited to animal models or retrospective population-based data. Thus, risk assessment while rendering medications during pregnancy is important while keeping in mind the physiological changes that occur during pregnancy. Therefore, this paper reviews the current evidence on the preventive, diagnostic, restorative dental treatment and safety of medications commonly used in endodontics including local anesthetics, analgesics, anxiolytics, and antibiotics.

### Abstract 521

#### The era of bioactive glass

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Silica containing Bioactive Glass are a group of surface reactive glass ceramic biomaterials which include the original bioactive glass – Bioglass and silica. Larry Hench's 45S5 Bioglass® (wt%: 45SiO<sub>2</sub>–25CaO–25Na<sub>2</sub>O–6P<sub>2</sub>O<sub>5</sub>) was the first artificial material that was found to form a chemical bond with bone, launching the field of bioactive ceramics. Bioactive biomaterials are used as scaffolds for bone tissue engineering. Having the ability to bond well with the surrounding tissues (hard tissues as well as soft tissues) in either osteoconductive or osteopductive roles, bioactive glasses (BG) form a carbonated hydroxyapatite layer (HCA) when exposed to biological fluid. This layer is responsible for the strong bonding between bioactive glasses and human bone. More recently, it was also observed that ionic dissolution products from Bioglass® (e.g. Si, Ca, P) and from other silicate based glasses stimulate expression of several genes of osteoblastic cells. Furthermore, bioactive glasses were shown to stimulate angiogenesis in vitro and in vivo, whilst possible antibacterial and inflammatory effects of bioactive glasses have also been investigated. So, in this literature review the role of silica in bioactive glass with its unique biological properties in hard tissue engineering has been discussed.

### Abstract 522

#### Nonsurgical management approaches of primary failed root canal treated teeth: A case series

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India

Retreatment is defined as a procedure to remove root canal filling materials from the tooth, followed by cleaning, shaping and obturating the canals. Recent publications have reported failure rates of 14%–16% for initial root canal treatment. In order to prevent tooth loss in such cases, nonsurgical retreatment or apical surgery is often indicated. According to 2 recent meta-analyses, the pooled weighted success rate for nonsurgical retreatment is 76.6% and 78%, with a range of 62%–86% in the literature. Nonsurgical retreatment can be carried out in either multi-visit or more recently as single-visit. This presentation of 4 cases will discuss the management approaches of primary failed root canal treated teeth in either single visit or multi-visit.

### Abstract 523

#### Evaluation of regenerative endodontic procedure using platelet rich fibrin in human permanent teeth with persistent periapical pathology after conventional root canal treatment: A case series

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According to American Association of Endodontists, Regenerative Endodontic Procedures (REP) are biologically based procedures designed to physiologically replace damaged tooth structures, including dentin and root structures, as well as cells of the pulp-dentin complex. Successful REP results in the elimination of clinical signs and symptoms, the resolution of apical periodontitis, thickening of the canal walls and/ or continued root development with or without apical closure. REPs can even restore the vitality of the tooth and hence restore the immune defense mechanisms to protect the tooth from foreign invaders. REP has become a revolutionizing tissue engineering concept in the treatment of immature permanent teeth for over two decades. It has been described as a 'paradigm shift' in the treatment of immature teeth, since it fosters continued root maturation. REP has also been used to successfully treat human mature permanent teeth with necrotic pulps and apical periodontitis. However, there is not much consensus in using REPs in the previously treated permanent teeth with persistent periapical pathology. The aim of this case series is to describe REPs of 5 previously treated permanent teeth using PRF as a scaffold with long-term results upto 12 months.

### Abstract 524

#### Demystifying the intricate anomaly

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India

Dens invaginatus, first discovered by Ploquet is an anomaly of the tooth formation of embryonic origin that presents itself in several morphologic types. The complex anatomy of these teeth makes nonsurgical endodontic treatment complex and more so when its apex is dilacerated. Several investigators have reviewed the prevalence of multiple DI in the general populations. From time to time, additional exceptional cases have been reported for treatment consideration purposes. This case presentation includes a case of 24 years old girl named Anjana who had complain of swelling and pus discharge from upper right front tooth region. On radiographic examination type 3b dens invaginatus i.e. The invagination occurs as perforating at the root forming a second foramen in the apical area or in the periodontium was confirmed along with dilacerated root end. A surgical treatment was done for this case.

### Abstract 525

#### Combined regenerative and vital pulp therapy in mandibular molar: A case report

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The operating philosophy of contemporary endodontics is to disinfect and obturate by filling the instrumented root canals with inert materials. However if a tooth has different pulp status in individual roots, then regenerative endodontic procedure can be performed in the root with pulp necrosis to regain functionality of root including immune defense mechanisms and sensory innervations and vital pulp therapy can be used to preserve the vital pulp in other root. Maintenance and regeneration

Abstract

of vital pulp tissue is the ideal mode of treatment. Regenerative Endodontic Procedure results in elimination of signs and symptoms, healing of apical pathology (if there is any), thickening of root wall and/or continued growth of root (in immature tooth), positive response to vitality may be achieved. Vital pulp therapy will also result in continuation of root development, maturation of apex and thickening of root walls (in immature tooth), consequently strengthening the roots against fracture. This presentation of one case discusses the management of irreversible pulpitis and apical periodontitis in mandibular molar. After pulpotomy, based on in situ clinical assessment, VPT was done in the root with intact vital pulp and REP in the root where bacterial invasion has proceeded deeper. After irrigation, MTA plug of 3mm was placed over the vital pulp, followed by restoration of the corresponding part of access cavity with RMGIC. After measurement of the working length, minimum and gentle filing was done. Irrigation was done with 1.5% NaOCl. Calcium hydroxide was placed inside the canal followed by restoration of the corresponding part of the access cavity with Cavit. Second visit was done after 3 weeks; Cavit was removed by rinsing with 10 ml 1.5% NaOCl, saline and 20ml 17% EDTA. Bleeding was induced by lacerating the apical tissues with a #20 precurved K file. Collagen plug was placed on the top of blood clot below the CEJ. Subsequently, 3mm of MTA was placed over collagen plug. Composite restoration was placed after reducing the RMGIC. On Follow up visit tooth was found to be functioning normal.

**Abstract 526**

**Combined nonsurgical endodontic and vital pulp therapy for the management of mature permanent mandibular molar teeth: A case report**

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West Bengal, India

The type of diseased status of pulp found in multirooted teeth may vary from one root canal to the other. Current endodontic treatment strategies allow for different treatment options such as Vital Pulp Therapy, Root Canal Treatment and Regenerative Endodontic Therapy depending upon the status of pulp in a specific root canal. Considering the advantages of Vital Pulp Therapy over Root Canal Treatment in maintaining proprioception, hydration of tooth, defense mechanism and reduction in the propensity of tooth fracture has encouraged the adoption of Vital Pulp Therapy over Conventional Root Canal Treatment. Also, the concept of Minimally Invasive Endodontics and the introduction of hydraulic Calcium Silicate based materials with good sealing and bioactive potentials have opened a new era in Vital Pulp Therapy with more favorable outcomes. The prognosis of Vital Pulp Therapy in mature permanent teeth with the pulp exposed due to caries, depends upon proper case selection, strict aseptic conditions, biomaterial used and proper coronal seal. The presentation here demonstrates a case of conservative approach using Combined Treatment modalities in a Mature Permanent Mandibular Molar tooth with Vital Pulp Therapy in the Mesial root and Non Surgical Endodontic Therapy in the Distal root on the basis of clinical and radiographical assessment.

**Abstract 527**

**Removal of fractured nickel-titanium instruments from root canals using electrochemical dissolution process: A review**

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The cleaning and shaping of the root canal system may be impaired by fracture of endodontic instruments. These fractured instruments in the root canal represents an obstacle to endodontic therapy. The retrieval of fractured instruments from root canals has been mostly complex. The proposed methods for removing fractured instruments from root canals have limitations that may cause root weakening and perforation. Those mechanical methods present some limitations related to canal morphology, reduction of root strength, and operator ability. So, a less complex retrieval method that motives minimal harm to the dental structures is needed. Several authors have proposed the use of active dissolution of metal fragments as a method for the removal of fractured instruments from inside the root canal. Dissolution of a fractured instrument may characterize an authentic opportunity to solve this problem. This dissolution would enable the recovery of the original canal path without damaging the root structure. Therefore, this review paper will discuss in detail about the electrochemical dissolution process Nickel-Titanium fragments in the root canal.

**Abstract 528**

**Retreatment endodontic maxillary right central incisor with crown discoloration: A case report**

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DIAN AGUSTIN WAHJUNINGRUM**

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**Aim:** To report a case of root canal retreatment, which was carried out with prefabricated post-restoration and zirconia crown.

**Case:** A 48 years old male patient presented to the Department of Conservative Dentistry, Faculty of Dental Medicine of Universitas Airlangga with a chief complaint; the patient wanted to treat his maxillary right central incisor, which often felt pain, and wanted to achieve esthetic result.

**Case Management:** Endodontic retreatment performed using the crown down pressureless technique by starting with measuring the working length, confirming the working length using the apex locator, preparation using a rotary file until X3 matches the working length, then irrigation and activation of the endoactivator followed by thermoplasticized gutta-percha obturation and apply of prefabricated cast posts. The final restoration is the zirconia crown.

**Conclusion:** Retreatment and esthetic restoration are one an option with long-term success if root canal treatment is unsuccessful due to underfill filling.

**Abstract 529**

**Comparative evaluation of fracture resistance of teeth treated with calcium hydroxide and nano-calcium hydroxide as intracanal medicament**

Abstract

**P ARAVIND**

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**Aim:** The aim of the present study is to evaluate the fracture resistance of teeth treated with Ca(OH)<sub>2</sub> and nano- Ca(OH)<sub>2</sub> as intracanal medicament.

**Materials and Methods:** 30 freshly extracted single rooted teeth are selected and decoronated at the CEJ and divided into three groups(n=10).

Group 1: control without any medicament .

Group 2: Ca(OH)<sub>2</sub> as intracanal medicament.

Group 3: nano- Ca(OH)<sub>2</sub> as intracanal medicament.

Biomechanical preparation is done till F2 for all the samples. In group 2 and group 3 respective intracanal medicaments is placed for 1 week. After one week all the samples are tested under UTM for fracture resistance.

**Results:** There is decreased in the fracture resistance in the samples treated with intracanal medicaments. Nano Calcium hydroxide group has higher fracture resistance values when compared with the calcium hydroxide group.

**Conclusion:** Use of calcium hydroxide reduces the fracture resistance of teeth. And the values are limited when nano calcium hydroxide is used as the intracanal medicaments.

**Abstract 530**

**Endo-surgery and aesthetic management of multiple traumatic dental injuries of maxillary anterior teeth: A case report**

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TAMARA YUANITA**

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The incidence of complicated crown fracture ranges from 2% to 13% while horizontal root fracture is a rare entity where the frequency is only from 0.5% to 7% happened to a permanent teeth. Multiple restorative factors, materials choosing as well as the well-being of the injured area should be taken into consideration when dealing with traumatic injuries. Proper diagnosis, treatment planning and follow-up(s) are crucial to ensure the most favorable outcome is within reach. The present case report to describe the endo-surgery and aesthetic management of multiple traumatic dental injuries of maxillary anterior teeth. A 21 year old male suffered an injury one week ago, reported with complicated crown fracture of anterior teeth #12, #11, #21, with additional horizontal root fracture of tooth #11, and palatoversion inclination of tooth #22. The patient wished for aesthetic dental treatment. Endodontic treatment was initiated on teeth #12, #11, #21; cleaning and shaping, followed by obturation using gutta percha and MTA-based sealer. Root apex resection and retrograde filling with MTA was carried out as follow-up treatment on tooth #11. Teeth #12, #11, #21 were restored with lithium disilicate splint crown, and lithium disilicate veneer on tooth

#22. Endodontic treatment and endo-surgery are frequently in demand to treat traumatic injury to preserve the remaining tooth structure in healthy condition, combined with the advantage of beneficial and suitable biomaterials and aesthetic restoration for anterior teeth to not lose its functional and/or aesthetic purpose.

**Abstract 531**

**Comparative evaluation of smear layer removal in apical third using four different irrigants with ultrasonic agitation: A scanning electron microscopic analysis**

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SENTHIL KUMAR KUMARAPPAN,  
ANUPAMA RAMACHANDRAN, SADASIVA KADANDALE,  
SANKAR VISHWANATH**

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**Aim:** The aim of this study is to Compare the efficacy of four different irrigating solutions- EDTA, Ozonated water, Oxum and 3% Sodium Hypochlorite with Ultrasonic agitation in removing the Smear layer in apical third of root canals using Scanning electron microscopy.

**Materials and Methods:** Freshly extracted 20 human teeth with single straight root canals were cleaned and shaped using universal protaper rotary system. The final irrigation sequence with test groups: Group I: EDTA, Group II: 5% NaOCl, Group III: Oxum, Group IV: Ozonated water, Group V: Saline(control) for one minute. A size 15 file energised by ultrasonic vibrations in all groups. The samples were then longitudinally sectioned and examined under scanning electron microscope and scored by two different observers. Data was analysed using statistical package for social sciences (SPSS) at significance level of  $p < 0.05$ .

**Results:** The SEM images showed that among the tested irrigants Oxum has the best efficacy to remove the smear layer without altering the normal dentinal structures. The pictures of EDTA and 5.25% sodium hypochlorite group showed that even though it removed smear layer, it adversely affected the dentin structure.

**Conclusion:** within the limitations of the present study, the superior efficacy of oxum in smear layer removal without causing dentinal erosion when compared to other gold standard conventional irrigants has been proved.

**Abstract 532**

**One-visit endodontic with s-shaped root canal and Class IV composite application: A case report**

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IRA WIDJIASTUTI**

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**Aim:** This case report describes the treatment of one-visit endodontic on tooth #22 with s-shaped root canal and class IV composite application.

**Case Report:** A 16 years old female patient came to Universitas Airlangga Dental Hospital with chief complaint of cavities and pain

Abstract

in the upper front teeth as well as improving the aesthetics of her front teeth. On clinical examination tooth #22 was diagnosed with Symptomatic Irreversible Pulpitis. On periapical radiograph appear S – Shape root canal in tooth #22.

**Case Management:** Endodontic treatment with s-shape root canal starting from evaluation before treatment, namely through supporting examinations radiography. Good entry direction in space pulp to the apical constriction (glyde path) and formation of the coronal third of the root canal is the first step to determine success s-shape root canal formation. Treatment starts with working area was isolated, then the access cavity preparation was conducted. Root canal negotiation was carried out using the K-files files #8, #10, #15, and the working length measurement was conducted with the apex locator. The root canal was irrigated using the 5,25% NaOCl, followed by 17% EDTA. Preparation was carried out using the rotary instruments up to X2 (25/06). Trial gutta point X2 (25/06) then confirm radiography. Single cone obturation with gutta-percha point X2 (25/06) coated with resin-based root canal paste. At the next visit teeth filled with direct composite.

**Conclusion:** One visit endodontic therapy in s-shape root canal and filled with class IV direct composite provides good result root canal therapy and improve the aesthetic of the teeth.

### Abstract 533

#### Cryotherapy in endodontics: A review

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The term cryotherapy is derived from the Greek word cryos, meaning "cold." It is to decrease the tissue temperature, by extracting heat. In dentistry, cryotherapy has been used after intraoral excisional surgical procedures, implant placement periodontal surgery, and after extractions and was found to be effective in reducing swelling, pain, and arthritis associated with temporomandibular joint disorders. In the field of endodontics, cryotherapy has been reported to be used after periradicular surgeries and during root canal treatment to minimize postoperative pain and inflammation. Especially in teeth with preoperative pain, pulp necrosis, and symptomatic apical periodontitis. The first physiologic tissue response to cryotherapy is a drop in local temperature, leading to reduced cellular metabolism. In addition, it affects peripheral nerve endings by diminishing the threshold needed to activate the tissue nociceptors and the speed of painful nerve impulse. Cryogenic methods have been also used to increase the wear, abrasion, corrosion resistance, and to improve the strength of metals. It also provide an optimal anti-inflammatory and post-operative analgesic effect by using cold saline as a final irrigant contributing to improve patient's compliance during endodontic treatment. Other implementation of cryotherapy in endodontics is deep cryotherapy of nickel-titanium (NiTi) endodontic files, which offered enhanced cyclic fatigue resistance, reducing potential file separation. More recently, cryotherapy was successfully tried for hemostasis in vital pulp cryotherapy in conjunction with bioceramic materials. In this review paper the concept of cryotherapy, its mechanism and physiological effect, and different applications of cryotherapy in endodontics will be discussed.

### Abstract 534

#### "Light at the end of the tunnel" – A case series on broken instrument retrieval under magnification

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India

Iatrogenic instrument separation during canal preparation poses a challenge to conventional endodontics. This incidence ranges from 2-6 percentage of all the cases investigated. Rotary instrumentation plays a major role in instrument separation. Technological advancements in metallurgy has reduced the incidence of fractures. Attempt should be made to either retrieve or bypass the broken instrument to achieve adequate cleaning and shaping of root canal. Various retrieval systems coupled with the use of microscopes has made the clinicians breathe easy. There is certainly LIGHT AT THE END OF THE TUNNEL. This clinical presentation highlights the use of retrieval systems with the aid of magnification and ultrasonics.

### Abstract 535

#### Endodontic retreatment with previously treated teeth and anterior aesthetic rehabilitation: A case report

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**Aim:** To describe how to aesthetic rehabilitation treatment consists of several types of cases.

**Case:** A 34-year-old female patient came with chief complaint of discoloration on anterior teeth and she fell less confident. Patient had an accident 14 years ago, the upper left anterior tooth was treated 5 years ago but it wasn't completed because patient had to change domicile. Patient noticed a darker discoloration of the tooth and she also complained of an unfavorable shape and color. Periapical radiograph showed gutta point appears underfilling and radiolucent area with diffuse circumscribed appearance at apical of teeth #21.

**Management:** In this case, endodontic retreatment of teeth #21 were performed and finally restored with fiber post and e-max crown. On teeth #12, #11, #22 there are caries and white spots so restored with indirect veneer e-max.

**Conclusion:** Endodontic retreatment was done successfully. Indirect veneers are indicated in cases with discoloration, white spot and caries. Lithium disilicate ceramic veneers are most thin and can be used without excessive tooth structure removal. The patient was satisfied with the result.

### Abstract 536

#### Minimally invasive aesthetic approach in management of discolored tooth with an open apex: A case report

**PARAMITA TANJUNG SARI, EVRI KUSUMA NINGTYAS,  
GALIH SAMPOERNO, IRA WIDJIASTUTI**

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Medicine, Universitas Airlangga, Surabaya, Indonesia

Abstract

An individual's aesthetics are greatly influenced by their smile and anterior teeth. When an anterior tooth is injured, aesthetics is most commonly affected. Traumatic injury to developing dentition can cause pulp necrosis leading to cessation of root development and apical closure, and may also cause discoloration that interfere with the appearance of the anterior teeth. Currently, dental care is being developed towards a minimally invasive approach. The present report describes a clinical case of apexification and internal bleaching performed on discolored teeth anterior with an open apex post dental trauma. A 38-year-old woman complained of upper right anterior tooth (11) that darkened in color, making her less confident in her appearance. The patient had an accident 12 years ago and the tooth was not treated. Tooth 11 was discolored, diagnosed as pulp necrosis with an open apex. After filling out the informed consent, root canal treatment was initiated, prepared using a circumferential movement technique and calcium hydroxide (Ca(OH)<sub>2</sub>) was applied. On the second visit, an apical plug of 3 – 4 mm was placed using Mineral Trioxide Aggregate (MTA). On the following visit, root canal filling with thermoplastic gutta percha (backfill) was performed. The color was determination using a shade guide as 5 M2, gutta percha was removed 2 mm below the orifice and Glass Ionomer Cement (GIC) barrier was placed. Hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) 35% was applied to the cavity and temporarily sealed with GIC for five days. After obtaining a color match, the bleaching material is cleaned and Ca(OH)<sub>2</sub> was applied to the cavity. On the following visit, permanent composite restoration was performed. Discoloration of teeth with open apices can be treated with minimally invasive approach using apexification and internal bleaching.

**Abstract 537**

**Surgical management of the tooth with persistent periapical lesion: A case reportd crown discoloration: A case report**

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Universitas Airlangga, Surabaya, Indonesia

**Aim:** The aim of this case report is to describe the management of traumatic immature central incisor with open apex using MTA and tooth discoloration with internal bleaching.

**Case:** A 29 years old female patient presented to Departement of Conservative Dentistry, Faculty of Dental Medicine of Universitas Airlangga with chief complaint, discomfort when biting and tooth discoloration on maxillary right central incisor. The dental history revealed a traumatic injury of the anterior maxillary region 12 years ago. On radiographic examination showed incomplete root formation with wide open apex on tooth 11. The patient wished for aesthetic dental treatment in both of its colour and function.

**Case Management:** Apexification with MTA was performed followed by thermoplasticized gutta percha obturation and internal bleaching procedure with walking bleach technique. The final restoration is composite resin restoration.

**Conclusion:** Apexification with MTA on the open apex tooth and internal bleaching using walking bleach method in the case of

intrinsic discoloration due to pulp necrosis could give good results for patient satisfaction in terms of aesthetic and function.

**Abstract 538**

**Pro-resolving mediators in endodontics: A review**

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The human dental pulp is a specialized tissue that consists of host immunocompetent cells that fight against microorganisms and play an important role during tissue injury. The action of these cells varies according to different anatomical and physiological variations. The most common treatment done during pulpitis is the complete removal of pulp tissues from the affected tooth to resolve signs and symptoms and to prevent further progression to apical periodontitis. But, this procedure has many major drawbacks. In the past few decades, many studies are being done to find the solution to prevent the progression of acute inflammation to chronic inflammation by promoting repair and regeneration of damaged tissues. One of the recent methods to achieve the above goals are the incorporation of pro-resolving lipid mediators like lipoxins, resolvins, protectins, and maresins to the acute inflammation area. These pro-resolving lipid mediators do not have any direct anti-inflammatory effect instead it reduces inflammation by reducing the neutrophil infiltration into the inflamed area, enhancing efferocytosis and phagocytosis and by reducing inflammatory cytokine production. Various studies on pro-resolving mediators concluded pro-resolving mediators as a promising agent in resolving inflammation. This review paper aims to completely explain the use of pro-resolving mediators in Endodontics.

**Abstract 539**

**Nonsurgical endodontic retreatment of maxillary lateral incisor with overextended gutta-percha and periapical lesion: A case report**

**MADE AYU RICKA DWITRAYANI, FAUZIAH DIAJENG RETNANINGSIH, IRA WIDJIASTUTI**

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Failed root canal treatment may not always manifest immediately after treatment. One reason for root canal treatment failure is overfilling or overextended gutta-percha, leading to the symptomatic periapical lesion. Non-surgical endodontic retreatment can be considered a minimally invasive approach to treat the failure. The Conservative method is more preferable for the patient to avoid unnecessary surgical procedures. This case report describe management of overextended gutta-percha with a periapical lesion in maxillary lateral incisor by non-surgical endodontic retreatment. A 22 years old male patient came to Universitas Airlangga Dental Hospital with a chief complaint of recurrent swelling and pain on his upper right incisor. The tooth was treated with root canal treatment 18 months ago on periapical radiographic revealed a periapical lesion and overextended gutta-percha on tooth #12. Non-surgical

Abstract

endodontic retreatment was done on tooth #12. During root canal retreatment removing of material fillings was performed with rotary retreatment files. A root canal was reshaped with the crown down pressure-less technique and using non-setting calcium hydroxide as intracanal medicament. One week later root canal was obturated using gutta-percha with a warm vertical condensation technique. After two weeks, fiber post was inserted and followed by lithium disilicate crown as coronal restoration.

#### Abstract 540

##### Minimally invasive treatment to improve the aesthetics of discolored tooth: A case report

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One of the most frequent reasons patients seek dental care is discolored anterior teeth. Tooth injury can cause pulp necrosis and discoloration of the teeth can interfere with the appearance of the anterior teeth. One of the methods for treating the discoloration is by internal bleaching and it is minimally invasive. This case report describes internal bleaching of discolored anterior teeth post traumatic dental injury. A 28-year-old man came to the clinic with discolored upper front teeth and a desire to improve his appearance. The patient had an accident 4 years ago. Clinical examination revealed discoloration of tooth 12, percussion was positive, and the vitality test and palpation were negative. Radiograph showed absence of periapical lesion. The diagnosis was pulp necrosis. Root canal treatment was performed, using Crown Down Pressureless technique followed by obturation with single cone technique. In the second appointment, internal bleaching was carried out with 35% Hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>). After the bleaching was completed, calcium hydroxide was applied to neutralize the oxidizing agent. On the following visit, final restoration was performed with direct composite resin. Tooth discoloration caused by traumatic injury can be treated with minimally invasive approach using internal bleaching.

#### Abstract 541

##### Cryotherapy: A trending paradigm of treatment in endodontics

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The aim of this article is to discuss CRYOTHERAPY as A TRENDING PARADIGM OF TREATMENT IN ENDODONTICS and to discuss about the use of cryotherapy and its different applications in various clinical procedures in endodontics thereby, making decisions that are evidence based and also guides in promoting further studies. Post endodontic pain (PEP) is a major issue to be addressed in endodontic treatment. Thereby its management and prevention has become a main part of endodontic treatment. Attempts to deal the patient with post – operative pain (PEP) and by controlling it can increase patient confidence in their dentists, increase patient's pain threshold, and influence their attitude towards further dental

treatment. Root canal treatment (RCT) and, pulp therapy cause more severe and has reported higher incidence postoperative pain when compared to other dental operative procedure. The word cryotherapy is originated from the Greek word cryos, meaning "cold". In reality, cryotherapy does not actually means making the environment cold but rather it denotes extracting heat. Cryotherapy has been reported to be effective at reducing swelling, post-operative pain, inflammation, discomfort and recovery time. This review discuss the effect of Cryotherapy in Root Canal Irrigation, vital Pulp Therapy, endodontic Instruments, as local anesthetics. Intracanal cryotherapy can be considered as a simple, cost-effective, and non-toxic therapeutic treatment option for postoperative pain control in single visit RCT cases. It has also shown the potential to control pulpal bleeding in the case of vital pulp therapy. However further studies are required to provide strong evidence to prove its therapeutic effect in the field of endodontics.

#### Abstract 542

##### Surgical management of the tooth with persistent periapical lesion: A case report

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RAMADHANI PUTRI SALICHA,  
FAUZIAH DIAJENG RETNANINGSIH, SRI KUNARTI**

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**Aim:** To describe the periapical surgery management (or apicoectomy management) of right maxillary central insicor with persistent periapical lesion.

**Case:** A 29-year-old female patient came with chief complaint of recurrent swelling in upper right anterior tooth. Patient had a history of trauma 10 years ago, the teeth had previously been treated with root canal treatment 1 month after trauma but recurrent swelling still occurred. The patient went to an endodontist 6 months ago to get the teeth treated, but the swelling persisted. The teeth had been restored with direct veneer composite and still in good condition. Periapical radiograph showed radiolucent area involved apical of teeth #11 and #12. CBCT examination showed no fractured root on teeth #11 and #12 and there was periapical lesion involved apical of teeth #11 and #12.

**Case Management:** In this case, apicoectomy of teeth #11 and #12 were performed. The veneers were still in good condition so it were preserved. Vital sign and complete blood count were examined before the surgical procedure. Local anaesthesia was applied then the flap was performed. Enucleation of the lesion, apicoectomy, and retrograde filling with MTA were applied. Patient was observed at 1, 2 and 12 weeks after surgery. Patient was asymptomatic and the radiograph at 12 weeks showed the healing of periapical tissue.

**Conclusion:** Surgical management of tooth with persistent periapical lesion might be necessary. In this case, the tooth was diagnosed as radicular cyst and the apicoectomy was performed. Examination of 12 weeks post surgery showed healing of periapical lesion. That is proven that surgical approach makes the treatment more predictable when its applied in recurrent lesion.

### Abstract 543

#### The effects of phytic acid and ethylenediaminetetraacetic acid on blood clot in regenerative endodontic procedures

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**Objective:** To evaluate the effects of 1% Phytic acid and 17% EDTA on the characteristics and fiber density of blood clots using dentin blocks.

**Materials and Methods:** The roots of 30 human mandibular premolars were prepared to simulate open apices of 1 mm in diameter under 20 mL sodium hypochlorite irrigation. The specimens were then irrigated with the following protocols: (Group 1) Normal saline solution (NSS), (Group 2) 17%EDTA followed by NSS (5min), (Group 3) 1% IP6 followed by NSS (5min). The roots of the extracted teeth were split, human blood was placed onto the specimens which was collected from a healthy individual with his consent. The characteristics and fibrin density of clots were observed using a scanning electron microscope. Fibrin densities in all irrigation groups were evaluated using ImageJ software and statistically analyzed using the Friedman test and the Kruskal-Wallis test with Bonferroni adjustment. The null hypothesis tested was that there is no difference in blood clot characteristics among irrigation groups using scanning electron microscopy.

**Results:** Samples in the NSS and Phytic acid groups revealed denser fibers with an abundance of cells when compared with those in the EDTA group. No statistically significant difference at all levels was observed in all irrigation groups.

**Conclusion:** Decrease in clot formation and fibrin was observed in EDTA group compared to Phytic acid and NSS group.

### Abstract 544

#### Second wave of COVID-19 in India-differences in infection control measures amongst endodontists, specialty dental practitioners and general dentists: A cross-sectional survey

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RUCHI VERMA, DEVANSH VERMA**

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**Aim:** This survey was aimed at assessing the preventive measures adapted during endodontic treatment by Endodontists (E group), other specialty dentists (OSP group) and General dental practitioners (GDPs) in India during the second wave of Covid-19.

**Materials and Methodology:** A cross-sectional survey was circulated for three weeks (9th to 30th May 2021), when the country was experiencing the peak of second wave of Covid-19. The questionnaire was sent to 600 dental practitioners in India, enquiring about their demographic characteristics, professional and practice status and assessing approaches to prevent aerosol formation and differences, if any, in the infection control preventive measures taken during clinical practice.

**Results:** 436 dentists across the entire nation completed the survey. Statistical analysis was performed using SPSS version 25. Chi-Square and

Spearman correlation tests were used to assess the infection control protocols amongst E Group, OSP and GDPs. A total of 164 (37.6%) participants reported that they had limited the provision of endodontic treatment to emergency cases only ( $p < 0.05$ ). The responses showed agreement between E group, OSPs and GDPs regarding recovery of endodontic practices, pre-triage and few precautionary measures ( $p > 0.05$ ). Aerosol reducing measures, infection control protocols like surface disinfection, Dental unit waterlines disinfection, exchange of air in operatory differed in between groups ( $p < 0.05$ ). A large number of participants (39.4%) also encountered Covid-19 associated oral manifestations.

**Conclusion:** The survey reveals relevant findings in the differences between Endodontists, OSPs and GDPs in, aerosol reduction precautionary measures and in-office infection control protocols. Practitioners in India during the second wave were better prepared and took appropriate infection control measures in the dental operatory to combat the spread.

### Abstract 545

#### Apexification of a nonvital maxillary incisor with open apex using mineral trioxide aggregate: A case report

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**Aim:** This case report describes apexification and non surgical endodontic treatment of non vital maxillary incisor with open apex.

**Case Report:** A 24 years old female patient came to Conservative Dentistry Department of Universitas Airlangga Dental Hospital with chief complaint of the upper front teeth are not comfortable to chew. The patient has had orthodontic treatment for 2 years. Her upper front teeth had been involved in trauma 6 months back due to a motorcycle accident and received splinting therapy. Patient's medical history was not contributory. On clinical examination tooth #11 was diagnosed with pulp necrosis with symptomatic apical periodontitis. On periapical radiograph there is a radiolucent lesion in the periapical region of tooth #11 with open apex.

**Case Management:** The treatment involved apexification using MTA, nonsurgical root canal therapy and final restoration using direct composite restoration.

**Conclusion:** Combination of apexification with MTA and endodontic therapy provides good result in non vital maxillary incisors with open apex.

### Abstract 546

#### Esthetic rehabilitation of multiple caries and crossbite in maxillary permanent anterior teeth: A case report

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Caries and anterior crossbite of maxillary anterior teeth subsequently affects the esthetics, functions, and psychological well-being of the

Abstract

individual. In this case report, 4 maxillary anterior teeth were treated with direct composite and endodontic treatment with post and crown as final restoration. The aim of this case report was to present a clinical case of aesthetic rehabilitation of 4 maxillary anterior teeth. A 21 year old female patient came to Conservative Dentistry Department of Universitas Airlangga Dental Hospital reported with a complaint of multiple caries, crown fracture, and crossbite in the anterior maxillary teeth resulting in unaesthetic smile. Tooth #12 was vital and treated with direct composite restoration. Tooth #21 and #22 were non-vital and treated with endodontic treatment, fiber post and lithium disilicate crown. Tooth #23 was vital but treated the same tooth #21 and #22 due to the crossbite. Direct composite restorations, endodontic treatment with fiber post and lithium disilicate crowns provided a good result to restore the esthetic and function of maxillary anterior teeth.

#### Abstract 547

### Single versus multiple visit endodontic treatment of teeth with apical periodontitis: A systematic review of randomized controlled trials

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**Background:** The effectiveness of endodontic treatment regarding the number of sessions to complete the therapy is a matter of debate to date. One-visit root canal treatment (RCT) compared to multi-visit treatment allows a reduction in the total duration of treatment as well as the difficulties related to repeated injections, rubber dam placement, usage of armamentarium, and personnel. However, it remains uncertain whether completion of RCT in necrotic teeth in one visit or more than one visit has a bearing on the outcome of the procedure in clinical practice.

**Aim:** The aim of the present systematic review is to evaluate the outcomes of endodontic treatment of nonvital teeth at a single visit compared with multiple visits with respect to structured clinical and radiographic parameters.

**Materials and Method:** The protocol of the review is uploaded for registration in the PROSPERO database and is awaiting approval. Two electronic databases (PubMed, and Scopus databases) search for the systematic review was conducted from 2nd May 2021 to 28th June 2021. Two reviewers were involved independently in study selection, data extraction, and appraising the reviews that were included. Study eligibility criteria and participants. Randomized controlled trials published in the English language assessing outcomes of single versus multiple visit endodontic procedures for permanent teeth with apical periodontitis were included. Four Randomized controlled trials were included in the current review. One meta-analysis evaluating Randomized controlled trials assessing outcomes of single versus multiple visit endodontic procedure for permanent teeth was also included.

**Results:** No detectable difference was found in the effectiveness of root canal treatment between single and multiple visits. However, one study showed less post-obturation pain in the single-visit endodontic therapy group.

**Clinical Significance:** It is possible to get better cost-effectiveness for the patients to allow better patient compliance and optimization of the health care service. This is very important because the reduction of the cost to the patient allows it to become a complete treatment.

#### Abstract 548

### Evaluation of modified silver nano particles against *Enterococcus faecalis*: A review study

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The aim of the study is to evaluate the effect of modified silver nanoparticles against *E.faecalis* which is the most common oral pathogenic bacteria. Thus, it is important to study the role of nano particles in the form of silver electrons which has great biological and enhanced antimicrobial efficacy. The coated nano silver particles, serve not only as an antimicrobial agent but also have great healing effect. Therefore bio synthesised silver nanoparticles is one of the most important element which not only enhances the efficacy but is also in demand to be included as incorporated particles in various endodontic products.

#### Abstract 549

### Bioactive endodontics: A review

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There has been a paradigm shift in vital pulp therapy over the last few years. Today there is a better understanding of pulpal changes following caries involvement, and new developments in bioceramic materials. Hence, we have come to view vital pulp therapy as a permanent rather than temporary dental treatment. Bioactive means 'having a biological effect'. Bioactive Endodontics includes vital pulp cryotherapy and regenerative endodontics, as well as use of newer bioactive materials. The benefits of vital pulp therapy are its ability to eliminate pulpal inflammation and a patient's tooth pain without the complete removal of the dental pulp. It is established that cryotherapy can reduce nerve pain response, inflammation and haemorrhage, and can help reduce a patient's need for postoperative pain medications. The limitation of vital pulp cryotherapy is that this procedure can only be performed on vital teeth that can be permanently restored with composite or amalgam immediately after the procedure. Regenerative endodontics uses the concept of tissue engineering to restore the root canals to a healthy state, allowing for continued development of the root and surrounding tissue. Endodontists' knowledge in the fields of pulp biology, dental trauma, and tissue engineering can be applied to deliver biologically based regenerative endodontic treatment of necrotic immature permanent teeth resulting in continued root development, increased thickness in the dentinal walls and apical closure. These developments in the regeneration of a functional pulp-dentin complex have a promising impact

Abstract

on efforts to retain the natural dentition, the ultimate goal of endodontic treatment.

**Abstract 550**

**Management of mucosal fenestration with concomitant apicomarginal defect using connective tissue graft and regenerative technique**

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Mucosal fenestration describes the situation where the apex of a tooth is exposed to the oral environment following breakdown of the overlying bone and alveolar mucosa. Its etiology is poorly understood but may be attributed to imbrications or malpositioning of teeth, deficiencies of, or thin alveolar cortex, prominent morphology of the root apex, or severe periradicular inflammation with bone destruction. Exposure of the root apex to the oral environment may represent a complication for treatment as a consequence of plaque and calculus accumulation, which can cause mucosal irritation and prevent spontaneous healing. This case describes an unusual case of mucosal fenestration associated with necrotic infected teeth with apical periodontitis and endo- perio communication that resulted in the root apex being exposed to the oral cavity. Management was done by performing periapical surgery followed by placement of PRF membrane covering the bony defect and subsequently connective tissue graft to cover the mucosal defect.

**Abstract 551**

**Efficacy of biodentine as a dentinal substitute in the management of open apex, periapical lesion and as a pulpotomy agent: A case series**

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The completion of root development and closure of the apex takes up to 3 years following eruption of the tooth. Trauma or caries might result in pulp necrosis of young permanent teeth. Pulp necrosis in immature permanent teeth will eventually cause cessation of root closure. Thus, canal walls remain thin and fragile and apex of tooth remains open. These features impair root canal instrumentation and prevent the achievement of an adequate apical stop. Endodontic treatment of immature permanent teeth with open apices involves induction of apical closure by apexification procedures. Treatment is further challenging when these teeth are associated with large periapical lesions resulting in expansion and/or thinning of adjacent cortical plates. Biodentine, a calcium silicate based cement was introduced by septodont in 2010 and has claimed to be a bioactive dentin substitute for the repair of root perforations, apexification, retrograde apical filling with good sealing ability and favorable biologic response as a pulp capping agent. Furthermore, it preserves pulp vitality and promotes its healing process. This series presents three case highlights about

the use of biodentine in the management of permanent teeth with immature apices and large periapical radiolucencies to promote periapical healing.

**Abstract 552**

**Endodontic retreatment and aesthetic complex management on maxillary anterior teeth: A case report**

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**Aim:** The aim of this case report is to present an endodontic retreatment and complex aesthetic management on maxillary anterior teeth.

**Case Report:** A-52-years old female patient came to Conservative Dentistry Department of Universitas Airlangga Dental Hospital. Her chief complain was fractured crown and post on tooth 21, old filling with discoloration on tooth 12, 11, and slight rotation on tooth 22.

**Case Management:** Root canal retreatment with custom metal post and all porcelain crown on tooth 21, intentional root canal treatment with fiber post and all porcelain crown on tooth 11, and all porcelain indirect veneer on tooth 12, 22.

**Conclusion:** Inappropriate endodontic and old restoration on maxillary anterior teeth can be treated with good endodontic retreatment and complex aesthetic management.

**Abstract 553**

**Regenerative endodontics demystified**

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RUPAM KAUR**

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Teeth with incompletely formed root apex often poses a challenge to debride the infected root canals completely. Due to the thin and fragile dentinal walls, mechanical instrumentation is contraindicated. So, intracanal medicaments and irrigants are of greater importance to eliminate the bacteria from the root canals. These medicaments and irrigants has to be placed in order to infiltrate the dentinal tubules resulting in bacterial elimination producing antibacterial effect. Various antibiotics (Triple antibiotic paste, Double antibiotic paste) are introduced into root canals for high success of regenerative procedures, as they are also capable of differentiating the dental pulp stem cells into odontoblast like cells. So, regenerative endodontics is based on the possibility that dental pulp tissue still has some viable dental pulp stem cells even in cases with pulpal necrosis. Success of regenerative procedures depends upon the case selection, concentration, time duration for medicament to remain inside the root canal and best regimen for use of endodontic irrigants. High concentrations may lead to the irritation of peri-apex. So, this scientific paper entitles to put a light on the factors playing important role in the success of regenerative endodontics and proper case selection.

### Abstract 554

#### Regenerative endodontics: A new horizon

**DAIASHARAILANG LYNGDOH**

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India

Physical or microbiologic trauma to the tooth pulp can result in pulp inflammation and necrosis. Non-surgical root canal therapy is the current option for such patients. In regenerative endodontics, endogenous stem cells from induced periapical bleeding and scaffolds made of blood clot, platelet rich plasma, or platelet-rich fibrin have been used. This method has been dubbed a “paradigm shift” and is the first line of treatment for young teeth with pulp necrosis. Position statements and clinical considerations for regenerative endodontics have been released by the European Society of Endodontology and the American Association of Endodontists. Regenerative endodontics has three therapy outcomes: i) healing of clinical signs and symptoms, (ii) root maturation, and (iii) recovery of neurogenesis. Even though repair instead of true regeneration is achieved with current protocols, it is hoped that further research in the area of stem-cell-based tissue engineering will allow for true regeneration and improved treatment outcomes. True pulp regeneration is thought to be possible based on the notion of tissue engineering, which includes stem cells, scaffolds, and signalling molecules. This field is dynamic and exciting with the ability to shape the future of endodontics.

### Abstract 555

#### Guided endodontics: Boon of life to a nonvital tooth

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Saving a millimetre of dentin, is like giving a boon of life to the tooth. Imagine a world where we only lose a few millimetres of this precious dentin. A non vital tooth is as important as a vital tooth to maintain the oral ecosystem. The primary goal of endodontic therapy is the long-term retention of a functional tooth by preventing or treating apical periodontitis. However, there are many other factors that impact endodontic outcomes such as the quality of the restoration and structural integrity of the tooth after root canal preparation. A huge amount of dentin is lost during Endodontics access cavity preparation. The bulk of tooth is formed by the coronal portion, which is responsible to support, function and maintain its position in the oral cavity. The dynamic interaction between the inner and the outer forces acting on the tooth are majorly sustained by the dentin. The predominant reason that endodontically treated teeth are more prone to fracture relates more than any other attribute to the structural loss of the resilient component of the tooth. Not only dentin but preserving enamel, imparts toughness to the tooth. Conventional Endodontic access causes removal of more than 50% of the coronal tooth structure. With the introduction of the Guided endodontics minimum amount of tooth structure is lost. This review addresses current clinical and laboratory data to provide an overview of this new endodontic paradigm.

### Abstract 556

#### Nonsurgical endodontic retreatment in underfilled root canal of lower left premolar: A case report

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The most common cause of root canal treatment failure includes inappropriate mechanical debridement, persistence of bacteria in the canals and periapical area, poor obturation, over and under extension of the root canal filling and coronal leakage. Root canal retreatment is performed due to inadequate initial treatment or presence of microorganism persisting in root canal followed by subjective complains of pain, positive response to percussion, pain on palpation of the soft tissue and periodontal lesion. Retreatment performed initially with removal of root canal filling material and rotary instrumentation is the most efficient method for removing gutta percha from previously treated root canal. A 61-year-old male patient came with chief complaint of dull pain in left lower posterior tooth. The tooth had previously been treated with root canal treatment and direct composite 1 year ago. The restoration had fractured 2 weeks ago and the patient has been experiencing throbbing pain particularly during mastication for the past 3 months. The tooth was tender on percussion. Periapical radiograph showed underfilled gutta percha and periapical radiolucency area involving tooth #35. Retreatment was performed on tooth #35. Gutta percha removal was done with rotary file followed by root canal preparation, irrigation and intracanal medication with calcium hydroxide. The root canal was obturated with gutta percha to the estimated working length and restored with prefabricated post and crown. The symptoms resolved, the periapical lesion healed and the tooth was asymptomatic during the 3 month follow up period. A thorough cleaning and obturation to eliminate microorganism and also proper restoration of endodontically treated tooth is essential to prevent recurrence of secondary or persistent bacterial infection in root canal.

### Abstract 557

#### Apexification in immature permanent incisors with open apices using mineral trioxide aggregate: A case report

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**Aim:** To present a case of MTA apexification related to permanent immature maxillary central incisors after traumatism.

**Case Report:** A 17-year-old male patient came for treatment with chief complain of recurrent pain in his maxillary central incisors, particularly when biting down on food. History of trauma was given approximately 4 years back. On clinical examination revealed teeth #11 and #21 to be negative to cold and palpation, but tender to percussion. Apical gauging indicated the terminal diameter of canals were larger than K-files #70. Radiographic examination showed teeth #11 and #21 had open apices associated with diffuse

## Abstract

radiolucent areas in the apical.

**Management:** In this case, the treatment of choice was apexification teeth #11 and #21 with MTA. Cleaning and shaping of root canals system was achieved using circumferential filing motion with K-file #70 and 2.5% NaOCl solution. Calcium hydroxide was placed as intra-canal medication for a week followed by placing MTA as the apical plug in the next visit. Root canals were obturated with thermoplasticized gutta percha using backfill technique and access cavities were restored with direct resin composite. At follow-up performed at 3 weeks after treatment the teeth were asymptomatic.

**Conclusion:** Apexification using an apical plug of MTA can be considered an effective treatment of tooth with open apex. This procedure is predictable and has favorable outcome, as presented in this case.

### Abstract 558

#### Management of maxillary central incisors with open apex caused by trauma: A case report

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**Aim:** To describe the open apex management of maxillary central incisors.

**Case:** A 18 years old woman went to dental hospital Universitas Airlangga having the anterior restorations fell off. The teeth #11 and #21 were restored 6 months ago and the restorations were fell off 3 days ago, then she went to primary healthcare to get the teeth restored but the dentist decided to restore the teeth temporarily. The patient felt the pain and uncomfortable particularly when biting. Patient has a history of trauma when she was in elementary grade. The teeth showed non-vital and positive response to percussion. Radiographically, there were open apices and widening of periodontal ligament in periapical. The teeth were diagnosed as pulp necrosis with symptomatic apical periodontitis and apexification was planned due to the open apices.

**Management:** In this case, apexification of teeth #11 and #21 were performed. The canal were cleaned using circumferential filing motion with K-File #80 and 2.5% NaOCl then medicated with Ca(OH)<sub>2</sub> for a week. In the second appointment, MTA as apical plugs were placed in the apices about 3-4 mm coronally. In the third appointment, the canals were obturated with gutta-percha using backfill technique. The teeth were restored with composite due to the minimal loss of coronal structure. The patient was observed for a week then showed no symptoms and patient was satisfied with the result

**Conclusion:** Apexification procedure is necessary to treat the tooth with open apex. The selection of technique, irrigation solution, and apical plug material play important role. In this case, circumferential motion, 2.5% NaOCl, and MTA as apical plug have been proved suitable and resulted good outcome.

### Abstract 559

#### Targeted endodontic microsurgery: A review

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Targeted endodontic microsurgery (TEMS) combines a precisely designed 3-dimensional (3D)-printed surgical guide with a trephine bur for safe and efficient osteotomy and root-end resection. Targeted Endodontic Microsurgery (TEMS) replaces freehand carbide or diamond bur osteotomy and root end resection with a guided approach using an end-cutting trephine bur rotated within a guide tube. TEMS departs from traditional EMS in osteotomy size, control of resection level and bevel, surgical time and resection method. The TEMS digital workflow converts the patient's anatomy into digital data in 4 steps. First, bone, teeth, and neurovascular spaces are rendered with cone-beam computed tomographic imaging. Second, crowns and soft tissues are rendered with an intraoral optical scan, a benchtop optical scan of an impression or cast, or a cone-beam computed tomographic scan of an impression or cast. Third, these renderings are merged within design software to create a 3D construction containing a virtual model. Finally, guide design is performed on the virtual model for 3D printing. A significant gap in knowledge exists in that digital workflow principles and considerations are not documented in the endodontic literature. Apical surgery in challenging anatomic cases such as the palatal root of the maxillary second molar, fused molar roots, and root ends in approximation to the mental nerve are possible with TEMS. TEMS provided more efficient completion of osteotomy and resection, with a more appropriate root-end resection volume and bevel angle.

### Abstract 560

#### Comparison of smear layer removal of root canal walls after irrigation with a new HEDP-based solution versus traditional sodium hypochlorite followed by ethylenediaminetetraacetic acid: Scanning electron microscopic study

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**Aim:** Comparison of smear layer removal of root canal walls after irrigation with a new HEDP P (1-hydroxyethane-1,1-diphosphonic acid) based solution vs. traditional sodium hypochlorite followed by EDTA.

**Materials and Methods:** Thirty recently extracted single-rooted teeth divided into three groups according to irrigation protocol (n=10). An endodontic access cavity prepared, and apical patency established using a size 10 K-file. Root canal length determined by introducing a size 15 K-file. Apical foramina sealed with wax to intimate clinical situation.

Group 1

The root canals prepared with rotary files to the working length. During preparation, the root canals rinsed with 2 mL of 3% NaOCl delivered with a syringe and a 27-gauge needle. After completion of mechanical preparation, the root canals irrigated with 2 mL 17% EDTA. The above procedure followed by final irrigation with 2 mL 3% NaOCl to remove residual EDTA.

Group 2

The root canals prepared using the same protocol as in group 1 but

using HEDP solution as the only irrigant which was prepared by mixing 10 mL of 3% NaOCl with 2 capsule of Twin Kleen etidronic acid (HEDP) powder, according to the manufacturer's instructions. Group 3

The root canals prepared using the same protocol as in group 1 but Smear clear solution as irrigant was used.

The teeth were split longitudinally and subjected to SEM evaluation for the presence of a smear layer.

Kruskal-wallis test was used to compare the results.

**Results:** In all three groups, there were more cases with a smear layer in the apical third of the root canal than in the coronal third, but groups did not differ from each other significantly ( $p = 0.545$ ). The root canal walls in all groups were almost free of smear layer, showing no difference between the groups ( $p = 0.342$ ).

**Conclusion:** Within the limitations of the present study, the HEDP-based irrigation solution did not differ from 3% sodium hypochlorite followed by EDTA in terms of cleanliness or smear layer removal. Neither of the irrigation solutions could render all root canal walls free of a smear layer.

### Abstract 561

#### Endodontic and aesthetic management on maxillary anterior teeth with multiple caries: A case report

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Aesthetic dentistry plays a very important role in maintaining a person's self-confidence. The goal of restorative and endodontic treatment is to maintain good teeth function and aesthetics. Multiple caries, fracture, change of color and shape on teeth can have negative impact on a person's teeth function and self-confidence. A good treatment plan is needed to produce treatments that improve the aesthetic need of the patients. The purpose of this case report is to describe endodontic and aesthetic treatment management on maxillary anterior teeth with multiple caries. A 36-year old female patient came to conservative dentistry clinic at RSGM with complaint of pain and multiple caries on her maxillary anterior teeth. Intra oral examination showed multiple caries and crown fractures in 12, 11, 21, 22 and palatoversion in 13, 23. The patient wanted her teeth treated because she lacked confidence when smiling. Digital smile design was performed for digital smile analysis. Endodontic treatment was initiated in teeth 12, 11, 21, 22, continued with fiber post for teeth 12 and 21 and metal post for teeth 11 and 22. Teeth 12, 11, 21, and 22 restored with lithium disilicate crown and 13, 23 restored with lithium disilicate veneers to correct the palatoversion. The uses of digital smile analysis is crucial for aesthetic management of anterior teeth. Combination of good endodontic and restoration treatment is needed to accomplish the patients' good aesthetic requirement.

### Abstract 562

#### In vitro evaluation of tooth colour change caused by MB and TB photosensitizer removal using ultrasonic activation after photodynamic therapy in root canal treatment

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**Aim:** To evaluate the influence of ultrasonic activation (US) in the removal of methylene blue (MB) and toluidine blue (TB) photosensitizer (PS) after photodynamic therapy (PDT).

**Materials and Methods:** Fifty human single-rooted tooth will be accessed. Specimens will undergo root canal treatment and photodynamic therapy. After biomechanical preparation PDT will be performed using 0.01% MB and 0.01% TB with parameters of 5 min of pre-irradiation and a diode laser irradiation emitting at the range of 660-690 nm, 40 mW for 240 seconds. Specimens will be divided into six groups according to photosensitizers (PS) and method of cleaning PS.

- 1) MB (n=10) removal with 2.5% sodium hypochlorite
- 2) MB (n=10) removal with 2.5% sodium hypochlorite and US
- 3) TB (n=10) removal with 2.5% sodium hypochlorite
- 4) TB (n=10) removal with 2.5% sodium hypochlorite and US
- 5) MB (n=5) removal with 0.9% saline solution
- 6) TB (n=5) removal with 0.9% saline solution

The Colour change will be evaluated using digital spectrophotometer before (T0), immediately after PDT (T1) and immediately after PS removal (T2). The  $\Delta E$  colour change will be calculated using the CIELAB system ( $L^*a^*b^*$  values). During each time interval, three measurements of  $L^*$ ,  $a^*$ , and  $b^*$  will be taken, and  $\Delta L$ ,  $\Delta a$ , and  $\Delta b$  will be then calculated by subtracting the final data from the initial data from each time interval.

**Results:** Assessment of discoloration ( $\Delta E$ ), after PDT in the time periods of T0 and T1 the average values for 0.01% MB and 0.01% TB ranged between 2.07 and 3.05 with no significant difference. Assessment of discoloration after PDT in the time periods of T2 and T1, 2.5% NaOCl alone and 2.5% NaOCl with US activation removes PS equally with no significant difference.

**Conclusion:** It can be concluded that both 0.01% MB and 0.01% TB dye causes tooth colour discoloration with no significant difference. 2.5% NaOCl and 2.5% NaOCl with US activation were the treatments that presented the greatest cleaning results.

### Abstract 563

#### Surgical management of external root resorption with mineral trioxide aggregate and nano bone graft: A case report

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External root resorptions are processes in which the loss of cementoblasts occurs causing the mineralized surfaces to be susceptible to the action of clastic cells. The treatment of root resorption is basically root and / or periodontal endodontic treatment, depending on the location and extent of the resorption. This report describes a case of large radiolucency between roots of lateral incisor and central incisor along with external resorption on the mesial aspect of lateral incisor at the junction of middle one third

Abstract

and apical one third. Root canal treatment was performed followed by surgical intervention. The resorptive defect was debrided and part of root was rebuilt with MTA and Nano bone graft placed in the defect. Post-operative follow up revealed complete healing. This case highlights the importance of using MTA and Nano bone graft and successful management of resorption with a stable uneventful clinical recovery.

#### Abstract 564

#### Evaluation of regenerative endodontic procedure in mature permanent teeth with necrotic pulp and apical periodontitis using blood clot and platelet rich plasma: A case report

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The operating philosophy of contemporary endodontics is to disinfect and obturate by filling the instrumented root canals with inert materials. However if vital tissue with immune defence mechanisms and sensory innervations can be generated it would be the ideal treatment. So regenerating pulp and periradicular tissues with biological functions is a new direction for treating dental pulp and periradicular diseases. Regenerative Endodontic Procedure results in elimination of signs and symptoms, healing of apical pathology (if there is any), thickening of root wall and/or increasing the root length (in immature tooth), positive response to pulp sensibility test may be achieved. Aim of this case report is to establish the potential of growth factors present in Blood Clot & PRP to regenerate functional pulp dentin complex and healing of periapical pathology in human mature non vital permanent teeth with periapical lesion. 3 such patients were selected. On 1st appointment access cavity was prepared under local anesthesia and rubber dam application. After filing the root canals irrigation was done with NaOCl(1.5%) followed by placement of Ca(OH)<sub>2</sub> on drying the canal. Access cavity was sealed with cavit. On 2nd appointment thorough irrigation for removal of Ca(OH)<sub>2</sub> from the canal was done with 1.5% NaOCl (20 ml/canal 5 min.) & saline & final irrigation was done with 17% EDTA(20ml/canal,5 min.). Fresh bleeding was induced from periapex with the help of endodontic instrument in 2 patients while for rest patient autologous PRP prepared from 5 ml of blood as per the technique of Dohan et al 2006 was injected into the canal. After its clotting, 3 mm of MTA layer was placed followed by composite restoration on top of it. Followup visits were done at 3,6 & 12 months. Patients was seen asymptomatic and there was healing of periapical radiolucencies and the teeth were functioning normally. Therefore both BLOOD CLOT & PRP can be used as scaffold in REP.

#### Abstract 565

#### TruNatomy file system: Minimal damage, maximal preservation

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**Aim:** Effect of access cavity design on dentinal crack formation following canal preparation with TruNatomy files.

**Methodology:** A total of 45 mandibular molar teeth with mesiobuccal canal curvature between 20-40 degrees were included in the study. Teeth were mounted onto custom made acrylic blocks and were grouped as Group 1(n=15)- no preparation, Group 2(n=15) - Traditional Endodontic Cavity (TECs) and group 3 (n=15) Contracted Endodontic Cavity (CECs). In Group 2 and group 3 access cavities were prepared under microscope and the mesiobuccal canals were cleaned and shaped using TruNatomy files. 3% Sodium hypochlorite and RC Prep were used for irrigation and lubrication during instrumentation. After the canal preparation 1ml of 17% EDTA was used for 1min followed by a final flush of saline. All specimens were horizontally sectioned at 3mm,6mm and 9mm from the apex by a diamond disc at slow speed under water coolant. Then the specimens were stained with 2% Methylene blue dye for 30seconds, rinsed with tap water for 5seconds and dried with a brief blast of air. Specimens were observed under digital stereomicroscope.

**Results:** Group 3 (CEC) showed more number of cracks than group 2(TEC). Group 1(Control group) did not show any cracks. In Group 3(CEC ) showed 2cracks at 6mm,and 1crack at 9mm and 3mm. In Group 2(TEC) only one crack was noted at 6mm. However, no significant difference was noted among the three groups and within each group at different levels .

**Conclusion:** Canals prepared with TruNatomy files after traditional endodontic cavity had the least effect on dentinal crack formation when compared to contracted endodontic cavity. However the number of dentinal cracks were few and statistically insignificant. Hence TruNatomy files can be recommended for canal preparation even in contracted endodontic access.

#### Abstract 566

#### Healing of bony defects after periapical surgery using hydroxyapatite crystals with platelet rich fibrin: A case report

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Periapical lesions occur due to long standing endodontic infection of teeth. In cases where conventional root canal therapy fails to eliminate the lesion, surgery is the last alternative. Periapical surgery aims to remove periapical pathology followed by achieving complete wound healing by regeneration of the bone and periodontal tissue. Regeneration of periapical bone defects is a great challenge to endodontist, especially in case of large bony defects or through-through lesions. Platelet Rich Fibrin (PRF), second generation platelet concentrate possesses both regenerative & osteoconductive properties. Hydroxyapatite (HA) bone grafts is bone conductive in nature, which permit outgrowth of osteogenic cells from existing bone surfaces into the adjacent bony tissue. Hence, the combination of both has synergistic effect on bone regeneration. Others benefits of using a combination of PRF with HA are improved handling properties of graft materials, graft stabilization, hemostasis, promoting wound healing, bone growth and maturation. The present case report focuses about radiological bony healing of the large periapical lesion (10mm x

Abstract

8mm) through combination use of HA with PRF after periapical surgery. Endodontic treatment of the salvable teeth was performed before surgery. After anaesthesia full thickness mucoperiosteal flap was elevated followed by bony window preparation, 3mm root resection, curettage of the pathology was done and the specimen was sent for histopathological examination. Then under dental operating microscope after retrograde cavity preparation, root end filling was done with 3mm of Biodentine. PRF was obtained from patient's own blood. It was then mixed with HA & the bony defects was filled. The flap was reposition and sutured. On follow up visits the bone healing was seen to be in progress.

### Abstract 567

#### Comparative evaluation of fracture resistance between vertical and horizontal post system in endodontically treated teeth

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**Objective:** The purpose of this study was to evaluate the effect of a horizontal glass fiber post on the fracture strength of endodontically treated molars with mesioclusaldistal (MOD) cavities.

**Materials and Methods:** Forty five extracted intact molars were collected, treated endodontically, and divided into 3 test groups (n = 15) depending on the restoration type: G1 (MOD preparation with resin composite restoration), G2(MOD preparation with a vertical fiber post) and G3(MOD preparation with resin composite restoration and a horizontal fiber post inserted between buccal and palatal walls). The specimens were stored in normal saline at 37°C. Then specimens were quasi-statically loaded in a universal testing machine until fracture occurred. Failure loads were then analysed with one-way analysis of variance, followed by multiple comparisons by using Tukey honestly significant difference test (P = .05). The mode of failure was determined by visual inspection.

**Results:** Mean (standard deviation) failure loads for groups ranged from 1251.85 N to 1795.29 N. Among all the groups, vertical post group showed the highest fracture resistance followed by horizontal post. All groups had almost favorable fracture mode within the cervical third of the roots.

**Conclusion:** Within the limitation of this study, vertical fiber post showed the highest fracture resistance, it reinforced the crown as well as the root as compared to horizontal fiber post.

### Abstract 568

#### Cone beam computed tomography: A ray of hope in successful management of complicated endodontic cases

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The aim of a radiographic report is to provide an accurate interpretation of images to facilitate all aspects of endodontic treatment from diagnosis and treatment planning to assessing outcome. In common with other dental specialties, the use of advanced radiological imaging has become an important investigative

tool in Endodontics. Although Cone Beam Computed Tomography (CBCT) does not displace the periapical radiograph, it complements the 2D radiographs, particularly where cross-sectional imaging is required. Cross-sectional imaging becomes necessary in those cases where superimposition of roots or root canals are not easily distinguished in periapical radiographs taken at different angles. In addition, there may also be geometric distortion of the anatomical structures being imaged. Such limitations have prompted endodontists in the past to consider cross-sectional modalities like medical-facility based multidetector CT (MDCT), but it has only become popular after the advent of high-spatial resolution Cone Beam Computed Tomography with a much lower radiation dose. CBCT has become indispensable radiographic modality for dentists as it provides high-quality, accurate three-dimensional (3D) representations of maxillofacial structures. Use of 3D imaging in endodontics is described in the American Association of Endodontists (AAE) and the American Academy of Oral and Maxillofacial Radiology joint position statement and the SEDENTEXCT guidelines from the European Commission on Radiological Protection on the use of CBCT. They recommend that intraoral radiographs should be considered as the imaging modality for initial evaluation. CBCT is recommended when the data provided by periapical radiography are inconclusive or incompatible with the clinical information. To reduce dose, smaller field of view (FOV), smaller voxel sizes, lower mA setting (depending on patient size), shorter exposure time, and a pulsed exposure mode of acquisition are recommended. CBCT revealed more periapical lesions, missed canal, root fractures as compared to periapical radiographs. CBCT should be prescribed only after weighing the cost of radiation exposure with the benefit of diagnostic information that can be obtained from the scan.

### Abstract 569

#### Recent advances in gingival tissue management in postendodontic restorations

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Restorative dentistry is the art and science which plays an integral role in boosting the overall health of tooth. In all the restorative procedures, no matter how natural and life-like the restorations may be, the final esthetics and functional health depends upon health and level of surrounding gingival tissues. Recent advances in the gingival tissue management created superior relationship between soft- hard tissues and restorative materials. Gingival tissue management can be defined as, "The procedure of temporary eversion or resection of gingiva away from the tooth surface or deepening of gingival sulcus to expose the cervical portion of tooth in order to have proper marginal finish to the restoration or by establishing a good cervical cavo-surface margin to the tooth preparation". The dental restorations we make have a two fold purpose; the restoration of the tooth or teeth to function and the protection of the supporting tissues from injury. So, during dental restorative procedures, mechanical specifications of cavity preparation and functional ability of the restoration along with biological support from the surrounding soft tissues plays important

Abstract

role in the successful outcome of the restoration. Management of soft tissues during post-endodontic restorative procedures is the utmost challenge, especially gingival tissue mismanagement which can lead to failure of the restoration and also microleakage. The key to the success is effective soft tissue management, and goal of soft tissue management has been to provide healthy gingival tissues covering sound, smooth restorative margins. Thus the aim of this review is to describe the various recent advances in gingival tissue management procedures and their importance in post-endodontic restorative dental procedures.

#### Abstract 570

### Management protocols for two canal mandibular permanent incisors: A case report

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Complete debridement and obturation of the root canal system is a key factor for successful endodontic treatment. The clinician should therefore have thorough knowledge of canal configuration of the teeth concerned. Studies have revealed variations in canal configuration in permanent mandibular anteriors. The literature on mandibular incisors reveals that 11.5–50% of mandibular incisors possess two canals, although in many of these cases, the canals merge into one at the apical one third of the root. Lower incisors often have deviations in the number and the configuration of root canals. The inability to detect and treat extra canal, mostly lingual canal is the main reason for failure of endodontic therapy. Hence, it is important to analyse the tooth pre operatively and if extra canal is suspected, the access cavity should be extended buccolingually and gingivally beneath cingulum which will help to detect additional lingual canal if present in mandibular incisor. This case report discusses the Non Surgical endodontic management of mandibular incisors with two canals configuration.

#### Abstract 571

### Comparative evaluation of effect of root canal irrigants on the compressive strength of neo mineral trioxide aggregate plus, biodentine and bioaggregate cements: An *in vitro* study

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**Aim:** The aim of this study was to evaluate the effect of root canal irrigants on the compressive strength of hydraulic tricalcium silicate cements.

**Materials and Methods:** One hundred eighty Eppendorf tubes were randomly divided into three experimental group (n=60) in each group. Test materials were fabricated to standardized dimensions using cylindrical polyethylene molds having internal dimensions 8 mm height and 5 mm width. The materials were prepared according to the manufacturer's instructions (n = 60): Specimens (n = 180) of tricalcium silicate materials were randomly divided — Group 1 (n=60):Neo MTA PLUS powder were mixed with the liquid from the provided ampoules ; Group

2 (n=60): Biodentine was mixed in a triturator (n=60) and ;Group 3(n=60):Bioaggregate(IROOT BP PLUS) in injectable form . were exposed to one of the solutions (n = 15): Phosphate buffered saline (PBS; control), 2.5% NaOCl, 2.5% NaOCl followed by 17 % EDTA or 2.5% NaOCl followed by 15 % citric acid while being suspended in PBS. Compressive strength values were evaluated after 7 days of storage. The data were statistically analyzed by two-way ANOVA and Tukey's multiple comparison test (P = 0.05).

**Results:** Biodentine showed maximum compressive strength followed by Neo MTA plus and least by Bioaggregate. All the irrigants affected the compressive strength of Neo MTA Plus, Biodentine, Bioaggregate to root canal dentin. With respect to irrigant PBS showed the maximum compressive strength, then by 2.5% NaOCl then by 2.5% NaOCl followed by 15% citric acid . The minimum compressive strength was noticed in 2.5% NaOCl followed by 17 % EDTA.

**Conclusions:** Biodentine and NeoMTA Plus and Bioaggregate did not show a significant reduction in compressive strength when exposed to NaOCl. EDTA and citric acid reduced the compressive strength of the cements tested.

#### Abstract 572

### Comparative evaluation of efficacy of preoperative administration of ketorolac, amoxicillin- clavulanic acid and placebo on postendodontic pain in teeth undergoing endodontic treatment: An *in vivo* study

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**Aim:** To manage or prevent post endodontic pain using single dose of analgesic or with combination with antibiotics.

**Materials and Methods:** A total of 41 patients with total of 60 teeth were randomly divided into 3 groups- Group A- Placebo (Vitamin B12), Group B- Ketorolac 10mg, Group C- Amoxicillin Clavulanic acid 625mg. VAS scale was measured and premedication was done prior to anaesthesia, and endodontic treatment was performed but only apical preparation of root canal was done. Post-operative pain was measured 6hrs, 12hrs, 24hrs and statistically analysed. The data of the study are transferred to the Microsoft word 2019 table format and sent to the statistician keeping him blinded. Test of significance used were- ONE WAY ANOVA and LSD POST HOC MULTIPLE COMPARISON.

**Results:** There was higher pain score in Group C, followed by B & A at baseline altogether, there was no overall statistically significant differences between all the groups at baseline, 6 hrs, 12 hrs and 24 hrs post treatment. Although pain score reduced most in group C from baseline to 24hrs (from 3.25 to 1.30), followed by group B. In group A, initially VAS was lower at baseline (1.50) but it slightly increased to 2.30 at 6hrs post treatment which further increased to 2.35 at 12 hrs post treatment. At 24 hrs post treatment, there was reduction in pain score in all the groups.

**Conclusion:** Within the limitation of the study, it can be concluded pre medication of Ketorolac and combination of amoxicillin and clavulanic as single dosage slightly decreased postoperative pain

Abstract

better than without premedication, although not significant statistically.

**Abstract 573**

**A case report: Endodontic management of unusual permanent maxillary first molar with a single root and a single canal diagnosed with the aid of cone beam computed tomography**

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The variation of pulp cavity morphology, especially in multirooted teeth, is a constant challenge for diagnosis and successful endodontic therapy. Knowledge of the most common anatomic characteristics and their possible variations is fundamental, because the nontreatment of one canal can lead to endodontic treatment failure. Anatomic characteristics of permanent maxillary molars are generally described as a group of teeth with three roots, one palatal and two buccal, each root with one root canal. The Purpose of this case report is to present an endodontically managed maxillary first molar with an unusual morphology of a single root and a single canal, which has been reported to be 0.5 to 0.6% in general population. An accurate assessment of this unusual morphology was made with the help of a Cone Beam computed tomography. This report extends the range of known possible anatomical variations to include teeth with lesser number of roots and canals. This report also highlights the role of Cone Beam computed tomography as an objective method to confirm the three-dimensional anatomy of teeth. We conclude that this case report presents an unusual case of a maxillary first molar with a single root and a single canal. Anomalies in root canal morphology need not be in the form of extra canals. It could also be in the form of fused or fewer numbers of canals. This paper highlights the role of CBCT as an objective analytical tool to ascertain root canal morphology.

**Abstract 574**

**Evaluation and comparison of two chemical agents with a herbal agent for disinfection of gutta-percha cones against staphylococcus aureus: An *in vitro* study**

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**Aim:** To evaluate rapid, reliable, convenient and effective method of disinfection of Gutta-percha cones using readily available two chemical agents and a herbal agent against Staphylococcus aureus.  
**Materials and Methods:** 160 (Dentsply, Maillefer, ISO size 25, 4%) gutta-percha cones were selected and divided into 8 equal groups (n=20). 7 groups of gutta-percha cones were inoculated for 30 minutes with 20ml of 10<sup>8</sup> CFU/ml cultured with Staphylococcus aureus and 1 group was taken as a negative control. Except the positive control group, the gutta-percha cones of 6 groups were treated with the test solutions (5% Sodium Hypochlorite, 2% Chlorhexidine and Pancha Tulsi) for 1 minute and 5 minutes each.

The treated cones were placed on absorbent paper to remove excess of disinfectant. All the cones were then individually transferred to sterile test tubes containing 10ml of Mannitol Salt Broth and incubated at 37°C. The tubes were checked for turbidity after 24 hours. A micropipette was used to transfer 0.1 ml of turbid solution into mannitol salt agar media plates to find colony forming units. The plate was incubated for 24 hours at 37°C and colony forming units (CFU) was counted with digital colony counter. Student t-tests was used to find the significance between two groups, ANOVA for inter group analysis and further post hoc analysis for ANOVA test significance.

**Results:** Pancha Tulsi exhibited better results for rapid disinfection of GP cones in 1 minute and 5 minute groups, followed by 2% Chlorhexidine and 5% Sodium Hypochlorite. In 1 minute group, no statistical significance between Pancha Tulsi and 2% Chx was seen. But, both groups were significant when compared with 5% NaOCl. In 5 minutes group, the results were statistically non significant.

**Conclusion:** Within the limitations of the study, all the test groups showed disinfection against Staphylococcus aureus. Pancha Tulsi can be used as an alternative to chemical disinfection of gutta percha cones.

**Abstract 575**

**Healing of bony defects after periapical surgery using hydroxyapatite crystals with platelet rich fibrin and guided tissue regeneration membrane: A case report**

**SHUKDEB MANDAL**

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West Bengal, India

Periapical lesions are sequel to endodontic infection. Periradicular surgery is the last resort when conventional RCT fails. Regeneration of periapical bone defects is a great challenge to endodontist, especially in case of large bony defects or through and through lesions. Platelet Rich Fibrin (PRF) has come up as second generation platelet concentrate with regenerative properties. Hydroxyapatite (HA) bone grafts have excellent bone conductive properties, which permit outgrowth of osteogenic cells from existing bone surfaces into the adjacent bone material. The benefits of using a combination of PRF with HA are improved handling properties of graft materials, graft stabilization, hemostasis, promoting wound healing, bone growth and maturation. Barrier membrane technique through guided tissue regeneration (GTR) is of immense value in regeneration of periapical tissues, by preventing the epithelial cell migration into the bony defect. PRF is osteoinductive, and HA is osteoconductive. Hence, the combination has synergistic effect on bone regeneration. The present case report focuses about radiological bony healing of the large periapical lesion through combination use of HA with PRF and GTR membrane after periapical surgery.

**Abstract 576**

**Effect of autoclave sterilization on cyclic fatigue resistance of three different NiTi rotary instruments: An *in vitro* study**

**SUDHA KAKOLLU, BONNEY DOMINIC, KASTURI MARNI,  
SUJAN SUSHMA GUDIVADA, AMANI MAKKAPATI,**

Abstract

**HIMA BINDU NAGATHOTA, LAKSHMI CHANDRAN**

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Andhra Pradesh, India

**Aim:** To compare the cyclic fatigue resistance of Protaper, Hyflex, Trunatomy Nickel Titanium Rotary instruments.

**Materials and Methods:** A sample size of 48 freshly extracted mandibular first molars were taken for the study (n=48). Teeth were then divided into three groups based on the file system used for instrumentation. Group 1 was instrumented with Protaper (n=16), group 2 with Hyflex (n=16) and group 3 with Trunatomy file system (n=16). All the three groups were subdivided into two groups autoclaved group (a) and non-autoclaved group (b). Teeth samples were decoronated at the cemento-enamel junction. Files in group 1a, 2a, 3a are used continuous without autoclave sterilization while files in group 1b, 2b, 3b are autoclaved after using in each tooth. Teeth samples were instrumented until file separation occurred, and then the number of cycles to failure (NCF) was calculated and SEM imaging was done. The data were analyzed statistically using Kruskal–Wallis H and Mann–Whitney U tests.

**Results:** Autoclaved rotary files showed higher cyclic fatigue resistance than non-autoclaved file system. Hyflex EDM showed highest cyclic resistance when compared to Protaper and Trunatomy file system.

**Conclusion:** Autoclave sterilization increased the cyclic fatigue resistance of rotary endodontic file when compared to non-autoclaved rotary files.

**Abstract 577**

**Envisaging a reality – Platelet rich fibrin as direct pulp capping agent: A case series**

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West Bengal, India

Emphasis has shifted from the doomed organ concept of an exposed pulp to one of hope and recovery with the dawn of Vital Pulp Therapy which aims to preserve the pulpal health following the exposure of pulp. Direct pulp capping is the soul of vital pulp therapy along with pulpotomy and partial pulpotomy procedures. The introduction of MTA and other bioceramic or calcium silicate-based cements, and more lately PRF along with advanced treatment strategies, have evidently boosted its use. PRF is a Second generation platelet concentrate, which possesses growth factors that are known to play a fundamental role in hard tissue regeneration mechanisms, and has been proved to stimulate the differentiation of undifferentiated mesenchymal cells of the pulp into odontoblastic like cells, leading to reparative dentin formation. This presentation of 3 cases aims to explore the regenerative property of PRF membrane placed directly over a pulpal exposure and maintaining tooth vitality by subsequent radiographic and clinical follow-ups.

**Abstract 578**

**Esthetic rehabilitation of discolored maxillary central incisor with an open apex: A case report**

**PRAKRITI JAGGI, RENUKA JADHAO, RAJESH SHETTY,  
SANJYOT MULAY, ANITA SANAP TANDALE**

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Maharashtra, India

Pulpal involvement as a consequence of trauma or caries in immature permanent teeth can trigger the loss of pulpal vitality as well as directly affect root development, resulting in short roots with very thin walls producing a greater risk of fracture and challenges in post endodontic restoration.

The traditional use of Ca(OH)<sub>2</sub> to achieve apexification is being gradually replaced by mineral trioxide aggregate (MTA) as a one-step technique. Discolored anterior teeth are often perceived as an esthetic detraction. Because of the growing need for beautiful, white teeth and the establishment of esthetic treatment methods, the bleaching of nonvital teeth and indirect veneers have become increasingly important in recent years. This case report describes the management of Open apex in Maxillary Central incisor with MTA plug (#21) and management of discoloration with intracoronal bleaching and Ceramic veneer with over 6 months follow up period for periapical healing and normal tooth function.

**Abstract 579**

**Management of open apex using mineral trioxide aggregate: A case report**

**SMRITI BALAJI**

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Teeth with open apices are a constant challenge to the most skilled practitioners. The lack of an apical stop complicates the obturation and achievement of good apical seal. Apexification is considered as the best choice for the treatment of such cases. Calcium hydroxide has been routinely used in the past for apexification. But the disadvantages of long treatment time, fracture of teeth, and incomplete calcification of apical bridge have led to the development of newer biocompatible materials like MTA as the material of choice due to its superior clinical properties and clinical success which hermetically seals the pulp space, preventing bacterial contamination from the outside. This case report highlights the presence of a traumatized upper central incisor. The radiographic evaluation revealed open apices with blunderbuss canals, the canal was cleaned using intracanal instruments and 5.25% NaOCl and saline. In subsequent appointments, 3-4 mm was created with MTA and allowed to set. Subsequently, the root canals were obturated using thermoplasticized technique and recalled for post endodontic restoration. A positive clinical resolution can hence be derived for the use of MTA as an apical plug in teeth with open apex.

**Abstract 580**

**Management of discoloration of anterior tooth due to trauma with internal bleaching: A case report**

**YANSHA MUTIA DYAH KUSUMASTUTI,  
BINTANG ADIGUNA WIDJAJA, WIDYA SARASWATI,  
ADIORO SOETOJO**

## Abstract

Departement of Conservative Dentistry, Faculty of Dental Medicine, Universitas Airlangga, Surabaya, Indonesia

**Aim:** To report the successful internal bleaching procedure to restore discolored teeth due to trauma.

**Case Report:** A 35-year-old female came to Dental Hospital of Airlangga University with chief complaint of the upper left incisor tooth fracture and looks darker than the adjacent teeth. The patient fell 5 years ago. Intra oral examination, it showed that #21 had fracture Ellis class 2, discoloured, and non-vital. Radiographic examination, there was periapical lesion on the apex of #21 and the diagnosed of this teeth was pulp necrosis with asymptomatic apical periodontitis.

**Case Management:** Single visit endodontic treatment was done at the first appointment. At the next appointment, internal bleaching with hydrogen peroxide 35% was done and the access cavity was sealed with temporary restoration. This procedure was repeated for 2 cycles until it has achieved desired color (5M1 to 1M2, Vita 3D Shade Guide). Ca(OH)<sub>2</sub> was applied for a week to neutralize the oxidizing agent and to observe the color. The tooth then restored with direct composite as final restoration and the patient satisfied with the result.

**Conclusion:** Internal bleaching is a non-invasive technique to treat the discoloration of non-vital teeth. The internal bleaching procedure on the traumatized tooth provided benefits in terms of non-invasive procedure and has satisfactory results to restore the function and aesthetics according to the original tooth color.

### Abstract 581

**A comparative *in-vitro* evaluation of dentinal crack formation after root canal preparation using the reciprocating file system and continuous rotary file system**

**PRITU BANSAL, PRIYANKA PARIHAR, SANDHYA KAPOOR PUNIA**

Darshan Dental College and Hospital, Udaipur, Rajasthan, India

**Aim:** The role of motion kinematics in creating dentinal damage during instrumentation is not very clear. The aim of this study is to evaluate and compare the radicular cracks observed at the canal wall after canal instrumentation with reciprocal and the continuous rotary file systems.

**Materials and Methods:** A total of 60 mandibular premolar teeth were collected for this study. The selected specimens were cleaned of any debris/deposits using ultrasonic scaler and were stored in distilled water until used. The teeth were then decoronated 2 mm coronal to the proximal cementoenamel junction (CEJ). Patency was established for each canal using #10K file and working length was determined 0.5 mm short of the anatomical apex. All the canals were prepared till size #20K file under copious irrigation. The samples were then divided into 3 groups of 10 teeth each according to the system used for canal preparation Group A- (n=10) Control group (no further preparation was done); Group B – (n=10) Rotary file system; Group C – (n=10) Reciprocating file system. The canals in Group B were prepared with Protaper Gold and Group C were prepared with Wave One Gold file systems under copious irrigation following manufacturer's instructions. After canal preparation the samples were horizontally sectioned at 2, 5, and 8 mm from the

apex with a low speed diamond disc under water coolant and the cut surface was observed under a stereomicroscope for the presence of dentinal microcracks.

**Results:** No cracks were found in the control teeth. Microcrack incidence was observed to be less with instruments working in reciprocating motion compared with those working in continuous rotation. A statistically significant difference was found between reciprocating file groups and the continuous rotation group.

**Conclusions:** Dentinal cracks are produced irrespective of motion kinematics. According to this study, microcrack incidence is less with instruments working in reciprocating motion compared with those working in continuous rotation.

### Abstract 582

**Aesthetic management of traumatized maxillary anterior teeth: A case report**

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Airlangga University, Surabaya, Indonesia

**Aim:** Maxillary anterior teeth are the most frequently affected teeth in dental injuries and affecting the aesthetics and confidence of the patients. Thus, aesthetic and functional problem must be considered when determining the proper treatment method. This case report aims to report aesthetic management of traumatized maxillary anterior teeth.

**Case:** Twenty four years old female patient came to Conservative Dentistry Department clinic of Airlangga Dental Hospital, complaining about traumatized of anterior teeth caused by an injury 6 months previously with recurrent pain and swelling. Clinical examination revealed ellis fractures class 4 on 11,21,22,23 with eccentric rotation on 11, 21 and labioversion on 23. Radiographic examination demonstrating a radiolucent area in the periapical region leading to apical abscess formation. The patient wished for aesthetic dental treatment to restore the shape and function.

**Management:** Before treatment is initiated, impression was made for wax up and temporary crown. Endodontic treatment were performed and followed by placing fiber post in 11, 21, 23 and custom made post in 22, then restored with all-porcelain crown.

**Conclusion:** One month followed up show good results on 11,21,22,23. Chief complain eliminated, rotated teeth were corrected, and the patient satisfied with the result.

### Abstract 583

**Comparative evaluation of root canal transportation and centering ratio associated with three different root canal preparation systems using CBCT: An *in-vitro* study**

**PRIYANKA PARIHAR, PRITU BANSAL, SANDHYA KAPOOR PUNIA**

Darshan Dental College and Hospital, Udaipur, Rajasthan, India

**Aim:** The objective of the present study was to compare the canal transportation and centering ability of three different file systems using cone beam computed tomography (CBCT) in curved root canals to determine better instrumentation technique for maintaining root canal geometry.

Abstract

**Materials and Methods:** Total 45 extracted molars with curved root canals were divided into three groups of 15 teeth each. All teeth were scanned by CBCT to determine the root canal shape before instrumentation. In Group 1, the canals were prepared with conventional hand k file (Balanced Force technique; in Group 2 the canals were prepared with Rotary ProTaper files (Rotary motion); and in Group 3 canals were prepared with Wave One files (Reciprocal motion) following manufacturer instructions. After preparation, post-instrumentation scan was performed. Pre-instrumentation and post-instrumentation images were obtained at three levels, 3mm, 5mm, and 7mm from apical terminus of the root apex. These images were compared using CBCT software to access amount of transportation and centering ability. The three groups were than statistically compared.

**Results:** Recorded Data suggested that Wave One files presented the best outcomes for both the variables evaluated. Wave One files caused lesser transportation and remained better centered in the canal than hand k file and Rotary ProTaper files.

**Conclusion:** The canal preparation with Wave One files (Reciprocal motion) showed lesser transportation and better centering ability than K- File (Balanced Force technique) and ProTaper (Rotary motion). Within limitations of this study, it is recommended to use reciprocating files compared to rotary files in curved canals.

#### Abstract 584

**Effect of sonic and ultrasonic activation of four different root canal sealers on intertubular dentinal penetration: An *in vitro* study**

**ANCHAL ANCHAL**

ITS Dental College, Greater Noida, Uttar Pradesh, India

**Aim:** To comparatively evaluate the effect of ultrasonic and sonic activation of four root canal sealers on depth of sealer penetration.

**Material and Methods:** The root canals of sixty roots of single rooted teeth were prepared with NiTi rotary instruments under irrigation with 2.5% NaOCl and 17% EDTA. Canals were filled by lateral condensation of gutta-percha and AH Plus (n = 15), MTA Fillapex (n = 15), Sealapex (n= 15) and Tubliseal EWT (n=15). In all specimens, 0.1% rhodamine B was added to the sealer. Three subgroups (n = 5) were formed according to sealer activation: no activation (NA), sonic activation (SA, 20 s) and ultrasonic activation (US, 20 s). 1-mm-thick slices were obtained from each root middle and apical third. Intertubular penetration of rhodamine B-labelled sealers was assessed by Confocal Laser Scanning Microscope. Data were analysed by two-way ANOVA and Tukey's test.

**Results:** Ultrasonic Activation showed deeper sealer penetration than No Activation and Sonic activation. There was no significant difference between Sonic and No Activation groups. AH Plus had deeper sealer penetration than Sealapex, Tubliseal EWT and MTA Fillapex. The middle third had higher sealer penetration than the apical third.

**Conclusion:** Ultrasonic activation resulted in deeper sealer penetration than sonic and no activation techniques significantly. AH plus and Sealapex showed similar patterns of penetration into dentinal tubules. MTA fillapex showed least depth of sealer

penetration when compared to other groups. Sealer penetration was significantly more in middle third than apical third.

#### Abstract 585

**Evaluation of fracture resistance of endodontically treated teeth with various restorative materials, an *in-vitro* study**

**CHARUL SAINI**

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**Aim:** The purpose of this study was to compare the fracture resistance of endodontically treated premolars restored with different restorative materials in vitro

**Materials and Methods:** Sixty extracted human maxillary premolars were taken. All the samples were treated with root canal treatment. Each tooth was embedded in an acrylic resin cylinder up to 1.5 mm below the cemento-enamel junction (CEJ). Then MOD cavities were prepared in such a manner that the remaining lingual and buccal wall thicknesses measured  $2.5 \pm 0.2$  mm in the height of contour of each surface and the gingival cavosurface margin was 1.5 mm coronal to the CEJ. Samples were divided into 6 groups (n=10), group1- bulkfill composite, group2- cention n, group3- luxacore, group4- GIC base with bulkfill composite, group5- GIC base with cention n and group6- GIC base with luxacore. All the specimens were stored in an incubator at 37°C and 100% relative humidity for 24 h. Finally, a compressive force was applied at a strain rate of 0.5 mm min<sup>-1</sup> using a universal testing machine and the force necessary to fracture each tooth was recorded in Newton (N).

**Results:** In the present study groups without GIC base showed maximum fracture resistance than GIC base groups except bulkfill with GIC base which showed lower fracture resistance value. Group 1(bulkfill) shows the highest fracture resistance mean value followed by group 2 and group 3. And the groups where GIC used as base the order of fracture resistance mean value is highest in group 4 followed by group 5 and group 6.

**Conclusion:** Amongst all groups without GIC base, bulkfill composite showed maximum fracture resistance and the difference was statistically significant. Bulkfill composite and Cention N almost showed the similar fracture resistance value.

#### Abstract 586

**Nanoparticles: Exploring its frontiers in endodontics**

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The most common cause of endodontic pathology are microorganisms that induce irreversible changes in the pulp. The fundamental objective in the treatment of endodontic disease is the complete removal of bacteria, their byproducts and pulpal remnants from infected root canals followed by complete sealing of disinfected root canals. Effective disinfection and sealing of the root canal system are the hallmarks for successful endodontic treatment. However, the complex anatomy of root canal, the presence of bacterial biofilms and resistance to endodontic disinfectants pose a significant challenge to this goal. To overcome the drawbacks

Abstract

antimicrobial nanoparticles offering numerous advantages like large surface-area-to-volume ratio, ultra-small sizes and excellent chemical and physical properties have been introduced. Since, the major challenges in the form of dentinal tubules and microorganisms are all nanoscale, there can be a distinct advantage in using nanoscale materials to tackle these challenges better. Nanoparticles having a size from 1 to 100 nm are present in nature and are successfully used in many products of daily life. Introduction of nanoparticles against antimicrobial activity in treatment of oral cavity infections is possible because of its physicochemical properties, its antiadhesive nature, biocidal properties, potentially satisfying delivery capability. Various nanoparticles in the form of silver, chitosan, zinc oxide etc. have fetched and shown great results in various application in endodontics like incorporation of nanoparticles in sealers, obturating materials, irrigation, and intracanal medicament. They have also been explored in the disinfection strategies and photodynamic therapy. Nanoparticle applications also show promise in the field of regenerative endodontics, such as supporting the release of bioactive molecules and enhancing the biophysical properties of scaffolds. The advances in nanotechnology has lead to a new era of translational applications of nanoparticles in endodontic treatment. These biomaterials have helped in treatment of oral diseases, in counteracting the caries-related and endodontic microorganisms, in eradication of smear layer and biofilms. Considering all their beneficial aspects, there is no doubt that the future of endodontics is heading down the nano-direction. Hence the era of nano-endodontics is paving it's way to be the bright future in dentistry.

**Abstract 587**  
**Biofilm management in contemporary and prospective endodontics**

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Endodontic biofilm existing in the form of aggregates and a co aggregate attached by glycocalyx membrane is considered as primary etiology for endodontic infections. Seven of the failures, out of 53 teeth that were studied by Sjogren et al., were found to have the presence of bacteria in the root canal which were isolated at the time of root filling. This study highlights the importance of the influence of infection on the outcome of endodontic treatment. Endodontic microbiota is more complex and far more diverse than expected. The biofilm protects bacteria from host defenses and increases their resistance to intracanal disinfecting protocols. Understanding the virulence of these endodontic microbiotas within a biofilm is essential for the development of novel therapeutic procedures for intracanal disinfection. The primary goal of endodontic treatment is to eliminate the biofilm from root canal walls. Both the disruption of biofilms and the killing of their bacteria are necessary for effective treatment. Irrespective of the quality of the endodontic treatment, most treatment failures are due to the persistence of infection. As stated by Siqueira et al., 'The very high frequency of biofilms in the root canals of treated teeth with post-treatment disease may be

interpreted as indirect evidence that, depending on location and possible species composition, biofilms can be a challenge for proper root canal disinfection.' Thus, it is all the more imperative to focus on antibiofilm strategies in order to achieve successful endodontic outcomes. In light of this knowledge, a survey was undertaken amongst general practitioners and endodontists in regards to their current irrigating regimes. This review paper will aim to address the advance irrigating protocols in Endodontic Biofilm management and their importance.

**Abstract 588**  
**Regenerative endodontics: "Current knowledge and future directions" – An overview**

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Regenerative Endodontics is an exciting and developing field in the treatment of immature teeth with infected root canals that has been described as a "paradigm shift" in the management of these teeth and can result in continued root maturation and apical closure. This review outlines the biological basis and clinical protocols currently used in regenerative endodontic procedures (REPs) and discuss future directions in pulp regeneration approaches. Currently, this biologically based treatment is being recognized as the first treatment choice for immature teeth with pulp necrosis based on the success of many published cases in the literature. Our understanding of the clinical protocols has evolved to eliminate pulp infection and to also allow for stem cell potential to be induced in the canal and for the release of growth factors fossilized in the dentine walls. Regenerative endodontics presents a new era in biological and clinical endodontics.

**Abstract 589**  
**LASER activated irrigation: Distant and safe activation: A literature review**

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Current literature review aims at providing insights into the facts about LASER activated irrigation regarding its mechanism, mode of action, role, potential advantages and edge over other activation techniques. Basic aims of root canal irrigation include i) Flow ii) Physical Effect iii) Chemical Effect iv) Safety. Laser Activated Irrigation (LAI) is based on the creation of specific cavitation phenomena and acoustic streaming in intracanal fluids as a result of photothermal and photomechanical effects. The strong absorption of LASER energy in irrigant causes vaporization and formation of large elliptical bubbles. These vapor bubbles cause volumetric expansion of the original irrigant volume with high intracanal pressure which drives used irrigant out of the canal. Further, these bubbles implode, creating pressure which sucks fresh irrigant inside the canal, causing secondary cavitation effect, thus facilitating irrigant replenishment.

Abstract

This enhances overall intracanal fluid dynamics of irrigants and cleaning than that of non-activated irrigants. When conventional irrigation needle tips and tips of sonic and ultrasonic activator devices need to be placed as near as to the working length, tips of LASER device can be kept several millimeters away from the apical foramen or confined within the pulp chamber only, yet providing more efficient intracanal cleaning, removal of smear layer, cleaning of lateral canals and apical ramifications with superior safety than conventional activation techniques. A thorough search was made of literature published on the topic of interest till date and data is compiled to form this review.

**Abstract 590**  
**Management of Grade III endodontic-periodontic lesion without root damage**

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This case report is regarding a Grade III endodontic-periodontic lesion without root damage on an upper right first premolar in a periodontitis patient. The prevalence of endodontic-periodontic lesions is reported to be between 14.89-17.78% in various populations. The primary cause is differentiated based on which disease process presents first. This patient had a background of localised periodontitis and in this case, the periodontal disease progressed down the root surface leading to an area of communication with the pulp. The prognosis of primary periodontal lesions is poor and a highly predictable treatment option has not yet been found. The most critical determinant of prognosis is periodontal support and management with endodontic treatment followed by periodontal surgery is thought to provide a good chance of primary healing and better assessment of the periodontium. Indeed, treatment using endodontics in combination with a bone graft has been found to be the most widely performed treatment in endodontic-periodontic lesions. However, endodontic treatment alone is successful in some Grade III cases. Despite best efforts, failure of treatment may occur and this case report discusses the initial interdisciplinary approach of Grade III endodontic-periodontic lesions without root damage in a periodontitis patient, and how to subsequently manage failure with a successful prosthodontic outcome as it is equally important to consider failures in endodontics and how one might manage them.

**Abstract 591**  
**Use of eggshell derived hydroxyapatite for bone regeneration in periapical surgeries: A viable alternative**

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To study the effectiveness of eggshell-derived hydroxyapatite as an economical and eco-friendly option as a graft material in endodontic

surgeries. Endodontic surgeries eliminate post-operative infection and dead space and maintain bone contour, enhancing bone and soft tissue healing. Graft materials are used in periapical surgeries to replace missing bone. Grafts are broadly classified- Autograft, allograft, xenograft, and alloplast—graft materials derived from the patient's body or artificial, synthetic, natural substitutes. In the present case series, egg shell-derived nano-hydroxyapatite was used as a bone graft material. Eggshell-derived hydroxyapatite is a bioceramic-based synthetic xenograft. Its composition is similar to human bone and can process osteoprogenitor cells. This material is hydrophilic and stabilized because of rapid fibrovascular tissue growth and resists microcirculation. Periapical surgery was performed on the involved tooth in four different cases. A full-thickness mucoperiosteal flap reflected, the cystic lining was enucleated or curreted. Apicectomy was performed, root end cavity prepared, and the retrograde filling was done with MTA. The defect grafted with the material under consideration, and wound closure done using suture material. During the review of the cases, after six months, it was found that there was a trabecular appearance indicating bone formation. Egg shell-derived hydroxyapatite is a promising graft material for managing bony defects in periradicular surgeries. As egg shell-derived hydroxyapatite is economical, it is worthwhile to use as a bone substitute because of its safety, ease of use, ease of availability, and eco-friendly production methodologies.

**Abstract 592**  
**Management of mandibular teeth with extra canals – A case series**

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A clear understanding of internal anatomy of teeth is required for successful endodontic treatment. Knowledge of variations in the root canal anatomy and the prevalence of extra canals in mandibular teeth is needed for performing endodontic therapy in routine clinical practice. Teeth with missing canals were reported to be 4.38 times more likely to be associated with an periapical lesion leading to failure of the endodontic treatment. Pre operative radiographs gives the knowledge about the existence of extra canals in the teeth. The incidence of two canals in mandibular incisors is 12%-41.4% and in mandibular canines from 4.1% to 24%. The incidence of mandibular first premolars with more than one canal has been reported to range from 11.53% to 46% and in the mandibular second premolar was reported to be 9%. Mandibular first molar, sometime shows the presence of middle mesial canals and an extra distal root (29%). The clinician must be able to evaluate, identify and treat such teeth using appropriate available diagnostic and clinical methods. Radiographs like intraoral periapical radiographs, cone beam computed tomography, visual aids like loupes and dental operating microscope assist the operator in visualization of pulp chamber, root canal system and orifices. Several chair side methods to locate the missing orifices includes dyes, endodontic explorers, red line, white line tests, champagne bubble

Abstract

test etc., This case series highlights the management of mandibular teeth with extra canals.

**Abstract 593**

**Comparative evaluation of residual filling material of bioceramic sealer and epoxy-based resin sealer after retreatment with reciprocating file from oval root canals using micro-computed tomography**

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**Aims:** To evaluate and compare the amount of residual filling material after re-treatment in straight and oval root canals filled with, iRoot SP and AH Plus Sealer using V-Blue reciprocating systems through Micro-Computed Tomography.

**Materials and Methods:** Sixteen freshly extracted caries free human mandibular premolar with straight and oval canals were selected on basis of CBCT evaluations. Samples were prepared with Pro-Taper next file and were assigned to two groups for obturation with gutta-percha and AH Plus and iRoot SP sealer respectively. Obturation was confirmed with CBCT. After 1 month, re-treatment was carried with V-Blue reciprocating files and proper irrigation protocol was followed during the re-treatment procedure. All specimens before and after retreatment procedures were scanned by Micro-CT. The percentage of volume of filling material after retreatment was calculated. Data were analyzed using Kolmogorov-Smirnov test and two sample mean test.

**Results:** AH plus sealer group showed significantly less residual filling material when compared to iRoot SP sealer Group. iRoot SP sealer group showed the high percentage of residual filling material in retreated straight and oval canals root canal ( $p < 0.05$ ).

**Conclusion:** Bio-ceramic sealer (iRoot SP) are difficult to remove completely in retreatment cases as compared with Epoxy resin based sealer (AH plus) while using Reciprocating file system (V-Blue Reciproc).

**Abstract 594**

**Regen – Nextgen!!**

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S Linda Christabel, Veronica Aruna Kumari,  
Anand V Susila**

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Regeneration of functional pulp-dentin complex is the re-creation of tissues lost due to disease, trauma of the pulp. Regenerative Endodontics uses the concept of tissue engineering which paves the way for research to overcome the limits of conservative strategies. This review provides an overview, goals and techniques of pulp-dentin complex regeneration. The combination of inductive scaffold materials with stem cells optimizes the approaches for dentin-pulp complex regeneration. Currently, cell homing represents the most clinically viable pathway for dental pulp regeneration. Many issues exist that prevent these technologies to be widely used in clinical practice. These are due to the fact that we are dealing with

a small dead-end space and, when regeneration is needed, the space is more often infected. Controlled regeneration of the pulp vasculature is a challenge that must be met for future regenerative endeavors. Though these challenges are substantial, the potential benefits to patients and profession are equally ground-breaking. By understanding these, there is a future potential for regenerating the pulp as a routine dental procedure.

**Abstract 595**

**Porcelain laminates – Minimally invasive esthetic approach: A case report**

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In today's society, where appearance of one's teeth has become a concern. People are giving more importance to a healthy and attractive smile. With the advancements in the area of cosmetic dentistry, the dental professionals have been offered new opportunities in conservative and esthetic restorative procedures. Porcelain veneers are one of the most esthetic, durable conservative, and biocompatible anterior restorations. These are excellent alternative to full crown preparations, main advantage being the preparation limited to enamel only. This case report describes using indirect porcelain laminate veneer technique for a patient with esthetic problem related to generalize diastema in upper front teeth. Beginning with esthetic gingivectomy and ending up with bonding of laminates, a complete satisfying result was achieved.

**Abstract 596**

**Comparison of effect of laser activated irrigation and sonic activation on final irrigants for smear layer removal from root canals: A sem ex-vivo study**

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**Aim:** To assess and compare the effect of LAI(Er:Cr:YSGG) and sonic activation(sonic air 1500 mm) on MTA and EDTA as final irrigants for smear layer removal using scanning electron microscope.

**Materials and Method:** Sixty single rooted freshly extracted mandibular premolars were collected, disinfected and sorted in saline till use. Teeth were examine under a dental operating microscope. Specimen were cleaned using ultrasonics. Then the teeth were decoronated and working length was determined. The root apex was covered with sticky wax to prevent the irrigant extrusion. Cleaning and shaping were done in crown down with protaper universal Ni-Ti rotary system. After each instrument change the canal were irrigated with 5 ml of 5.25% Naocl and finally with 2 ml of saline for 1 minute. Then teeth were randomly divided into three groups based on the method of irrigant activation. Each group was further divided into two subgroups based on the final irrigant used. In sub group A the final irrigant used is EDTA and insubgroup B of all groups the final irrigant used is MTAD. In group I the final irrigants were activated with 20 size hand K file. In group II final irrigants were activated with sonic air 1500 MM. In group III final

Abstract

irrigants were activated with Er. Cr. YSGG laser using PIPS protocol. Then the teeth were dried, sectioned and gold sputtered for SEM analysis. Photomicrographs were taken at 100x and 200x.

**Results:** In all six groups smear layer were removed. Group II B i.e.MTAD activated with sonic airMM 1500: showed better smear layer removal compared to other groups. Laser activated irrigation showed better result compared to hand activation.

**Conclusion:** The result of this study showed that group II B is better than other groups in smear layer removal. Group III B showed inferior results compared to sonic activation and compared to hand activation.

### Abstract 597

#### A comparative evaluation of degree of conversion of bulk-fill composites with and without ivocerin photoinitiator after curing with two different light curing units

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India

**Aim:** To evaluate the degree of conversion of Tetric EvoFlow Bulk fill with ivocerin photobooster and Filtek Bulk Fill Flowable without ivocerin photoinitiator after curing with Polywave LED and QTH light curing units.

**Materials and Methods:** The specimens were prepared from two types of commercially available light cure Bulk-fill flowable composites designated as Group I ( Tetric EvoFlow Bulk fill with ivocerin photoinitiator ) and Group II ( Filtek Bulk Fill Flowable Restorative without ivocerin photoinitiator ). Each group was divided into two subgroups based on the LCU used. Subgroup A( cured using polywave LED) and subgroup B (cured using QTH). Each subgroup consisted of 3 groups with 5 specimens, each of dimensions 5mm×5mm×2mm, 5mm×5mm×3mm and 5mm×5mm×4mm respectively. Specimens were prepared using custom made stainless steel molds. After positioning the molds on a glass slide, composite resin was injected into the molds as a single increment. Specimens in subgroup A were cured using Polywave LED light curing unit and subgroup B was cured using QTH light curing unit at standard intensity for 20 seconds. After 24hours of light proof storage at 37°C, bottom surface of the samples were analyzed for degree of conversion using Raman spectrometer.

**Results:** Tetric EvoFlow Bulk fill composite containing photoinitiator ivocerin and cured using Polywave LED curing unit significantly showed better degree of conversion when compared to Filtek bulk fill composite (P<0.05).

**Conclusion:** The photoinitiator ivocerin when combined with polywave LED curing light exhibited increased degree of conversion.

### Abstract 598

#### Influence of various access cavity designs and pericervical dentin thickness on fracture resistance of endodontically treated teeth restored with different restorative materials: *In vitro* study

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India

**Aim:** To assess the impact of access cavity design and pericervical dentin thickness on the fracture resistance of endodontically treated teeth restored with short fiber reinforced composite and conventional posterior high strength GIC.

**Materials and Methods:** 60 extracted human mandibular molars are divided into three groups based on the access cavity design i.e., Truss access cavity (TAC), Ultra conservative or Ninja access cavity (NAC), Conservative access cavity (CAC). All the specimens were mounted and subjected to CBCT analysis before and after access cavity preparation for the measurement of pericervical dentin. Cleaning and shaping of all the teeth were performed followed by obturation. Teeth were further subdivided based on post endodontic restorative material i.e., short fiber reinforced composite and posterior high strength GIC, and the samples were subjected to fracture resistance test using universal testing machine.

**Results:** Highest pericervical dentin thickness was observed in NAC. The highest fracture resistance values were observed in NAC with EVER X POSTERIOR subgroup and lowest in TAC with POSTERIOR HIGH STRENGTH GIC subgroup. (P > .05)

**Conclusion:** NAC is the most conservative followed by CAC & TAC. SHORT FIBER REINFORCED COMPOSITE has performed better than HIGH STRENGTH POSTERIOR GIC in terms of fracture resistance.

### Abstract 599

#### Guided endodontics: An overview

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One of the most essential criteria for a successful endodontic procedure is to achieve access. Guided therapy is highly successful and precise as it an image guided treatment. Imaging plays a vital role in endodontic therapy in the recent times as it not just gives accurate information but also preserves normal anatomy of the tooth and its surrounding tissues. Guided endodontic therapy was found to be a time-saving method to obtain accurate results during various endodontic procedures like autotransplantation of teeth using 3D surgical templates for osteotomy preparation and donor tooth placement. These procedures are thought to give favourable and positive outcomes. Clinically, this may help to easily access specific areas in the root, which are obstructed due to resorptions or perforations with minimal invasion. For root resections and osteotomies, guided microsurgical endodontic therapy seems to be a feasible approach. This technique has become an incomparable option in saving teeth after being aware of the iatrogenic risk in acutely calcified root canals. The aim of this paper is to review the literature and present the clinical applications, advantages and disadvantages of the novel 'Guided Endodontics' procedure.

### Abstract 600

#### Storage medium for avulsed tooth: "Nature to nurture"

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SHAMINI SAI, ANAND V SUSILA**

## Abstract

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Dental avulsion is defined as the complete displacement of a tooth from its socket in alveolar bone owing to trauma. Storage/ transport medium helps in cases where avulsed teeth cannot be immediately re-implanted. The extraoral dry period and storage medium used to store teeth before reimplantation determines the prognosis of the avulsed teeth. The treatment outcome depends on storage of the avulsed teeth in media capable of maintaining the viability of periodontal ligament cells. Natural products may be more effective in maintaining the PDL cell viability compared to synthetic products as they have greater efficacy and longer storage time as compared to Hank's balanced salt solution which has been recommended by the International Association of Dental Traumatology as standard solution for the storage of avulsed teeth. It was found that natural products such as milk, propolis, coconut water, green tea, aloe-vera, red mulberry, egg-white and pomegranate have shown ability to maintain viability of periodontal ligament cells of avulsed teeth. Few natural products such as milk and coconut water can be used in raw form, while other products such as red mulberry and green tea need processing. However, the ability of storage media can affect cell viability and success of treatment. Although research has been undertaken on a wide variety of materials to be used as storage media for the transport of avulsed teeth, high cost and lack of availability limit the use of majority of these media. This review mainly discusses various storage/ transport media for avulsed tooth obtained from natural sources.

### Abstract 601

#### Cryodontics: Making endodontics cool

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PAULAIAAN BENIN, R SENTHIL KUMAR**

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India

Over the years, cold therapy has been a fundamental modality for pain relief in the field of medicine. Cold therapy can be performed in the form of cryosurgery, cryogenic ablation or cryotherapy. The human body functions through various mechanisms and cycles that enable to maintain homeostasis. These mechanisms are dependent on the temperature and other environmental conditions. Any alteration in this mechanism would result in a change in the temperature there by liberating heat. Cryotherapy benefits the human body by removing the liberated heat and helps in restoring the normal tissue temperature. The concept of cryotherapy actually does not imply cooling the target tissue but rather reduces the heat and extracellular fluid collection within the tissues due to the inflammatory response. These actions are achieved by vasoconstriction which is followed by cold induced vasodilation, commonly known as the "Hunting Response". In the field of Endodontics, cold treatment is used for various clinical and non-clinical applications. Clinical applications include the reduction of post-operative pain in root canal treatment, to achieve haemostasis during peri radicular surgeries / vital pulp therapy. Non clinical applications include the cryogenic treatment of Ni-Ti rotary instruments which is said to enhance their cyclic fatigue resistance and reduces the potential for file separation. Hence, this

review presentation highlights the concept of cryotherapy and cryogenic treatment, its mechanism, physiologic effect, and its different applications in the field of endodontics.

### Abstract 602

#### Cone-beam computed tomography evaluation of modifications in the canal anatomy of curved canals following glide path preparation using two different file systems: An *ex vivo* study

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India

**Aim:** To evaluate modifications in the canal anatomy of curved canals following glide path preparation using two files systems.

1. Hyflex Glide Path File
2. Scout-Race Files

**Materials and Methods:** Forty freshly extracted mandibular first molars were selected and divided into two groups (n=20). Teeth were decoronated at the cemento-enamel junction. Teeth of both groups were mounted on an acrylic template. Pre-instrumentation Cone Beam Computed Tomography (CBCT) imaging of all teeth was done at distances 0, 1, 2, 3, 5 and 7mm from the apical point of each specimen. Group 1 was prepared with Hyflex Glide Path File system and Group 2 was prepared with Scout-Race File system. Post-instrumentation CBCT imaging was done in a similar method as preinstrumentation scan and the amount of dentin removed was calculated using Carestream 9600 CBCT CS3D & Invivo Anatomage softwares. Statistical Analysis Post-Hoc Bonferroni test was used for inter group comparisons and One-way Anova Test was used for Intra Group Comparison.

**Results:** When canal modification characteristics of Hyflex Glide Path File System and Scout Race File System were evaluated, following was observed: of Scout Race File System > Hyflex Glide Path File System. Hyflex Glide Path File File system did the least modification in canal area and volume.

**Conclusion:** Hyflex Glide Path File System and Scout Race File System both maintained the original canal anatomy. It was concluded that Hyflex Glide Path File System was more superior in maintaining the original canal anatomy as compared to Scout Race File System. However large sample size along with clinical trials is necessary to validate the results of present study.

### Abstract 603

#### Cone-beam computed tomography evaluation of shaping characteristics of two different file systems in mesial canals of mandibular first molars: An *ex vivo* study

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India

**Aim:** To evaluate the Shaping Characteristics of Two Ni-Ti rotary File Systems

1. Edge Endo

Abstract

## 2. Hyflex EDM

### Objectives:

1. To Evaluate the Shaping Characteristics of Two Ni-Ti Rotary File Systems.
2. To Compare the Transportation and Residual Dentin Thickness in Curved Root Canals of Mandibular Molars using CBCT(Cone Beam Computed Tomography)

**Materials and Methods:** Forty freshly extracted mandibular first molars were selected and divided into two groups (n=20). Teeth were decoronated at the cemento-enamel junction. Teeth of both groups were mounted on a acrylic template. Pre-instrumentation Cone Beam Computed Tomography (CBCT) imaging of all teeth was done at distances 0, 1, 2, 3 and 5mm from the apical point of each specimen. Group 1 was prepared with Edge Endo file system and Group 2 was prepared with Hyflex EDM file system. Post-instrumentation CBCT imaging was done in a similar method as preinstrumentation scan and the amount of dentin removed with canal volume was calculated using Carestream 9600 CBCT CS3D & Invivo Anatomage softwares Statistical Analysis Post-Hoc Bonferroni test was used for inter group comparisons and One-way Anova Test was used for Intra Group Comparison.

**Results:** When canal modification characteristics of Edge Endo File System and Hyflex EDM File System were evaluated, following was observed: of Hyflex EDM File System > Edge Endo File System. Hyflex EDM File system did the least modification in canal area and volume.

**Conclusion:** Hyflex EDM System and Edge Endo File System both maintained the original canal anatomy. It was concluded that Hyflex EDM File System was more superior in maintaining the original canal anatomy as compared to Edge Endo File System. However large sample size along with clinical trials is necessary to validate the results of present study.

## Abstract 604

### Smart seal obturation – A seal forever

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The success of endodontic therapy depends upon the achievement of the endodontic triad which is debridement, disinfection and three-dimensional obturation. Root canal obturation being one of the significant phases of root canal therapy, has the objective of providing a fluid-tight seal within the prepared root canal thereby preventing re infection by microleakage. Various methods have been used to achieve a three-dimensional root canal filling. Among the various methods lateral condensation, warm vertical condensation single-cone obturation techniques are commonly used, all of which use gutta-percha as the core material. But gutta-percha lacks rigidity, undergoes shrinkage and does not bond to root canal dentin. To overcome this drawback hydrophilic polymer based endodontic obturating materials have been developed as an alternative for conventional gutta-percha so as to obtain an impervious seal. Smart seal is one such obturation system comprising of Propoint and Smartpaste/Smartpaste Bio. It is a two paste system made up of a central

polyamide core comprising of two nylon polymers of which the outer layer is a cross linked co polymer of acrylonitril and vinyl pyrrolidone. This deformable endodontic obturating material is available in different tip sizes and tapers and is designed to expand laterally and not axially, it expands by absorbing residual water from the instrumented canal space from the naturally-occurring intra radicular moisture. It is biocompatible and has an advantage of controlled expansion and self sealing ability. This review paper highlights about this novel technique of the water expandable root canal obturating system which is, THE SMART SEAL OBTURATION SYSTEM.

## Abstract 605

### Comparative evaluation of coronal sealing ability of light cure temporary restorative materials with conventional temporary restorative material using stereomicroscope: An *in vitro* study

**SREEJA NAIR, AMIT PATIL, ASHISH JAIN, RAHUL RAO, SHEETAL MALI, HIMMAT JAISWAL**

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**Aim:** The coronal seal is a crucial factor in success of any pulp therapy. When endodontic therapy is being carried out in multiple visits, there is a need to seal the access cavity by interim restorative materials that prevents the leakage of oral fluids and bacterial invasion into the access cavity and thus obviating reinfection. Hence the aim of the present study was to assess the sealing ability by evaluating microleakage of three different types of interim restorative materials.

**Materials and Methods:** A total of 80 extracted human premolars were divided randomly in to 4 groups. Group A: Control group, Group B: Systemp Inlay, Group C: Temp IT Blue, Group D: Cavit-G. Standardized access cavity preparation was done followed by placement of cotton pellet in the access cavity, Interim restorative materials were placed as per the assigned group of restorative materials. Teeth were stained with 2% methylene blue solution for 1 week after which all the teeth were analysed for dye penetration under stereomicroscope. Statistical analysis of data was done using one-way ANOVA and Post Hoc Tukey test with a significance level of  $P \leq 0.05$ .

**Results:** Systemp Inlay showed the least micro leakage value. Intergroup comparison showed statistically significant difference between Systemp Inlay and other groups whereas Temp IT Blue and Cavit G showed no statistical significance.

**Conclusion:** Though none of the tested materials were completely able to prevent the micro leakage, newer light cure interim restorative material Systemp Inlay provided better marginal seal than the other commercially available interim restorative materials.

## Abstract 606

### Chitosan – Improving the cure by nature

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Abstract

Searching for better materials with improved properties in the field of medicine is the backbone for successful treatment. The field of medicine and dentistry has always emphasized on the use of natural products for the treatment of diseases. However, in day - to - day clinical practice synthetic materials have overcome the use of natural products. Synthetic materials although they have quicker remedial action, also have certain side effects due to their incompatibility to human body. Chitosan, a natural product which has numerous applications in medicine is less understood and studied in the field of dentistry. Chitosan is a biopolymer obtained by extensive deacetylation of Chitin, which is present abundantly in the exoskeleton of Crustaceans. Incorporation of this natural biopolymer with the current materials have improvised the treatment outcome by improving physical, chemical and biological properties of the materials used in Endodontic treatment. This review highlights and enlightens the applications of chitosan in the field of endodontics.

**Abstract 607**

**Influence of the final irrigation solution on the push out bond strength of bioceramic and epoxy sealers: An *in vitro* study**

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**Aim:** To evaluate the influence of different irrigation solutions on push out bond strength of Bioceramic and Epoxy sealers.

**Materials and Methods:** One hundred single rooted teeth are selected and decoronated to obtain standardized root length of 16mm. The root canals are prepared using ProTaper GOLD rotary files progressively till F3. Between each instrument, canals were irrigated with 2 ml 5.25% NaOCl solution except for group irrigated with saline. Samples were randomly divided into two groups according to the sealer used (n = 50):

Group A = Angelus Bio C [Bioceramic], Group B = Dia proseal [epoxy resin], further subdivided into five subgroups according to final irrigation protocol (n=10): Group A1, B1 – 5% Glycolic acid, Group A2, B2– 17% Glycolic acid, Group A3, B3-0.2% Chitosan, Group A4, B4 -17%EDTA, Group A5, B5- saline. Samples from each group were obturated with gutta percha and in combination with one of the mentioned sealers (n=50) and sealed with temporary filling material. Then they were allowed to set for 1 week before push-out assessment. Two horizontal slices of 2 mm thickness were sectioned from each sample and subjected to Push out bond strength using Universal testing machine. The maximum load at failure was recorded and expressed in MPa. The data were statistically analyzed using one way ANOVA and independent Student t-test.

**Results:** Angelus Bio C significantly exhibited higher push out bond strength than Diaproseal sealer (P<0.05). Higher push out bond strength was seen in both the sealer groups after treatment with glycolic acid with no significant difference between 5% and 17% glycolic acid. Angelus Bio C sealer significantly exhibited higher push out bond strength.

**Conclusion:** The push-out bond strength of the root canal sealer

was significantly affected by the type of irrigation solution. The highest push out bond strength is seen with Angelus Bio C sealer after treatment with glycolic acid with no significant difference between 5% and 17% Glycolic acid.

**Abstract 608**

**Comparison of cyclic fatigue resistance of rotary file system using scanning electron microscope: An *in-vitro* study**

**M APARNA, AKASH MANOJ, AKHIL THOMAS, ANIL TOMER, KRIPA KRISHNA KUMAR, AYUSHI KHANDELWAL**

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**Aim:** Aim of this in-vitro study is to evaluate and compare the cyclic fatigue resistance of rotary files system using SEM (Scanning Electron Microscope).

**Materials and Methods:** Thirty freshly extracted single rooted mandibular premolars were selected and divided into three groups (n=10). Three Niti rotary file system Protaper gold, Two Shape, Hyflex EDM were used in this study. Three files were used in each file system and tested with cyclic fatigue torsional resistance tests. Every instrument was inspected for defects or deformities before the experiment. The rotary files were used with an endodontic motor X-SMART. The files used were scanned using Scanning Electron microscope.

**Results:** Hyflex EDM significantly showed highest fatigue resistance.

**Conclusion:** Each file was tested in simulated root canal until instrument fracture. The time to fracture in seconds was multiplied by the number of rotation cycles per second to obtain the number of cycles of fracture for each instrument. According to manufacturer, three reciprocating cycles describe a complete instrument rotation.

**Abstract 609**

**Comparative study on the efficacy of removal of gutta percha from the root canal walls using three different retreatment file systems – An *in-vitro* study**

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**Introduction:** During Retreatment Procedure, Complete removal of root canal filling material is of utmost importance in order to achieve effective cleaning and disinfection of canal anatomy. Therefore, in order to allow effective removal of filling material and Shorten the treatment time various rotary nickel titanium retreatment instrument systems have been introduced over the last decade.

**Aim:** The aim of this in vitro study was to compare the efficacy of three retreatment rotary systems in the removal of Gutta percha (GP) and sealer from the root canal walls.

**Materials and Methods:** Thirty extracted human mandibular first premolars were prepared and obturated with GP and AH Plus sealer. Samples were then randomly divided into three groups. Group 1

## Abstract

Specimens were retreated with Protaper Retreatment files, Group 2 Were retreated with Neo Endo Retreatment Files and Group 3 Were retreated with Waldent Retreatment files. Subsequently the cleanliness of canal walls was determined by stereomicroscope ( $\times 20$ ) and AutoCAD software.

**Results:** Significantly less amount of residual filling material was present in Protaper retreatment files followed by Neo Endo retreatment files and Waldent Retreatment files.

**Conclusions:** None of the instruments were able to remove the filling material completely from the root canal. Protaper Universal Retreatment files were more efficient and faster compared to Neo Endo and Waldent Retreatment Files.

### Abstract 610

#### Knowledge, attitude and practice of bioceramic root canal sealers among dental practitioners, postgraduate students and endodontists

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**Aim:** The aim of this survey was to evaluate the knowledge, Attitude and Practice of Bioceramic root canal sealers(BRCS) among Dental practitioners, Post graduate students and Endodontists.

**Materials and Methods:** A cross-sectional Knowledge, Attitude and Practice survey was conducted for data collection. An online questionnaire is created using the "Google Forms" platform consisting of 16 questions which includes both multiple choice and closed ended questions .These questions will help to get quantitative data on clinician demography and Knowledge, Attitude and practice of bioceramic root canal sealers .Statistical analysis was applied to determine association.

**Results:** Among participants(114) 73.5% heard about BRCS of which endodontists were more. And only 20% used BRCS sealers the primary reason is their physical and chemical properties. Among the BRCS users 54.5% used single cone obturation which included non endodontists mostly and endodontists preferred thermoplasticised obturation techniques . On difficulty of retreatment 40.9% said new techniques need to be developed and 22.7% said less chances of retreatment and remaining users said it is difficult/same as other sealers.40.9% BRCS users felt these sealers can replace other conventional sealers and 45.5% felt maybe.

**Conclusion:** This study highlights that there is less clinical usage of BRCS and major difference in clinical application of these sealers in endodontists and non endodontists is seen. For better evaluation there should be increased usage of BRCS and further studies should be conducted.

### Abstract 611

#### Lasers: A boon in endodontics (a literature review)

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Lasers have long been used in the field of endodontics for the optimization of endodontic irrigation in particular. The photomechanical effects of lasers at low settings are used in the laser-activated irrigation (LAI) technique. In intracanal fluids, they cause specific cavitation and acoustic streaming. Recently, a new Er:YAG laser technique with sub-ablative energy (20 mJ, 15 Hz) and ultra-short pulses (50 s) has been used. As a result of photoacoustic and photomechanical effects, intracanal cavitation and shockwaves occur. Photon-induced photoacoustic streaming is the name for this phenomenon (PIPS). The literature on Er:YAG LAI and PIPS on endodontic irrigation is compared to other irrigation methods in this review. The Er:YAG LAI and PIPS appear to be promising in terms of canal disinfection, as well as debris and smear layer removal.

### Abstract 612

#### Restoring the endodontically treated tooth: Using bundled glass fibre reinforced composite post: A case report

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Teeth having extensive tooth structure loss either due to trauma or tooth decay which have undergone root canal treatment have to be restored for their esthetic and functional rehabilitation. Posts are one of the highly successful modalities for such restorations if all the fundamental criteria of case selection and post placement are taken into consideration. In the era of technological evolution in every bit of endodontic dentistry, we have a lot many options to choose from in terms of post systems. This case report describes the use of bundled glass fibre reinforced composite post for the esthetic rehabilitation of an endodontically treated tooth of a 25-year-old male patient who reported with a fractured endodontically treated maxillary left central incisor (tooth #21). Treatment comprises of removal of gutta percha to make post space followed by post placement and core build up and all ceramic crown placement. This new post system used in this case is a bundle of individual posts of equivalent diameter having properties like high flexural strength and fracture resistance, high radiopacity, translucency, elasticity similar to that of dentin and also supposed to be excellent for atypical root anatomies. It provides homogenous reinforcement to the core build up which was not seen in cases of conventional post systems. In the discussion, we outlined the advantages of using bundled glass fibre reinforced composite post along with the literature evidences.

### Abstract 613

#### Advanced laser endodontic therapy-SWEEPS technology

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One of the main problems in endodontics is the non-turbulent

Abstract

fluid dynamics of irrigants in the confined and complex canal space, which hinders deep penetration of the irrigant, hence the traditional method does not completely clean all the infection present in the root canal of the tooth. Hence, more effective tools like advanced Laser endodontic therapy has been introduced for effective irrigation, debritment of canal and removal of smear layer with new technology in recent years. The laser-activated irrigation technique is based on the photomechanical effects of the lasers at low settings. They create specific cavitation phenomena and acoustic streaming in intracanal fluids. Several wavelength laser has been investigated for root canal cleaning and disinfecting like Er:YAG-2940 nm, Er,Cr:YSGG-2780 nm, Nd:YAG- 1064 nm, Diode-635 to 980 nm and Carbon dioxide (CO<sub>2</sub>)- 9600 and 10 600 nm. The wavelengths of erbium lasers (Er:YAG, Er,Cr:YSGG) are well absorbed in water and hydroxyapatite; thus, these are used with new technology. Laser-activated irrigation has evolved to include photon induced photoacoustic streaming (PIPS) and shock wave enhanced emission photoacoustic streaming (SWEEPS) technologies designed to enhance the effectiveness of laser-activated irrigation. A new SWEEPS (Shock Wave Enhanced Emission Photoacoustic Streaming) modality for Er:YAG laser has been introduced especially to improve the cleaning and disinfecting efficacy of laser-assisted endodontic procedures. Typically, shock waves are not emitted during laser-assisted irrigation of spatially confined root canals. However, by using the new SWEEPS modality, an acceleration of the collapse of the laser-induced bubbles is achieved, leading to the emission of shock waves also into narrow root canals. The emitted primary shock waves that reach the smear layer at super-sonic speeds and the shear flows created by the fast collapse of secondary bubbles near the canal walls enhance the cleaning and disinfecting efficacy of laser induced irrigation. With its precise delivery of shock waves into cleaning fluids and the resulting enhanced fluid dynamics, SWEEPS promises to represent an entirely new way of thinking about root canal therapy.

**Abstract 614**

**A novel approach of management of invasive cervical resorption: A case report**

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Management of Invasive cervical root resorption (ICR) is challenging clinically because of loss of tooth structure in the connective tissue attachment zone. Several predisposing factors are responsible for resorption of tooth. Among these trauma is considered to be a prime importance. In order to overcome invasive cervical resorption several treatment options have been discussed. Earlier only calcium hydroxide placement used to be carried out in cervical space which will not fulfil the all requirements. Multiple steps of treatment can produce better result. Early diagnosis and proper treatment may lead to long-term retention of the tooth. The treatment should aim toward complete removal of the resorptive defect and reconstruction by placement of a suitable filling material. The present report demonstrates the management of a maxillary lateral incisor with invasive cervical

root resorption by surgical elevation of the flap, using fibre post for reinforcement and strengthening of the remaining tooth structure followed by Biodentine as a core material for the defect.

**Abstract 615**

**Management of avulsion and lateral luxation: Case reports**

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Traumatic dental injuries of permanent teeth frequently occur in children and young adults. Avulsion injuries are most common in young dentition. The root development is still incomplete, and the periodontal ligament is still resilient. Avulsion injuries account for .5 to 16% of all dental injuries. Avulsion injuries affect esthetics, function and also cause immense psychological trauma to the patient. The treatment of choice is reimplantation, which maintains bone height, preserves arch length, and is expected to provide satisfactory results. Case Report:1 In this case, the avulsed tooth was brought to the clinic in polythene wrap with an extra-oral dry time of more than 20 hours. The tooth was washed with saline to remove debris from the root surface; endodontic treatment was performed extra-orally before reimplantation. After further examination, local anesthesia was given, socket examined for alveolar fracture, and irrigated. The tooth was re-implanted with digital pressure, secured with passive flexible splint and composite for two weeks. Case Report:2 Luxation injuries are the most commonly occurring of all dental injuries. The objective of the treatment is to maintain the pulp vitality, achieve periodontal healing, avoid fracture of the tooth, avoid the complication of pulp necrosis and inflammatory resorption leading to pre-mature loss of the tooth. In the present case report, the displaced tooth is repositioned by disengaging from its locked position into its original location under LA. The tooth is stabilized for four weeks using the passive flexible splint. Proper diagnosis, treatment planning, and follow-up are essential for achieving a favourable outcome. The present case reports discusses the management of avulsion and lateral luxation.

**Abstract 616**

**Minimally invasive endodontics: Dilemma for endodontist**

**PURVA SHAH**

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India

The main goal of endodontic therapy is the long-term retention of a functional tooth by preventing or treating apical periodontitis. Operative requirements were the primary deciding factor for traditional endodontic access and restorative needs and tooth needs were not given due importance. We have to maintain balance between all these three factors. The traditional straight-line access cavity preparation was causing removal of an excessive amount of peri cervical dentin which was compromising the long-term structural integrity of the tooth. An alternative approach is to minimize structural changes during root canal therapy, which may result in a new strategy that can be named as 'minimally

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invasive endodontics' (MIE). The concept behind minimally invasive endodontics assumes that maximum preservation of healthy coronal, cervical and radicular tooth structure during the endodontic treatment leaving the tooth with sufficient strength to function successfully. MIE requires specialized devices and instruments such as; surgical microscope, ultrasonic-assisted preparation techniques, modern flexible file systems and irrigation activation systems, also the clinician deep knowledge in root canal anatomy for good predictable outcome and reduce the errors which result in safe endodontic practice. MIE remains a controversial issue as protection of structural integrity of tooth might overweigh the iatrogenic complications like missed canals, deviations and/or instrument fracture, removal of pulp remnants, dentinal debris, blood, filling materials and other residues, which may cause tooth discoloration, support microbial growth and have a negative impact on treatment outcome.

### Abstract 617

#### Simulated external root resorption detection through two diagnostic methods in non-endodontically and endodontically treated teeth: *In vitro* study

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**Aim:** Simulated External root resorption (ERR) detection in teeth treated with and without endodontics was evaluated using two diagnostic methods: Digital Periapical Radiography (DPR) and CBCT, which were contrasted with the accurate measures of synthetic teeth.

**Materials and Methods:** The sample size was established as twelve teeth considering an alpha risk of 0.05 and a beta risk of 0.1 in a two-sided test. These teeth were prepared from a synthetic resin radiopaque, and they were matched with the human dental tissue. Then, the ERR was performed by the same operator in three places: mesial, distal and palatine. Moreover, the size of the ERR were 0.12, 0.18, 0.20 mm, and the depth was 0.5mm. The DPR and CBCT images have been taken after the gradual generation of the order of lesions created. One hundred twenty images were evaluated under two groups: Endodontically treated teeth (n=60) and Non-endodontically treated teeth (n=60). Sensitivity, Specificity, AUC and likelihood ratio were calculated.

**Results:** Intra- and inter-examiner agreement of eight raters had excellent ICC values ( $p < 0.001$ ). The detection of ERR was compared and assessed through the 120 images of DPR vs gold standard (real resorption), obtained a sensitivity of 90.7% and an AUC of 95.4%. Nevertheless, when the 60 images of endodontically treated teeth vs gold standard (real resorption) were selected, the sensitivity decreased to 81.5% and AUC of 90.7% compared to the sensitivity 100% and AUC 100% in teeth without root-filling. In addition, regarding the quality of the diagnostic tests, CBCT obtained an LR-0.00 while DPR of endodontic teeth obtained an LR-0.19.

**Conclusions:** From a statistical point of view, it can be concluded that CBCT and DPR are excellent diagnostic methods for ERR.

Nevertheless, root filling material modifies the diagnostic capacity of the imaging modalities evaluated. Thus, the intra-canal material makes the detection of ERR using DPR less accurate in endodontically treated teeth than their counterparts.

**Funding Sources:** Santander Research 2019/2020 and the Complutense University of Madrid- Spain, under the BOUC 14-3-2019 (ED01/19) grant. Also, it was financed in part by the University of Guayaquil-Ecuador 2017/2021 under the (UG-CGB-126-17-7-2017) grant.

### Abstract 618

#### Combined root canal therapy – A changing paradigm

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The diagnosis and classification of pulpal disease has changed over the years and continues to evolve. No single modality has been able to accurately detect the true pulpal condition, as they may vary from the coronal to the radicular area depending on the extent of injury caused by various irritants. The irony is that the decision to perform endodontic treatment still relies on these routinely practised techniques. In doing so, the vital pulp tissue often succumbs which otherwise would have survived after selective elimination of diseased tissue. The preservation of dental pulp is crucial for maintaining the integrity of a tooth, thus modern therapies aim at preserving as much vital tissue as possible. With the advancements in magnification and illumination, the control of bleeding can be used as a guide to differentiate between reversible and irreversible pulpal inflammation. Thus, combining treatment approaches for multirooted teeth provides the opportunity to select procedures that may have specific benefits, such as maintaining pulp vitality where possible. Ultimately, the combined therapy may benefit the patient and increase the tooth survival rate. Through, this paper an attempt will be made to critically review and analyse the merits and demerits of this approach and its scope in the coming era.

### Abstract 619

#### Evaluation of quality of life in root canal treated patients by various instrumentation techniques: A systematic review

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**Objective:** This systematic review aims to evaluate the effect of various instrumentation techniques on the post-operative quality of life in the root canal treated patients. This systematic review has been registered in the PROSPERO Public registry of systematic review (CRD42020222824).

**Materials and Methods:** A broad literature search was conducted in the electronic databases like PubMed / MEDLINE, Google scholar, Scopus, EBSCO dentistry, LILAC, OVID, Cochrane databases along with the manual search to identify the articles published until January 2021.

The PICOS for the studies under inclusion criteria includes Patients (P): Patient's with endodontically treated teeth

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Intervention (I): Endodontic treatment with machine assisted instrumentation

Comparison (C): Endodontic treatment with hand or any other machine assisted instrumentation

Outcome(O):

Primary outcome: Post-operative Quality of life

Secondary outcome: 1. Post-operative pain 2. Analgesic intake

Study Design(S): Randomized clinical trials

A total of three randomized clinical trials that met the inclusion criteria were included in this present systematic review.

**Results:** A total of 234 patients with a mean age group of 16-66 years from three randomized trials were included in the systematic review. Instrumentation protocol for root canal treatment in three studies were performed with ProTaper Next Vs Reciproc, ProTaper™ Vs Waveone™, Stainless steel k- files Vs Reciproc. In two studies single visit root canal therapy was performed and in one study root canal therapy was performed in two visits. Quality of life was assessed using Oral Health Impact Profile-14 (OHIP-14) in two studies and ad hoc questionnaire in one study. Risk of bias was assessed using the Cochrane's risk of bias tool. Out of the three studies ; two studies were judged as low risk and one study as high risk.

**Conclusion:** In the present systematic review, it can be concluded that reciprocating technique has shown better post-operative quality of life in comparison with the other protocols performed for the root canal treatment.

### Abstract 620

#### Comparison of apical extrusion of debris using different file system: An *in vitro* study

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AYUSHI KHANDELWAL**

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**Introduction:** Root canal therapy comprises three main steps, namely access preparation, biomechanical preparation, and three-dimensional Obturation. During the process, the debris of the root canal system is pushed out from the canals, leading to treatment failure and flare-ups.

**Aim:** Aim of the Study is to compare the apical extrusion of debris using Hyflex EDM, Neo Endo S and EdgeEndo.

**Materials and Methods:** Thirty extracted human teeth with single canal were selected; the sample tubes were preweighted before instrumentation and were then allocated into three groups along with the sample teeth. All the samples were instrumented and debris was collected in the collector tubes. The debris collected was weighted in an analytical balance to determine the extruded debris.

**Results:** The results of our study showed that Hyflex EDM resulted in least amount of apical extrusion of debris. However, there was no statistically significant difference between Neo Endo S and Edgeendo, while all files showed minimum amount of debris extrusion.

**Conclusion:** The Hyflex EDM extruded less amount of periapical debris than the other file systems.

### Abstract 621

#### Guided endodontics: A paradigm shift in endodontics?

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The most critical and important step for successful root canal treatment is access cavity preparation. The Conventional Endodontic access is prone to technical failures and substantial loss of dental hard tissue, which may weaken a tooth considerably or result in root perforation. To overcome such complications, recent advancements in treatment modalities and shift to digitization in the field of dentistry have been introduced. Imaging plays an important role by providing morphologic and functional information, focusing and guiding treatment and assessing response to endodontic therapies. The virtually planned concept of "Guided Endodontics" has been introduced in accordance with Cone Beam Computed Tomography (CBCT) and 3D printing. Guided endodontics is about strategic dentin preservation and restoring the balance, planning access and shape using a directed approach, and evaluating response to treatment. The novel concepts of guided endodontics has been reported as an effective method to obtain safe and reliable method during various endodontic procedures. Also, in future, guided endodontics may help to easily and precisely access and treat specific areas in the root, which are hampered due to calcification, resorptions, perforations or fractured endodontic instruments. So, in this review, we discuss about the role of image guided endodontics like static CT guidance & Dynamic guidance, guided rail based on CBCT (3D printer-based template) used in conventional endodontic therapies and in endodontic surgeries.

### Abstract 622

#### Three-dimensional printing in Endodontics: A new era in dentistry

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Computer-aided design (CAD) and computer-aided manufacturing (CAM) technologies can utilize cone beam computed tomography (CBCT) data for production of objects used in surgical and nonsurgical endodontics and in educational settings. 3D printing is a promising new technology in the field of dentistry. It is an "additive manufacturing" method in which 3D item is formed by laying down successive layers of material. It is a technology which can design and produce 3D models and is proving to improvise the quality of the treatment to the patients as it is less technique sensitive and more precise. Various dental parts can be printed using methods like selective laser sintering (SLS), stereolithography, fused deposition modeling and laminated object manufacturing. 3D printing can be combined with oral scans and CAD/CAM design to produce crowns, bridges, stone models and various orthodontic appliances. 3D printing is transforming digital dentistry by extensively giving opportunities in diagnosis, treatment, and education. 3D printing could be a milestone in the field of dentistry due to its accuracy, efficacy, potency, and

Abstract

minimal time consumption in the fabrication process. It's efficiency in treatment planning and analysis of treatment outcomes improvises the quality of treatment provided by the dentist to the patient improving the patient satisfaction. This review paper describes an overview on 3D printing and its applications in Endodontics.

**Abstract 623**  
**Barotrauma**

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Changes in air pressure during activities like flying or diving can lead to physical injury causing barotrauma or tooth pain known as barodontalgia. These changes can also exacerbate the pre-existing pulpal and tooth pathologies. Also, such incidences are more common during epidemics and pandemics associated with respiratory problems like coronavirus outbreaks. present review article in form of paper presentation aims to make dental surgeon aware of such association so as to indentify the pre-disposed individuals and to take necessary precautions while treating them.

**Abstract 624**  
**Antimicrobial efficacy of sodium hypochlorite with surfactants against *Enterococcus faecalis* in extracted human and bovine teeth: A systematic review**

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MATHEW SEBEENA, KUMARAVADIVEL KARTHICK,  
NT DEEPA**

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**Objective:** The purpose of this systematic review was to evaluate the antimicrobial efficacy of Sodium Hypochlorite with Surfactants against *Enterococcus faecalis* in extracted human and bovine teeth.

**Methods:** The literature search was conducted in PubMed, Google Scholar, Web of science from January 1991 – December 2020 using keywords. Ninety-one studies were identified after applying limits. Twenty-nine irrelevant and duplicated articles were eliminated. Among sixty-two articles obtained, forty-eight articles were eliminated after reading the titles and the abstracts. After assessing the full text, ten articles were eliminated. Articles were providing about in-vitro studies, in which the antimicrobial efficacy of sodium hypochlorite with surfactants against *Enterococcus faecalis* in extracted human & bovine teeth were evaluated. Reviews, Case reports, Letters to editors, Editorial and In Vivo studies were excluded.

**Results:** A total of 91 articles were examined, among which 4 In Vitro studies were selected for the final synthesis. All of the articles concluded that Sodium Hypochlorite with Surfactants showed significantly improved antimicrobial efficacy against *Enterococcus faecalis* in extracted Human & Bovine teeth.

**Conclusion:** This systematic review was able to gather adequate information that addition of surfactants to sodium hypochlorite exhibited significantly improved antimicrobial efficacy against *Enterococcus Faecalis*.

**Abstract 625**  
**Dynamic navigation – Third eye in endodontics**

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In this era of the rapid evolution of technology, there has been increased use of computer navigated systems in the field of medicine, especially neurosurgery. Dynamic navigation is essentially a computer-aided surgical navigation technology, quite similar to satellite navigation. In dentistry, for the very first time, this technology was adapted in implantology. Now, it is being used in field of endodontics. Enhanced precision inferable from real-time feedback increases the success rate of minimally invasive access cavity preparation of complex and calcified root canals, retreatment, and planning osteotomy site along with root-end resection. With this innovation coming into practice, we see the changing world of endodontics. This review paper describes the principles, procedure, application of dynamic navigation system along with its advantages with an eye for the future of endodontics.

**Abstract 626**  
**Minimum for maximum – Newer trends in endodontic access preparation: A review**

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Access cavity preparation is of paramount importance as it is the vital stage that governs the success or ease of the ongoing treatment. Access not only precedes all other maneuvers, it determines their likelihood of success. Traditionally, each type of tooth has corresponded to a particular access shape. They focus on removing tooth structure to allow straight- line entry which predispose previously treated teeth to fracture via increased removal of tooth structure. To overcome these, newer approaches have been made which employ more flexible instruments, new materials and techniques to preserve more tooth structure with focus placed on saving pericervical dentin which improves force distribution and covers fracture susceptibility. The aim of this article is to review the various methods of minimally invasive endodontics in comparison to traditional approaches.

**Abstract 627**  
**Restoration of tooth fracture using fiber post and fragment reattachment: Case report**

**MAMTA KATAL**

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Mostly affected teeth from dental trauma are maxillary anterior teeth. The immediate agglutination of original fractured tooth part is a good alternative option in the scope of emergency treatment for remaining esthetical and functional problems. In permanent dentition, dental trauma is a more common event in young patients and resulting in

Abstract

fracture of anterior teeth. These fractures subsequently lead to esthetic, functional, and phonetic problems. Management of the dental trauma requires a comprehensive and accurate diagnostic and treatment plan. Reattachment of tooth fragments can be used only when the intact tooth fragment is available and this technique is a viable alternative to conventional approach with minimal or without violation of biologic width. This technique is a simple conservative approach to provide functional rehabilitation and economically acceptable and it can offer good and long-lasting esthetics (as the original tooth anatomic form, color, and surface texture are maintained). This case report presents restoration tooth using fiber post and fractured fragment reattachment.

**Abstract 628**

**Comparative evaluation of stress distribution in spring machined nickel-titanium rotary files with different cross-sections: A three-dimensional finite element analysis**

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**Aim:** To compare and evaluate the stress distribution in spring machined rotary files with non-spring machined files in simulated root canal using a 3D finite element analysis.

**Materials and Methods:** NiTi rotary files of five cross-sectional designs without springs were created with apical diameter 0.25 mm, 25 mm full length, and 6 % taper. Five cross-sectional designs were Convex triangle, Triangle, Radial landed U type, Experimental 1 (EXP1), and Experimental 2 (EXP2). EXP1 had a convex triangle at coronal third, triangle at middle third, radial landed U type at apical third, while EXP2 had radial landed U type at coronal third, triangle at middle third, and convex triangle at apical third. Five other NiTi files were created with similar cross-sections in which 6 mm spring machined into their shaft with 2600-degree spring coils. A 3D model of simulated 45° curved root canal with a 6mm radius was constructed. All 3D simulated models were created using commercial software ANSYS 18.1 and Solidworks 2019. Each file was placed in the simulated root canal till a working length of 16 mm and then rotated 180° at 240 rpm by applying 2 Nm torque. Von Mises stress value for each file was calculated and recorded in Mpa. Statistical analysis was performed using one way ANOVA test and independent t-test.

**Results:** Higher bending stress was observed in all five designs of non-spring machined NiTi files compared to spring-machined NiTi files. All values were statistically significant ( $p < 0.05$ ).

**Conclusion:** Under the limitations of the present study, spring machining in the shaft portion of five NiTi rotary files significantly minimized bending stress and improved their mechanical properties compared to non-spring files. Spring machined Experimental1 file (EXP1spr) with a convex triangle at coronal third, triangle at middle third, and radial landed U type at apical third presented with the least bending stress compared to all the other tested file designs.

**Abstract 629**

**Application of nanotechnology in endodontics**

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Nanotechnology is considered to be an upcoming technology. Nanotechnology in the field of dentistry helps in diagnosis, prevention and treatment. Nanotechnology incorporates the usage of nanoparticles less than 100 nm. This technology can be used in various aspects of dentistry. In the present study, a comprehensive literature review is conducted on the applications of nanotechnology in endodontics. It was concluded that nanotechnology can be utilized in fillers, irrigants and photodynamic therapy to achieve more beneficial results. It can also be used for testing mechanical properties of endodontic instrument. Based on the reviewed studies, it is well acknowledged that antibacterial nano particles can be used for disinfection and have shown acceptable efficacy in elimination of bacterial cells from root canals. Moreover, nanotechnology is applicable to sealers used in endodontics. By using nano-sized materials, anti-leakage property of the sealer can be enhanced. In addition, nanotechnology can be applied in photodynamic therapy in endodontics. Nanotechnology possesses tremendous potential but social issues of public acceptance, ethics, regulation, and human safety must be addressed before nanotechnology can be looked upon as the hope for the future.

**Abstract 630**

**Evaluation of remaining dentin thickness using cone beam computed tomography in mandibular molars after instrumentation with different file systems: An *in-vitro* study**

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**Aim:** To evaluate the remaining dentin thickness of the distal portion of the mesial root of mandibular first molar after instrumentation with hand K file, NeoEndo and ProTaper Gold using cone beam computed tomography.

**Materials and Methods:** Forty-five extracted human mandibular molars were collected. Teeth were randomly assigned to three groups (n= 15). Samples were stabilized on wax blocks. The working length was determined by using a ISO 15 K file. Preparation was carried out according to the manufacturer's instructions. Finally, canals were instrumented upto working length for each group. After each instrumentation, root canals were irrigated with 5.25% sodium hypochlorite solution followed by 17% EDTA solution. Final irrigation was done with saline. Post instrumentation cone beam computed tomography scans of all samples in the 3 groups were collected and statistically analysed for RDT.

**Result:** Inter group comparison (>2 groups) was done using one way ANOVA followed by pair wise comparison using post hoc test. Mean value of RDT for each group: Group 1-  $1.300 \pm 0.192$  Group 2-  $1.053 \pm 0.155$  Group 3-  $0.800 \pm 0.185$ . There was a statistically significant difference seen for the values between the groups ( $p < 0.01$ ) with higher values in group 1 (hand k file) & least in group 3 (protaper gold )

Abstract

**Conclusion:** It is concluded that Hand K file system removed less dentine than NeoEndo file system and Protaper Gold file.

**Abstract 631**

**Determining the presence of second Mesio-buccal canal and inter-orifice distance in permanent maxillary first molars in Rajasthan sub-population: A cone beam computed tomographic study**

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PRACHI MITAL, DEEKSHA KHURANA, ASHA JETWANI,  
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**Aim:** The aim of this cone-beam computed tomographic (CBCT) study was to evaluate the occurrence of second mesio-buccal (MB2) canal and the inter-orifice distance (IOD) between mesio-buccal (MB1) and MB2 in permanent maxillary first molar tooth in Rajasthan sub-population.

**Materials and Methods:** CBCT scans of 292 permanent maxillary first molars were studied using 146 CBCT scans for the presence of MB2 canal in the axial sections. The IOD between the MB1 and MB2 canal was measured in the where the MB2 canal was first visualized. Its location was determined in relation to MB1 and the palatal canal. The prevalence and mean IOD was statistically analyzed.

**Results:** The prevalence of MB2 canal in 292 permanent maxillary molars in 146 CBCT scans was found to be 54.8%. The mean inter-orifice distance between the MB1 and MB2 was found to be  $2.7 \pm 0.13$  mm. There was a statistically highly significant difference seen for the values between the groups ( $p < 0.01$ ) with higher values in presence of 2 MB2 in both the quadrant in one scan.

**Conclusion:** Prevalence of MB2 in maxillary molars in Rajasthan sub population is considered to be considerably moderate. Inadequate visualization of presence MB2 leads to incomplete treatment and symptoms of pulpal infection remains even after root canal treatment of the tooth. Clinically, the access cavity must be modified from a triangular shape to rhomboid shape in search of MB2 canal. CBCT reveal more accurate internal anatomy of root canals especially MB2 canals.

**Abstract 632**

**Negative pressure irrigation systems**

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Endodontics has reached a level where major developments and innovations are happening routinely. Needles, ultrasonics, biocompatibility of filling materials, rotary devices, and imaging techniques have been undergoing major changes over the decades. However, the developmental changes in irrigating the root canal system have shown a slow progress. However, nowadays, we are seeing a developmental surge in advanced irrigation technology. The

endodontics has the ultimate goal in cleaning the root canal system effectively. The apical third of the root canal is the most critical area. This is due to the fact that the presence of deltas, fins, and canal spaces in the root canal makes it the highly complex anatomical network, making the instruments inaccessible. The apical third contains over 98% of the canal ramifications. The apical negative pressure irrigation technique has changed the common grounds in apical irrigation. This technology could allow the chemical irrigants to reach the full working length of the root canal space. This irrigation technique creates negative pressure by suction method. The negative pressure created is used to pull the chemical solutions injected into canal space from the reservoir to the working length using high-speed suction. The high-speed suction at the tip of the cannulae drives the negative pressure current force. When the blockage of the cannulae occurred or disturbance to the suction force occurred, solutions would not be present in the apex. This is due to the dependent nature of the technology on the suction force to deliver the chemical solution to the full working length of the canal space. This review of the negative pressure apical irrigation will show a descriptive difference with the positive pressure irrigation, technology used. It has emerged as one of the most advanced canal cleansing by minimization of risks, maximization of effectiveness and the clinical impact. This paper highlights the mechanism of Minimum Invasive Irrigation process via Endovac and other systems, which works under the same principle of negative pressure, will provide a new ray of hope in the root canal irrigation and disinfection.

**Abstract 633**

**Magnification in endodontics: A review**

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SHIVANGI JAIN, NIVEDITA SAINI,  
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Conventional ways of endodontics treatment is based upon feel not the sight, the field of endodontic has witnessed significant technological advances over the past decade. One area is the evolution of visualization. Magnification increased to visualize even the smallest detail, which functions as the third eye for the endodontist. The application of magnification devices in endodontics is mainly meant for visual enhancement and improved ergonomics. With the recent advances of magnification devices with increased magnification and illumination there is improved technical accuracy and performance. This review article highlights the role of magnification, types of magnification devices and their clinical application in endodontics.

**Abstract 634**

**Comparative evaluation of antimicrobial efficacy of two endodontic sealers before and after addition of nanoparticles of silver vanadate against *Candida albicans*: An *in-vitro* study**

**UTKARSHA SHELKE**

## Abstract

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**Aim:** To evaluate the antibacterial effect of two types of root canal sealers before and after addition of the nanostructured silver vanadate decorated with silver nanoparticles (Agvo3) against *Candida albicans*.

### Objective:

- 1- To evaluate the antibacterial effect of Bioroot RCS.
- 2- To evaluate the antibacterial effect of MTA Fillapex.
- 3- To evaluate the antibacterial effect of Bioroot RCS after addition of the nanostructured silver vanadate decorated with silver nanoparticles (Agvo3).
- 4- To evaluate the antibacterial effect of MTA Fillapex after addition of the nanostructured silver vanadate decorated with silver nanoparticles (Agvo3).
- 5- To compare the antibacterial effect of Bioroot RCS and MTA Fillapex sealer before and after addition of the nanostructured silver vanadate decorated with silver nanoparticles (Agvo3).

### GROUPS

1- MTA Fillapex

Subgroups- 1. MTA Fillapex sealer

2. MTA Fillapex sealer incorporated with Nanoparticles of Silver Vanadate.

2- Bioroot RCS

Subgroups- 1. Bioroot RCS sealer

2. Bioroot RCS sealer incorporated with Nanoparticles of Silver Vanadate.

**Methods:** Sealer cements were mixed in accordance with the manufacturers' instructions. Nanoparticles of Silver Vanadate (AgVO<sub>3</sub>) were added at the concentrations of 5% to endodontic sealers in subgroups 2. Agar disc diffusion method were performed for both the subgroups. Suspensions of the cultures were adjusted to 0.5 McFarland standard (1.5x10<sup>8</sup> colonies/ml). Mueller Hinton Agar plates were prepared and cultures (200 µL) were spread on agar plates. Inoculation were performed using sterile swab brush across media. Sterile discs were immersed in a particular sealer and placed on the agar plate. Sterile paper discs were impregnated with sealer for 1 min. The sterile paper discs were then placed on to the agar plates. The plates were then be kept in an incubator at 37° C. Zones of inhibition were measured after 24 hrs for each groups.

**Results:** Mean zone of inhibition for MTA Fillapaex was 17mm and that for Bio-Root RCS was 22mm, which increased to a significant amount after addition of Nanoparticles of Silver Vanadate.

**Conclusion:** Bio-Root RCS has better antimicrobial efficacy against *Candida albicans* before and after addition of Nanoparticles of Silver Vanadate.

### Abstract 635

**Microhardness characteristics of radicular dentin following the use of five different intracanal medicaments: An *in vitro* study**

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**Aim:** The aim of this study is to investigate the microhardness of the radicular dentin after using five different intracanal medicaments.

**Materials and Methods:** Fifty extracted human central incisors were included in study. The crowns were decoronated by double faced diamond disc. biomechanical preparation for all teeth was done. horizontal section of 5mm length is made of root. intracanal medicament is placed and Teflon tape is wrapped around it. The first control group received no treatment. The second group 1mg/ml DAP [ AMOXICILLIN+METRONIDAZOLE] with chlorhexidine. the third group is 1mg/ml MTAP [ METRONIDAZOLE + CIPROFLOXACIN + CEFACLOR] with clove oil. the fourth group is 1mg/ml CLINDAMYCIN + METHYLCELLULOSE with CHLORHEXIDINE. The fifth group is CLINDAMYCIN + METRONIDAZOLE + CIPROFLOXACIN + METHYLCELLULOSE. The sixth group is CALCIUM HYDROXIDE with CLOVE OIL. after 7days of incubation, the samples were tested in Vickers harness testing machine for microhardness test. the result were analysed by statistical analysis by one way ANOVA test.

**Results:** The results was statistically analysed by one way ANOVA test and level of significance is less than 0.05 is considered significant. Group – 6 followed by group 5 & group 4 change in microhardness is seen in intra radicular dentine .

**Conclusion:** There is highest microhardness of control group. Calcium hydroxide group showed almost similar microhardness to control group followed by DTAP and clindamycin group. While lowest microhardness was seen in triple antibiotic paste group.

### Abstract 636

**Sterilization of endodontic files: An *in-vivo* study**

**YASHKUMAR SHAH**

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Maharashtra, India

### Aim:

- To compare the sterility of endodontic files by sterilizing solutions, ultrasonic cleaner and combination of both.

### Objectives:

- To evaluate the efficacy of garlic oil in sterilizing the endodontic files.
- To evaluate the efficacy of clove oil in sterilizing the endodontic files.
- To compare the efficacy of garlic oil and clove oil in sterilizing the endodontic files.
- To evaluate the efficacy of ultrasonic cleaner in sterilizing the endodontic files.
- To evaluate the efficacy of ultrasonic cleaning + garlic oil in sterilizing endodontic files
- To evaluate the efficacy of ultrasonic cleaning + clove oil in sterilizing endodontic files
- To compare all of the above

**Materials and Methods:** A randomized controlled trial with rotary files (17 number, 4 % taper) by neoendo (n=30) were used to prepare the endodontic canal (used only once in to and fro motion

## Abstract

till apex) in patients (indicated for endodontic treatment) under all aseptic precautions with the use of lubricant (17% EDTA) and sodium hypochlorite (5.5%). These files were subdivided into 3 groups. Group 1 and 3 were divided into 2 subgroups. The rotary files (17 4%) were then be checked for sterility by three different methods. GROUP 1 (Directly keeping them in sterilizing solution for 5 mins)

Group 1A (garlic oil)

Group 1B (clove oil)

GROUP 2 (ultrasonic cleaning for 8 mins and checking for sterility)

GROUP 3 (ultrasonic cleaning for 8 mins + sterilizing solutions)

Group 3A (garlic oil)

Group 3B (clove oil)

Then they were transferred to sterile test tubes containing nutrient broth and were kept overnight in an incubator. The inoculum from the test tube was spread on to the blood agar plate with the help of sterile cotton swab. The blood agar plate was checked for any colony growth after keeping it in an incubator for 24 hours.

**Results:** Garlic oil was more effective than clove oil for sterilizing the endodontic files.

**Conclusion:** Combination of ultrasonic cleaning + immersing them in sterilizing solutions is more effective than other methods.

### Abstract 637

#### Extra-radicular obturation techniques: A new nuance

**MANDIRA KAMBLE**

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In a challenge as daunting as achieving a near perfect root canal seal, the clinician often stays in pursuit of a system which can make the process more tenable. At the same time, we're compelled to create a multidimensional seal amidst the intricacies of root canal system, which is a benchmark for assured clinical success. Choosing a specific obturation technique among the available repertoire depends primarily upon the anatomical root canal configuration at hand as well as an array of desired treatment outcomes. The constantly evolving arena of technology driven endodontics has endowed success savvy clinicians with devices that can deliver heated gutta percha with optimized flow & force parameters, both with & without the titular master cone concept. However, a series of thermoplasticized systems have been making quiet a buzz owing to the sheer simplicity of their workflow. Such systems include The Obtura II, Calamus flow, Elements obturation unit and the Ultrafill 3D obturation. Hence, the purpose of this poster is to set the narrative on these techniques which employ heat and vibration for wholesome compaction of the obturating materials, claiming dramatically to transform the practice of endodontics, steering it towards added success.

### Abstract 638

#### Comparative evaluation of canal transportation, centering ability, and remaining dentin thickness with three different rotary Ni-Ti file systems: An *in vitro* cone-beam computed tomographic study

**DURGA BHAVANI PANITHINI,**

**MANTHENA SITA RAMA KUMAR,**

**GIRIJA S SAJJAN, K MADHU VARMA, R KALYAN SATISH,**

**KALLEPALLI MEGHANA**

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**Aim:** This study aimed to evaluate the canal transportation, centering ability, and remaining dentin thickness with ProTaper Next (PTN), TruNatomy (TN), and Neohybrid (NH) file systems using cone-beam computed tomography.

**Materials and Methods:** Thirty extracted single-rooted mandibular premolars were selected, decoronated, and divided into three experimental groups, with ten teeth in each Group (n=10). Group I - ProTaper Next (PTN), Group II - TruNatomy (TN), and Group III - Neohybrid (NH) file systems. The teeth were embedded in the putty blocks to obtain a constant position. A Cone-beam computed tomographic pre-instrumentation imaging of all teeth were done, followed by biomechanical preparation with the respective file systems. Post-instrumentation CBCT imaging was done in a similar method as the pre-instrumentation scan. The two scans were compared to determine canal transportation, centering ability, and remaining dentin thickness at 3 mm, 6 mm, and 9 mm from the root apex using DICOM Software CS 9000 3D, version 3.5, Rainbow CT machine. One-way ANOVA and Tukey's post hoc test were used for statistical analysis.

**Results:** The mean canal transportation at 6mm in Group I, Group II, and Group III were  $(-0.13 \pm 0.14)$ ,  $(0.05 \pm 0.05)$ , and  $(0.05 \pm 0.17)$  respectively. The difference was statistically significant between the Groups at the level of 6mm ( $p < 0.05$ ) and insignificant differences were seen at 3mm, and 9mm ( $p > 0.05$ ). Moreover, the mean centering ability was higher in Group I at the level of 3 mm  $(0.73 \pm 0.27)$ , and Group II at the level of 6mm and 9mm  $(0.75 \pm 0.26, 0.76 \pm 0.25)$  respectively). However, no statistically significant difference was found between the groups at all three levels ( $p > 0.05$ ). The amount of remaining dentin thickness was found to be higher in Group II at the level of 6 and 9mm  $(0.13 \pm 0.04, 0.17 \pm 0.07)$  respectively, Group III at the level of 3mm  $(0.14 \pm 0.06)$ , and the difference was statistically significant ( $p < 0.05$ ).

**Conclusion:** Under the *in vitro* conditions of the study, all three file systems have shown similar behavior concerning canal transportation and centering ability. TruNatomy (TN) followed by Neohybrid (NH) file systems preserved more amount of dentin when compared to ProTaper Next [PTN] file system.

### Abstract 639

#### Electronic apex locators - influence on target: A review

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One of the most reliable methods in determining the working length in today's era is with apex locators. Apex locators work based on impedance, resistance, frequency, multifrequency, Two frequencies-impedance ratio, Two frequencies- impedance difference. An apex locator acts as an adjunct to intraoral radiographs in multiple ways. Although many generations of the apex locators were introduced with advancements, there are numerous factors that determine the accuracy of the apex locators. This review paper describes various factors affecting the accuracy of the electronic apex locators.

### Abstract 640

#### Capillary condensation technique for simulated internal resorption cavity: A cone-beam computed tomographic study

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**Objective:** The management of internal resorption is highly complex owing to the irregular surface created by the clastic activity. The function of obturation is not only to render bacterial tight seal but to strengthen the remaining dentin of the root canal system.

**Aim:** To compare the quality of two different root canal obturation techniques: Hybrid technique, capillary condensation technique in teeth with simulated internal resorption cavity by using cone beam computed tomography.

**Materials and Methods:** A total of 18 mandibular premolars with single canal were selected. Teeth were decoronated at the cementoamel junction to obtain a standard root length of 12 mm. Biomechanical preparation was done with ProTaper Universal rotary up to F4 at 300 rpm with torque 2 N/cm along with irrigation. #08 size Round bur was used to make an internal resorption cavity of uniform diameter in the middle third of the root and equal dimension was confirmed with buccolingual and mesiodistal radiograph. The teeth were randomly divided into two groups of 9 each. Group I: Teeth with Bioceramic sealer (EndoSequence BC Sealer, Brasseler, USA) application with conventional technique and Hybrid technique of obturation. Group II: Capillary condensation technique of Bioceramic sealer (EndoSequence BC Sealer, Brasseler USA) with single cone gutta percha obturation to aid in retreatment or post placement. Cone beam computed tomography was used to measure filling area and voids at coronal, middle and apical third of the root canal with "On-Demand 3D App" software. Data was statistically analysed by One-Way Anova and multiple comparison of Tukey HSD tests with p value <0.05.

**Results:** The mean area of void were  $0.3963 \pm 0.3299$  mm<sup>2</sup> for group I and  $0.4022 \pm 0.4101$  mm<sup>2</sup> for group II. There was a significant difference in the amount of voids present in coronal, middle and apical area within a group but without significant difference between the groups. Minimum voids were seen in the apical area.

**Conclusion:** Capillary condensation technique with single cone obturation is comparable to conventional sealer application and hybrid technique of obturation for filling internal resorption cavity.

### Abstract 641

#### Infection control in dental office during COVID-19 outbreak: A review

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In December 2019, in Wuhan(China) there were described the first cases of a severe acute respiratory syndrome caused by SARS COV-2 and named as COVID-19 and in March 2020 the WHO

declared it as pandemic. It has emerged disrupting many socio-economical and health care aspects across the world. Clinical presentations of COVID-19 range from asymptomatic cases to severe Pneumonia that can lead death also. The patients with COVID-19 usually present with clinical symptoms of fever, dry cough and myalgia. In addition less obvious symptoms such as nausea, diarrhea, reduced sense of smell and abnormal taste sensation have also been reported. It has become clear that among healthcare professionals, Dentists are the most exposed category to the risk of such infection because the infection is typically spread from one person to another via respiratory droplets produced during coughing and sneezing. Distinctive work settings makes dentist to come in close contact with the patients and aerosols during certain dental procedures leading to the heightened risk of SARS COV2 transmission from infected patients and vice versa and subsequently to other patients if appropriate protective infection control measurements are not undertaken. Each country started its own specific approach in preventing the spread of COVID-19 among the local populations, starting with promoting social distancing and heightened hygiene. Moreover police curfew, lockdown were the effective measures in preventing virus spread. Though routine dental checkup was suspended due to fear of spreading COVID-19 but still some urgent dental conditions like pain, swelling, infections still need to be treated with proper care and protection. Dental team led by the dentists are very familiar with universal personal protective equipment like full gown, N95 mask, protective eye wear, gloves, face shield etc. and other cross infection control measures and risk assessment. Patient screening, sanitization of dental office and sterilization of instruments also play very important role to prevent the transmission of COVID-19 in dentistry. If the recommendations issued by the regulatory authorities are meticulously followed, the risk of disease transmission can be lessened.

### Abstract 642

#### To save or not to save - retreatment of maxillary central incisor with inflammatory root resorption

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The response of the dentoalveolar apparatus to infection is characterized by inflammation which may result in tooth resorption. Root resorption may occur after various injuries, including mechanical, chemical or thermal injury. Trauma is the most common etiological factor accounting to 43% of the cases. Depending upon the type of resorption and etiology, different treatment regimens have been proposed. A comprehensive understanding of the pathologic process is required so as to identify the cause and arrest the resorptive process. Various materials are available to induce remineralization and healing. The following case demonstrates an infection induced internal-external inflammatory root resorption in a previously root canal treated maxillary incisor which was arrested by conventional nonsurgical retreatment. Combined treatment

Abstract

plan involving repeated dressings of intracanal medicaments to promote healing and use of a bioactive material like Biodentine to induce remineralization was employed. The tooth was reinforced with multiple fibre posts and core followed by crown. Follow up of 1 year revealed signs of healing and arrest of root resorption.

**Abstract 643**

**Bioceramic-based root canal sealers: A review**

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In addition to a variety of other considerations, the prevention of reinfection of the root canal space is critical to the success of root canal treatment. Apical periodontitis prevention or healing is the ultimate goal of root canal therapy. To achieve this purpose, the use of biologically active agents to seal root canal systems has been widely recommended in modern endodontics. There are various commercial bioceramic formulations available, each with modest differences in composition that could result in significant differences in attributes in the clinical setting. This narrative review aims to provide a quick overview of the many bioactive ceramic formulations now available in the field of endodontics, as well as their features and applications.

**Abstract 644**

**Endodontic management of a 3 rooted maxillary first premolar**

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Maxillary premolars exhibit anatomical variations in the numbers of roots and canals, which pose a challenge during root canal therapy.

**Objective:** to report diagnosis and successful clinical management of a patient with anatomical variation in maxillary first premolar. A 21-year old male patient reported to the Department of Conservative Dentistry and Endodontics, Manav Rachna Dental College with the chief complaint of pain in the upper right back tooth region. Periapical diagnostic radiography did not provide adequate information about the morphology of the root canal system and number of roots. Subsequently, a 3D cone-beam computed tomographic (CBCT) image was obtained, which revealed three roots in right maxillary first premolar (#14) and Root canal treatment was performed under rubber dam isolation.

**Conclusion:** Maxillary premolars have a highly variable root canal morphology, therefore, clinicians should be able to predict the anatomical variations in maxillary premolars and have adequate knowledge and skills for managing such situations.

**Abstract 645**

**Management of external cervical root resorption using egg shell derived graft: A case report**

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India

External cervical root resorption is the loss of hard tissue of tooth as a result of odontoclastic activity, it usually begins on the cervical region of the root surface of the teeth. It usually spreads out in the thickness of the dentin in an irregular manner. Exact etiology is not clear but several predisposing factors include orthodontic forces, trauma, intracanal bleaching, surgical procedures, periodontal therapy, bruxism, intra coronal restorations, developmental defects and systemic diseases. Clinically, it may not be visible, asymptomatic before involvement of the pulp and is often a rare finding noted on radiographic examination. Effective management depends upon accurate diagnosis, assessment of true nature and accessibility of lesion. This case report discusses external cervical resorption in left maxillary central incisor of a 20 year old in which root canal treatment was done followed by placement of Biodentine in the defect area from the internal aspect of root canal. For external repair, surgical approach was performed and the defect was filled with egg-shell derived graft. Biodentin has better biocompatibility, sealing properties and it acts as substitute for dentin. Egg-shell derived graft is chemically pure form of nano-crystalline hydroxyapatite with egg-shell origin. This egg-shell graft was superior to that of other commercially available grafts due to its excellent bone formation ability. This case highlights the importance of using biodentine and egg-shell derived graft for successful management of external cervical root resorption with a stable uneventful recovery.

**Abstract 646**

**Cervical root resorption - consequence to non-vital bleaching of endodontically treated teeth: An overview**

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India

**Aim:** The present Narrative review is to find the association of external cervical root resorption following internal bleaching of endodontically treated and the barriers materials used to prevent it.

**Search Methods:** An extensive search of the literature for papers related to cervical resorption due to bleaching of endodontically treated teeth was performed on the databases of PubMed (Medline), Scopus, and Google Scholar. A total of 74 articles were retrieved from the database and 17 were included based on following criteria: Studies that evaluated the Cervical resorption due to nonvital bleaching of endodontically treated teeth and barriers materials used.

**Results:** Seventeen studies were identified and included in the present narrative review, based on which the most cited risk related to internal bleaching is external cervical resorption (ECR), which is a significant complication that could eventuate the loss of the bleached tooth. The incidence of ECR is more in teeth treated with the thermo-catalytic bleaching method and high concentration of hydrogen peroxide along with heat or etching. ECR is seen in almost 10% cases, where the potential barrier is not placed or placed improperly. It has also been speculated that the peroxide, by diffusing through the dentinal tubules, initiates an inflammatory reaction that denatures dentin.

## Abstract

**Conclusion:** Sodium perborate mixed with water is considered as the best bleaching method for endodontically treated teeth as it gives good result with very minimal or no adverse effect. Light cured composite resin, mineral trioxide aggregate, GIC type II, compomer, an ormocer, a packable composite, resin modified GIC and fuji triage are some of the materials used as the barrier. Among these materials Fuji Triage satisfies the criteria proposed for an ideal intraorifice barrier. Hence, use of effective gingival barrier is a prerequisite for clinical success as it prevents the leaching of the bleaching agents into the periodontium during the clinical procedures.

### Abstract 647

#### Comparative evaluation of microleakage of endodontic sealers under a stereomicroscope: An *ex vivo* study

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This study will evaluate microleakage of endodontic sealers under stereomicroscope using 2 sealers:

1. MTA
2. Apexit

**Materials and Methods:** 40 Freshly Extracted Human Permanent Mandibular First and second Premolars were collected from the Department of Oral & Maxillofacial Surgery, Seema Dental College & Hospital. Clinical crowns were sectioned at the cemento-enamel junction using a high speed airoter handpiece. The working length were determined by subtracting 0.5 mm from length at which a no. 15K file appeared at the apical foramen. The root canals were biomechanically prepared by using step-back technique and were obturated with gutta percha using the lateral condensation technique. The sections will be then examined under stereomicroscope (40X magnification) to evaluate dye penetration. The samples were then be immersed in 1% methylene blue at room temperature for 72 h, 96 h and 1 week. The teeth were sectioned buccolingually. The dye penetration were measured in millimeter. After completion of the study, all the data were collected and subjected to Statistical Analysis.

**Results:** The statistical analysis showed that the MTA group showed the least dye leakage as compared to the Apexit group.

**Conclusion:** Bio ceramic sealers being hydrophilic show better sealing ability compared to resin based sealers.

### Abstract 648

#### Demystifying artificial intelligence in restorative dentistry and endodontics

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Artificial intelligence is a broad inter-disciplinary field of science and engineering concerning logic, cognitive psychology, statistics, decision theory, linguistics, neuroscience, computer engineering, and cybernetics. Present generation of human-safe robots are able to work with human co-workers by relieving them of laborious and tedious routine tasks, thus offering a high degree of performance

and economical relevance. Dentistry, being a unique profession and extremely demanding, requires knowledge and precise clinical skills. Thus, it is moving ahead towards new era of a data-driven, robot-assisted medicine which provides multiple opportunities for assistive work and automation of simple tasks, supporting the dental staff while improving quality of treatment. In restorative dentistry and Endodontics too, artificial intelligence and robotics aims to aid in various realms. It is being used for magnification and X-ray imaging radiographs to accurately locate caries prone areas of tooth and complex periapical pathologies, define boundaries of lesions more precisely, detect and characterize proximal caries, which may often go un-detected. It can aid in analyzing the life span of different restorative materials and successfully locate the minor apical foramen thereby strengthening the accuracy of working length. Although, there are still major challenges and limitations being faced to achieve this, it does form a promising area in enhancing treatment quality. Artificial Intelligence-based applications will be able to provide treatment at lower costs for a broader population and eventually facilitate predictive, preventive, personalized, and participatory dentistry. More effort and research still needs to be done in order to create value to this field. The pace of innovation in this novel field should be accelerated in the coming years and future endodontists need to be familiarized with digital and real-world human-robot interaction skills, as and when developments take place. This succinct paper provides an overview of existing applications, limitations and concepts of future possibilities of artificial intelligence and robotics in the field of restorative dentistry and Endodontics, thus aiming to provide the community with novel technological developments.

### Abstract 649

#### Root resorption: A review

**TANU YADAV**

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Dentists often come across certain ailments which defy all the scientific logic and remain unexplained. Root resorption is one such ailment which is of concern to the dentist in general and the endodontist in particular. Tooth resorption is a perplexing problem for all dental practitioners. Dental resorptions constitute a challenge to dentistry due to the organic complexity that such processes unchain. It is a condition associated with either a physiologic or a pathologic process resulting in the loss of dentin, cementum, or bone. The course of tooth resorption involves an elaborate interaction among inflammatory cells, resorbing cells, and hard tissue structures. It is more prevalent in cervical area of the tooth where it presents as 'pink spot'. Root resorption can be either dental or non-dental origins and it can be internal or external resorption. Dental cause can be infective/inflammatory, pressure caused by orthodontic treatment. Non dental cause can be Herpes zoster infection, neoplasia and cysts of the jaws and systemic disorders. Separating root resorption of non-dental origins from that of dental origins is important because the treatment of non-dental types will usually require medical therapy while those of dental origins will necessitate traditional dental therapy. Cone

Abstract

beam computerized tomography (CBCT) is a more powerful tool which allows an earlier and more accurate diagnosis of these lesions. Thus, this review paper discuss the various forms of root resorption, its etiologic factors, diagnosis and recent advances in treatment plan.

**Abstract 650**

**Comparative evaluation of coronal microleakage in teeth with different intraorifice barriers under stereomicroscope: An ex vivo study**

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**Aim:** To evaluate and compare the intra-orifice sealing ability of two experimental materials after obturation of the root canal system under Stereomicroscope.

1. MTA
2. Flowable composite

**Methods:** Forty freshly human extracted mandibular premolars were collected from the Department of Oral & Maxillofacial Surgery, Seema Dental College & Hospital.,randomly divided into 2 groups (n=20). Coronal access was achieved, cleaning and shaping procedure was carried out using Hyflex EDM file and obturated using gutta-percha. Gutta-percha was removed to a depth of 3.5 mm from the orifice. MTA and Flowable Composite were placed as intraorifice barriers. Specimens were submerged in a vacuum flask containing Methylene Blue dye and allowed to remain for 7 days. Specimens were longitudinally sectioned and leakage was measured using stereomicroscope (10X).

**Results:** MTA exhibited less microleakage than Flowable Composite.

**Conclusion:** MTA showed significantly less microleakage when compared with Flowable composite.

**Abstract 651**

**A review of comparative evaluation of conventional periapical radiograph and cone-beam computed tomographic for endodontic evaluation**

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In endodontic diagnosis, radiology plays an essential aids in planning and execution of the endodontic treatment. The superimposition of structures can be overcome with the help of CBCT in endodontics. Two dimensional images do not allow to detect additional number of root canals with consequences on the success rate. Some anatomic structures can obscure the area of interest causing a difficult radiological interpretation of the images. With the introduction of CBCT in dentistry it permits us to have a detailed three-dimensional evaluation of the teeth, maxillofacial skeletal region, and relation among anatomical structures. The CBCT in endodontics not only gives a three-dimensional evaluation but also appropriate resolution of images that allows a detailed analysis of tooth and surrounding alveolar anatomy in three dimensional view. CBCT can be a powerful instrument in endodontic diagnosis, as well as in the treatment planning and follow-up.

**Abstract 652**

**Comparative evaluation of the shear bond strength of different core build up materials: An ex vivo study**

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**Aim:** To evaluate and compare shear bond strength of two experimental materials.

1. Paracore
2. Multicore

**Methods:** Forty extracted permanent human mandibular premolar teeth were chosen, cleaned with ultrasonic scaler and stored in distilled water at room temperature for 7 days. The teeth were sectioned horizontally with a carborandum disk beneath the dentinoenamel junction to expose the coronal dentin surface and later finished with silicon carbide paper to create a uniform flat surface. The teeth were mounted in custom-made wax molds by auto-polymerizing. The teeth were then randomly assigned to two groups on the basis of material used (Group A- Paracore, Group B- Multicore each group consisting of twenty samples. These were initially light-cured for 10 s per surface to initiate polymerization and to achieve final set, left for 8 min for auto-polymerization. The molds were disassembled and were stored at 100% humidity at 37°C. Finally, the samples were subjected to SBS test using Universal Testing Machine.

**Results:** The statistical analysis showed that Muticore is better than Paracore.

**Conclusion:** MultiCore dual-cure resin based core build-up material showed the highest mean shear bond strength as compared to ParaCore.

**Abstract 653**

**Nonsurgical root canal treatment of teeth associated with large periapical abscess using a bio-ceramic based sealer**

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Periapical abscess is among the most common pathologies in endodontics. It is usually associated with peri-radicular bone alterations, which could be identified in periapical X-rays. The treatment of periapical abscess has always been an important occupation in the modern practice of endodontics. Research has described a success rate of up to 87%, and the failure has been associated with non-hermetic root canal filling. Sealing ability and bioactivity are interesting properties to enhance the success of root canal treatment. Bio-ceramic based sealers have been incorporated into endodontic practice to improve the outcome of root canal treatment. This case report discusses the nonsurgical root canal treatment (RCT) of teeth associated with large periapical abscess using a single-cone and a bio-ceramic based sealer.

**Abstract 654**

**Advances in endodontic instruments**

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Conventional endodontic treatment has become more efficient and predictable since the introduction of NiTi rotary file instrumentation in the 90s. due to the superelasticity of the alloy, NiTi files allow for improved tracking around curvatures of canals compared to stainless steel hand files. In addition, NiTi files are associated with significantly faster canal preparation, stay centered in canal better, extrude less debris apically during preparation. The early rotary files ran in a slow speed handpiece whereas today's files can run upto 500rpm. Rotary files have improved significantly in regards to electric slow- speed handpiece, file taper, clinical technique, flute designs, metallurgy and the file designs. Therefore, improving the file efficiency and effectiveness in removing dentin within a canal. Advancements in rotary NiTi files have provided a better understanding of the effects of torsional stress and cyclic fatigue. Current advancement in NiTi files has been the development of reciprocating motion. This change has remarkably helped to reduce the number of actual files needed to properly prepare a root canal system and demonstrated significantly less cyclic fatigue stress on the file during clinical usage. The aim of this paper is to review the advances of NiTi endodontic instruments with an emphasis on metallurgical, mechanical properties, the design features of each generation with a special focus on the latest generation of NiTi instruments.

**Abstract 655**

**Trunatomy – A new minimally invasive single file rotary system**

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Root canal therapy requires effective shaping to facilitate irrigation and disinfection of the canals. This should be done in such a conservative manner that the structural integrity of the tooth is respected and dentin is preserved where possible. In particular, removing structural integrity and preserving peri-cervical dentin are key factors that determine the long-term prognosis (relating to fracture resistance) in these teeth. Recently, Trunatomy (Dentsply Sirona Maillefer, Ballaigues, Switzerland), a new generation of rotary files has been launched. Trunatomy files are slim and highly flexible, designed to shape root canal systems to a continuously tapering preparation with maximum preservation of peri-cervical dentin while following the natural anatomy of the root canal system. This review paper describes design features, fatigue resistance, torsional resistance, and guidelines for use of the Trunatomy file system.

**Abstract 656**

**Antimicrobial efficacy on enterococcus faecalis in curved root canals by different irrigation techniques: An *in vitro* pilot study**

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**Aim:** To compare the antimicrobial efficacy on Enterococcus Faecalis (E.faecalis) in curved mesiobuccal roots of maxillary molar by Ultrasonic, EndoVac and Photodynamic therapy.

**Materials and Methods:** This is an invitro study. Thirty maxillary first molars with curved mesiobuccal roots were used. After instrumentation, root canals were inoculated with E.faecalis (ATCC 29212). The tooth samples were divided into three groups (n= 10): Group 1 – Ultrasonic irrigant activation, Group 2 – EndoVac and Group 3- Photodynamic therapy with diode laser. All the samples were irrigated with 5.25% sodium hypochlorite and 17% EDTA. Reduction in the E.faecalis colony forming units were assessed by comparing the counts both before and after the irrigation. The tooth samples were then split into two halves to access the smear layer at coronal, middle and apical thirds of root canals using scanning electron microscopy. Statistical analysis was done by Kruskal Wallis test.

**Results:** Significant reduction in E.faecalis counts were noted in all groups (P<0.05). Ultrasonic irrigation (99.98%) exhibited greatest reduction in the E.faecalis count followed by EndoVac (99.96%) and Photodynamic therapy (99.51%). There was no statistical difference between the three groups in removing smear layer from coronal and middle third of the root canals. However, EndoVac (mean score- 2.4±0.51) showed better removal of smear layer in the apical third than Ultrasonic (2.7±0.48) and Photodynamic therapy (2.8±0.42).

**Conclusion:** This study concluded that activation of sodium hypochlorite by Ultrasonic and Endovac exhibited better antimicrobial activity against E.faecalis than the photodynamic therapy with diode laser.

**Abstract 657**

**Successful retrieval of metal post using ultrasonics and nonsurgical retreatment of maxillary central incisor: 18 months follow-up**

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Removal of different materials from the root canal in a failed endodontic treatment is a prime requisite for endodontic retreatment. Complete removal of the materials such as gutta percha, broken instruments, or post is of particular importance for accessing endodontic space, cleaning, shaping, and disinfection of the root canal system. Intra-radicular post removal poses a challenge to the clinician with associated risks. This report describes the successful removal of metal post using ultrasonics and non-surgical retreatment of a maxillary central incisor. A 45-year-old male patient presented with a complaint of pain in relation to 11. The patient reported that the tooth was endodontically treated 30 years back. Upon clinical and radiographic examination, it was found that root canal filling was present and a metal post was placed associated with periapical radiolucency. Local anesthesia was administered, and a rubber dam was placed. The metallic post was removed using Ultrasonic and after thorough debridement, calcium hydroxide was placed as intracanal medicament. The patient was followed up periodically and once reduction in the periapical radiolucency was noted,

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obturation was done followed by placement of a fiber post. Patient was followed up for six months. Radiographic examination was done during the follow-up period of 2,4 and 6 months. Successful post removal is possible only if there is proper operator judgment, training, experience, and most importantly the clinician's ability to use the available instruments in a clinical setup. Clinicians need to weigh risk versus benefit for every treatment decision that is made so they may best serve the patients who entrust them with their care.

### Abstract 658

#### Regenerative endodontic therapy on a traumatized immature maxillary central incisor with periapical lesion using platelet rich fibrin – An eighteen month follow up

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**Background:** Revitalization or regenerative therapy in teeth with incomplete root formation and pulp necrosis has become part of the therapeutic endodontic spectrum and should be regarded as an alternative to regular apexification. Revascularization may be considered because the stem cells present inside the canal and Apical papilla stem cells may help in the closure of the open apex by differentiating into cells required for root formation.

**Case Description:** This case report describes a 14-year-old female patient with an immature non-vital Right Maxillary Central Incisor with a grade I mobility and apical pathology, which was treated via revascularization using 1.5% NaOCl and 17% ethylene diamine tetraacetic acid as irrigants; triple antibiotic paste as intracanal medicament and platelet-rich fibrin (PRF) as the scaffold. After 3-months, the clinical examination revealed a reduction in mobility to physiologic level, negative responses to percussion, and palpation tests. 6-month, 1-year, and 1.5-year radiographic examination revealed regression of the periapical lesion and increased root wall thickness.

**Conclusion:** Based on the follow-up of this case report, it can be concluded that regenerative endodontic therapy using PRF can be a viable treatment option for necrotic infected immature teeth.

### Abstract 659

#### Comparative evaluation of apically extruded debris using three niti rotary file systems in severely curved canals: An *in-vitro* study

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**Aim:** To evaluate and compare the apical extrusion of debris during root canal preparation in severely curved canals using three NiTi rotary file systems: ProTaper Gold, NeoEndo Flex and NeoEndo S.

**Materials and Methods:** Sixty six extracted permanent maxillary molars were selected. Teeth with severely curved mesiobuccal canals (having more than 25° curvatures according to Schneider's technique) were selected. Mesiobuccal root was resected using diamond disk

to obtain a standardized 14mm root length. Working length for each specimen was determined using #10 K-file. Initial weight of an uncapped Eppendorf tube was determined with an analytical balance accurate to 10-5 g. A modified experimental model designed by Myers and Montgomery was used to assess the amount of extruded debris through apical foramen after instrumentation. Samples were randomly allocated to three experimental groups (n = 22) according to the file systems used as: Group – I: ProTaper Gold, Group – II: NeoEndo Flex and Group – III: NeoEndo S. Samples in each group were prepared according to manufacturers' recommendation. Double distilled water was used as an irrigant during canal preparation. After instrumentation, debris extruded through the apex was collected in the Eppendorf tube. Samples were kept in an incubator at 70°C for 5 days to evaporate the irrigant. Post instrumentation weighing was performed using the same weighing procedure used for initial weighing. The value in grams of extruded debris was obtained by subtracting the initial mean value from the final mean value of Eppendorf tube. Obtained data was statistically analyzed using One way ANOVA test.

**Results:** Samples in group – II extruded the least amount of debris which was comparable to group – III. Group – I samples led to significantly higher debris extrusion than the other two groups (P<0.05).

**Conclusion:** ProTaper Gold, NeoEndo Flex and NeoEndo S file systems led to apical debris extrusion during preparation of severely curved mesiobuccal canals. NeoEndo Flex and NeoEndo S file systems extruded significantly less debris than ProTaper Gold file system.

### Abstract 660

#### Comparative evaluation of surface changes on gutta-percha cones treated with different herbal disinfectants: A scanning electron microscopic study

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**Context:** Sterilization of gutta-percha (GP) cone plays a crucial role during root canal obturation and it is mandatory for successful root canal therapy. In literature various disinfectants have been used including herbal solutions such as aloe vera and lemon grass oil which are very effective for disinfection of gutta-percha. It is necessary to have hermetical seal between gutta-percha cone and sealer for successful obturation. This is possible only if surface changes of gutta-percha are less after its disinfection. There are very limited studies for evaluation of surface changes in gutta-percha cones after disinfection with different herbal disinfectants.

**Aim:** The aim of this study was to analyze surface topography of gutta-percha cones after rapid chemical disinfection with 5.25% sodium hypochlorite, 96.30% aloe vera gel and 100% lemon grass oil.

**Materials and Methods:** 28 GP cones of size F3 protaper were taken from a sealed packet and were divided into four groups containing 7 GP cones in each group. The groups were as follows: Group 1- Control group, Group 2- Sodium hypochlorite, Group

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3- Aloe vera gel, Group 4 - Lemon grass oil. GP cones from each group were immersed in the respective disinfectant solution for 1 minute and then observed for surface topographic changes under scanning electron microscope. Statistical analysis was carried out using Chi-square test to compare the results between the groups. P value <0.05 was regarded as statistically significant.

**Results:** Results of the study showed that least surface changes in gutta-percha were seen with aloe vera gel as compared to sodium hypochlorite and lemon grass oil.

**Conclusion:** Within the limitation of the study, it is concluded that even though lemon grass shows high antimicrobial activity it is not as safe as aloe vera as it causes high surface changes in gutta-percha after disinfection. So, aloe vera gel can be considered as a safer alternative for gutta-percha cone disinfection.

### Abstract 661

#### Gentle wave system - An innovative minimally invasive approach to root canal disinfection

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Successful endodontic therapy aims to remove vital or necrotic tissue and irritants from the root canal system and enhance healing. Hence, optimal root canal cleaning and disinfection are essential to achieve faster healing of periradicular tissue and successful endodontic therapy. Complex anatomies like curved apical third, narrow isthmi, apical deltas, ribbon-shaped and oval canals present within the root canal system are known to contribute to endodontic failure which provide challenges during detection and navigation which ultimately lead to debris and bacteria unknowingly remaining, even after chemomechanical endodontic therapy. It is well accepted that current cleaning and shaping procedures cannot reach all the intricacies of the root canal system. As such, chemomechanical preparation and instrumentation do not completely eradicate the tissue or microbiota present in the anatomic complexities of the root canal system. Currently, an endodontic therapy has been reported to meet the demands for a more effective method of debridement and disinfection of the root canal system. GentleWave system, the innovative endodontic therapy, is designed to deliver distilled water, sodium hypochlorite (NaOCl), and ethylenediaminetetraacetic acid (EDTA) throughout the root canal system using advanced fluid dynamics, acoustics, and tissue dissolution chemistry. Utilizing multisonic ultracleaning, the Gentle Wave system debrides and disinfects areas of the root canal system often untouched or undetected by standard techniques. It provides pulp tissue dissolution of eight to ten times faster than ultrasonic devices and needle irrigation without extrusion at apex. To use the GentleWave System, the teeth have to be only minimally instrumented. Clinical study showed 97% of successful healing in the teeth treated with the GentleWave System. This paper highlights the mechanism of Minimum Invasive Irrigation process via Gentle Wave system which will provide a new ray in root canal disinfection.

### Abstract 662

#### Management of instrument separation – An endodontic challenge: A case series

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Complete cleaning and shaping of the entire root canal system is a very important objective for a successful outcome of root canal therapy. However, unpleasant accidents or mishaps, such as the separation of endodontic instruments, may occur during this step. The separation of endodontic instruments is a procedural problem creating a major obstacle to normal routine therapy. The separated instrument, particularly a separated file, leads to metallic obstruction in the root canal and impedes efficient cleaning and shaping. It influences the final outcome of root canal therapy. Management of separated endodontic instruments is a delicate and challenging process. It is generally accepted that the optimum management strategy is the removal of the separated instrument to enable sufficient debridement of the root canal system. Many techniques, devices, instrument systems, and methods have been used in the last several decades such as wire loop technique, canal finder system, micro-forceps grasping technique, softened gutta-percha technique, Masserann technique, Feldman and coauthors technique, Meitrac Endo safety system, the instrument removal system (IRS), the endo rescue, endo extractor system. Another effective method for removal of the separated instruments is the braiding technique which involves the use of several Hedstrom files inserted along the length of the instrument and the files are twisted to grasp it and then withdrawn as one unit. It has been used successfully over the past few decades. The ultrasonic technique involves the generation of ultrasonic vibrations. However, specially designed ultrasonic tips are currently used. Ultrasonic is one of the most common techniques. The combination of ultrasonics with magnification provided by a dental operating microscope has made the removal of separated instruments more predictable. The following case series describe various cases in which a combination of braiding and ultrasonic techniques were used to remove separated instruments from the root canal.

### Abstract 663

#### Sterilization in endodontics

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With the whole world looking at eradication of existing infectious diseases and preventing any new infections, sterilization of instruments is significant to ensure optimal patient care. Endodontics is the aspect of dentistry involved in the treatment or precautions taken to maintain the vital pulp, moribund tooth, or non-vital tooth in the dental arch. Reuse of instruments in dentistry is common and endodontic treatment involves the use of instruments which are usually reused. During endodontic instrumentation, vital tissue, dentin shavings, necrotic tissue, bacteria, blood, blood by-products, and other potential irritants

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are encountered with accumulation of the debris on the flutes of the instruments. Transfer of these debris from patient to patient and to dental staff is highly undesirable, as these debris can act as antigens and infecting agents capable of transmitting diseases. In the absence of adequate infection control procedures, there is a high probability of transmitting pathogenic microorganism through endodontic instruments. Reusable instruments can be a source of infection for the professional, and if sterilization and disinfection procedures are not correct, patients may be exposed to an infectious risk too. Cross contamination can place a dentist at serious risk of contracting illness. Hence the sterilization of instruments in endodontic dentistry is required to protect patients and oral health care staff from cross contamination through instruments. Our primary concern should be to reduce the possible transmission of infectious disease such as HIV, hepatitis B, and hepatitis C. Successful endodontic treatment relies primarily on bacterial control. Moreover healing may be compromised even due to minimal bacterial contamination. So it is very important for endodontic instruments to be cleaned, disinfected, and sterilized effectively. Today the universal norm is if you can sterilize an instrument, sterilize it, otherwise dispose it off.

**Abstract 664**

**Magnification: A boon to dentistry**

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Enhancing the visualization of dental professionals is a core focal point that can help clinicians to generate better outcomes, master even highly complex cases, to gain greater enjoyment and satisfaction from their work and finally – but most importantly – improve patients' outcome. Introduction to microsurgical principles in dentistry has led to surpass outcomes. Thus endodontics have also developed new techniques for the root canal treatment to amplify the surgical visualization. By this endeavour where magnification devices like surgical microscopes, endoscopes and magnifying loupes have added a boon to the operator for the convalescent visualization. Optical Magnification has expanded the horizons of the dentistry as a whole. Several dentists have used and are using microsurgical principles to enhance visual activity and the accuracy of existing surgical techniques to widen the scope of dentistry with the knowledge adopted from medicine. Thus, the use of magnification devices in restorative dentistry and endodontic dentistry requires precise motor skills along with the keen visual acuity. Many options are available in trade to improve visual acuity from simple loupes to surgical microscopes. Each one of them has its own advantage as well as limitations but they all have led to improved accuracy beyond unaided vision. The high-power magnification that is the 4x to 6x or more provides enhanced visual information for diagnosing and treating dental pathologies when compared with the unaided vision and with the entry level of 2.5 X magnification. In various areas of general dentistry, the enhanced visual detail which is provided by higher magnification eliminates the bewilderment in diagnosis and treatment planning, improve control

in treatment delivery, permits the dentist to provide restorations with more ergonomics and it enhances the clinical outcomes when compared to clinical work which is performed with unaided vision.

**Abstract 665**

**Broken instrument retrieval: Endodontics rescue hour**

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India

The success of root canal therapy depends upon the astute cleaning and shaping of the intricate canal anatomy. Separation of endodontic instruments may hinder such goals, potentially impacting the outcome of treatment. A broken file often occurs in the presence of difficult canal anatomy, seen mostly in the posterior teeth. Factors like poor access, small canal diameter, torturous canal regions as well as sharp curvatures can contribute to this common mishap. Both hand instruments and machine driven NiTi files can potentially break owing to fatigue. Treatment recommendations in such instances include retrieval or bypassing of the separated fragment. However, these decisions are subject to the separated file's visibility, its location the canal and the remaining root structure. Furthermore, ardent procedure such as this often requires special assistance because of the risk of complications involved such as apical displacement of the separated fragment beyond the apex, risk of root fracture due to aberrant stress upon remaining dentin, root perforation as well as the occurrence of a ledge. The ever evolving discipline of endodontics has made several advancements in terms of the techniques and the tools making separated instrument retrieval, not just a possibility but a predictable treatment choice. Such novel approaches including the use of ultrasonics, microtubes, plier devices under the assistance of a microscope to facilitate visibility and maximize illumination. Hence the purpose of this poster is to compile such novel methods and bring them to the mainstream of clinical dentistry.

**Abstract 666**

**Radix entomolaris and paramolaris: A case series with clinical implication**

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A clinician should have complete knowledge about anatomic variations, the external as well as internal anatomy of the tooth which is essential for a successful root canal treatment. Successful endodontic treatment includes locating the root canal orifice, chemo-mechanical cleaning, and shaping the root canals before placement of a dense root canal filling with a fluid-tight seal. Anomalies in the teeth are often encountered which poses difficulties in dental treatments. As in any other teeth, mandibular molars are also prone to anatomic malformations. Anatomical variations have been described in mandibular first molars, including the number of root canals or the number of roots. An additional third root, first mentioned in the literature by Carabelli, is called the Radix Entomolaris (RE) and is located distolingually in mandibular

Abstract

molars, mainly first molars. An additional root, mesiobuccally is called the Radix Paramolaris (RP). According to Trautman EK et al. incidence of RE is less than 5% for mandibular first molars. Visser's prevalence was 0% for the mandibular first and 0.5% for the mandibular second molars. This case series focuses mainly on the diagnosis and management of various root canal anatomies like Radix Entomolaris and Radix Paramolaris in mandibular molars.

**Abstract 667**

***In vitro* comparison of fracture resistance of immature teeth following apexification using two different bioactive materials**

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**Aim:** To compare the fracture resistance of immature teeth subjected to apexification with two different bioactive materials.

**Materials and Methods:** Thirty non-carious, single-rooted premolar teeth with straight canals were collected for the study. The samples were decoronated at cemento-enamel junction, standardizing 13 mm length. Access preparation was performed and the canals were accessed with #10 K-file. Biomechanical preparation was done using Ni-Ti ProTaper rotary files upto F3. The canals were irrigated using 2 mL 2.5% NaOCl, 17% EDTA and 5 ml of saline. To simulate immature roots with open apices, #1-5 Peeso reamers were passed through the apex enlarging to 1.5 mm diameter (#5 Peeso reamer). Later, samples were randomly divided into 2 different groups, Group I: Biodentine apical plug and Group II: GuttaFlow Bioseal apical plug. Samples were filled from the apex using Biodentine and GuttaFlow BioSeal to make an apical plug of 5mm. After 24 h, remaining part of the root canals was obturated with gutta-percha cones and AH Plus sealer by lateral condensation. To stimulate periodontal ligament lining of the root surfaces, C-Silicone light body impression material was used. The samples were stored for 1 week in 100% humidity at 37°C to ensure that the sealer set in an environment that simulate the clinical situation. Later, fracture resistance was evaluated using the universal testing machine with the speed of 0.5mm/minute.

**Results:** Group I (Biodentine) showed statistically significant higher fracture resistance when compared to Group II (GuttaFlow Bioseal).

**Conclusion:** Biodentine shows higher fracture resistance as compared to GuttaFlow Bioseal when used for apexification.

**Abstract 668**

**Retrieve to achieve**

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File separation inside the root canal has become a common error in endodontics. The separated instrument, particularly a broken file, leads to the root canal obstruction and prevents thorough cleaning and shaping procedures. There can be continuous pain or discomfort if the cleaning and disinfection of the involved tooth is restricted by the separated instrument. This clinical case report series describes

the use of two techniques for endodontic file retrieval from the root canal and management technique for instrument retrieval.

**Abstract 669**

**Comparative evaluation of the apical sealing ability of lateral condensation and single cone technique (with guttaflow bioseal): An *in vitro* study**

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**Aims and Objectives:** To evaluate and compare the apical sealing ability of cold lateral condensation and single cone technique with flowable gutta percha (GuttaFlow bioseal).

**Materials and Methods:** Thirty extracted mandibular premolars were collected and decoronated at the cemento-enamel junction to obtain a 16 mm long root. Access preparation was performed using an endo-access bur. Glide path was determined by inserting #10 K and working length was established. Biomechanical preparation was done using rotary Ni-Ti ProTaper Gold files and irrigation was performed with 3% sodium hypochlorite, 17% EDTA and normal saline. Teeth were equally divided into two groups and obturated Group I: Cold lateral condensation (n=15), Group II: single cone technique with flowable gutta percha (Gutta-Flow bioseal) (n=15). Samples were placed in 2% methylene blue dye for 72 hours. All the roots were sectioned longitudinally with a diamond disc under continuous water-cooling. Both sectioned surfaces were then directly examined under a stereomicroscope at 0.8X magnification. The linear extent of dye penetration was measured in millimeter from the apical end of the preparation.

**Results:** Group I showed more dye penetration when compared with Group II and the difference was statistically significant (p<0.05).

**Conclusion:** Gutta-Flow bioseal when used in combination with Guttapercha cone has the good apical sealing ability and shows promise as an obturation technique.

**Abstract 670**

**Effect of calcium hydroxide and triple antibiotic paste intracanal medicaments on human apical papilla cells survival: A systematic review**

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**Aim:** To evaluate and compare the effect of calcium hydroxide and triple antibiotic intracanal medicaments on the survival of human apical papilla cells.

**Methods:** The literature search was conducted using electronic databases such as PubMed, Cochrane database, EMBASE, Web of science and Google Scholar from January 2000 to December 2020 using appropriate key words. Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 statement was followed throughout

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the study. Two independent reviewers were involved in the study selection, data extraction, screening and summing-up the included studies and disagreements were solved by the third reviewer. One hundred and twelve articles were identified after applying limits. Around 36 studies which were duplicates, irrelevant and repeated, case series and case reports were eliminated. Seventy-six articles were obtained and were individually evaluated if they fit into the eligibility criteria and 64 articles were eliminated after reading their titles and abstracts. After the full text assessment 4 articles were excluded and finally 8 studies were included. Quality appraisal was checked using ROBINS-I tool.

**Results:** The included studies had low and moderate risk of bias. Both the medicaments have influenced the survival, proliferation and attachment on various concentrations.

**Conclusion:** Both calcium hydroxide and triple antibiotic paste have direct and indirect effects on human apical papilla cells on concentration dependent manner. Calcium hydroxide has positive effect on human apical papilla cells survival and attachment when compared to triple antibiotic paste.

#### Abstract 671

##### Endodontic retreatment in maxillary permanent anterior tooth with custom metal cast post and zirconia crown: A case report

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**Background:** Retreatment is usually indicated in inadequate endodontic treatment where contamination of the canals by remaining infected necrotic tissue, microorganisms, and their by-products occurs. This causes continuous irritation to the periradicular tissues resulting in endodontic failures.

**Case Report:** a 56 years old male patient reported to Department of Conservative Dentistry, Universitas Airlangga Dental Hospital with a complaint of pain in right upper anterior tooth with unaesthetic appearance, sometimes it feels tender, and that tooth have been previously treated. Radiographic examination revealed underfilled canal and presence a diffuse periapical lesion. The remaining coronal structure was less than 25% or <3-4 mm from cervical level. Treatment plan of retreatment followed by custom metal cast post and core (NiCr alloy) with zirconia crown was made. Custom metal post and core has been chosen because they fit to the root configuration, adaptable to large, irregularly shape canals and orifices, and strong because the post and core forming in a single unit. Zirconia is polycrystalline ceramic with no glass component with better aesthetic value, mechanical properties and biocompatibility than other ceramics, that will reinforce the tooth, and transmit the forces on the core to the root. Case management: tooth #11 non-vital and treated with endodontic retreatment with remove an old post and crown, glide path, canal preparation using crown down pressureless technique, obturation, and installation of post and crown as the final restoration. The case with the follow up result in 5 weeks after retreatment, patient has no complaint, size of periapical lesion is smaller and crown in a good condition.

**Conclusion:** Endodontic retreatment with custom fabricated post and core with crown as a final restoration provides good result to restore the esthetics and function of maxillary anterior tooth.

#### Abstract 672

##### Green tea and cocoa pod husk extract mouthwash as a prophylaxis endodontic treatment

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**Background:** Endodontic treatment is a dental procedure in which the damaged pulp of the tooth is removed and the inside areas are filled and sealed. The failure of endodontic treatment can be caused by bacterial contamination. Mouthwash is one of the oral prophylaxis that can reduce bacteria in the oral cavity. Biofilms make bacteria more resistant to antibiotics and environmental changes due to the presence of extracellular polysaccharides (EPS) matrices. Mouthwash can be used to inhibit the formation of biofilms. Green tea and cocoa pod husk are widely known to contain polyphenols which have antibiofilm ability.

**Purpose:** To determine the effect of green tea and cocoa pod husk extract mouthwash as a prophylaxis in endodontic treatment.

**Materials and Methods:** Experimental study using the *S. mutans* biofilm was divided into 5 groups: (1) group with no extracts, (2) mouthwash base group, (3) 0.1% chlorhexidine gluconate group, (4) green tea extract group, and (5) cocoa pod husk extract group. Each mouthwash was put into sterile 96-well flat-bottomed plastic tissue culture plate and incubated for 8 minutes at 37° C followed by washing the microtiter plate with PBS four times. Furthermore, staining of 0.1% crystal violet and alexa dextran fluorine 647 were used to measure biofilm density as seen from optical density (OD) and biofilm thickness using Confocal Laser Scanning Microscope (CLSM).

**Results:** The group treated with chlorhexidine, green tea, and cocoa pod husk had lower EPS biofilm thickness values than the negative control group and the base mouthwash group. The percentage value of inhibition of the biofilm chlorhexidine group, green tea extract mouthwash, and cocoa pod husk mouthwash is 71%, 47% and 64.5%.

**Conclusion:** Green tea and cocoa pod husk extract mouthwash can reduce the density and thickness of EPS *S. mutans* biofilm where cocoa pod husk extract mouthwash is more effective in reducing the density and thickness of the EPS *S. mutans* biofilm compared to green tea extract mouthwash.

**Funding source:** The Government of Indonesia through Institution of Research and Technology, Airlangga University.

#### Abstract 673

##### Barricading the estuaries

**SRIKANTH RENIKINDHI, L KRISHNA PRASADA,  
MK RAMYA**

Abstract

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One of the keys to successful root canal therapy is to adequately obturate the prepared root canal space. Obturation of the canal system has historically been achieved with core material and a sealer. Root canal obturation aims to provide a complete filling of the canal in all dimensions to create a hermetic apical seal to prevent ingress of bacteria and their toxins and their flow into the periapical tissues. After an effective microbial-control phase, an adequately prepared and filled canal should contribute to a high probability of success. Obturation plays an important role in the success of the Root Canal Therapy. The complete sealing and filling of the cleaned and shaped root canal system are important steps that can affect the long term success of root canal treatment. To achieve 3D seal of the root canals there are many different obturation techniques which include Single-cone technique, Multiple-cone technique, Chemo-plasticized gutta-percha, Thermo-plasticized injectable gutta-percha obturation, Paste-only root fillings, SPAD/resorcinol formaldehyde. All these techniques have their own merits and demerits because of this it is been difficult to stick to one particular technique. This review paper stresses on different obturation techniques and their possible ways of obtaining air tight seal.

#### Abstract 674

### Management of retreatment and bicuspidization in tooth with endodontic failure and perforated in furcation area: Case series

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**Background:** Present of periapical lesion and complaint from patient after endodontic treatment is an endodontic failure, that is needed to do retreatment. The purpose of retreatment is to relieve the patient complaint, retain the tooth in oral cavity as long as possible, and the tooth is able to function effectively. In the case which associated with furcation area is needed to do surgical treatment, namely bicuspidization. Bicuspidization is a procedure split the tooth vertically from furcation and leave two roots separately. The purpose of this treatment is to facilitate patient to maintain oral hygiene.

**Objective:** This case report describes the procedure of retreatment and bicuspidization in tooth with endodontic failure and perforated in furcation area.

**Case Report:** A 48 years old male patient reported with complain that frequent bleeding in his mandibular left molar which had endodontic treatment but uncompleted one year ago. On clinical examination, there was a deep caries perforation without restoration. On radiographs, it shows that the tooth #36 has perforated in furcation area. Case management: Retreatment and bicuspidization was performed to retain the tooth #36. Root was separated to be mesial and distal. When control there was asymptomatic and no complaint was found, then the fabricated fiber post was installed. Crown restoration using Porcelain Fused to Metal. Retreatment and bicuspidization produces a satisfying result, since in control 2 weeks post insertion crown tooth #36

there was no complaint from patient, on clinical examination, percussion and bite test was negative, good condition of crown, and gingiva was in normal condition.

**Conclusion:** Retreatment can be performed on tooth with endodontic failure and bicuspidization is one of the alternative treatments to evade extraction to tooth with perforated in furcation area. Additionally, bicuspidization is afford to restore the tooth function optimally and facilitate patient to maintain oral hygiene effectively.

#### Abstract 675

### An overview on the factors influencing the fracture resistance of endocrown

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**Aim:** The present narrative review focuses on the factors that have to be taken into account while choosing endocrown as a post endodontic restoration.

**Search Methods:** An extensive search of the literature for papers related to endocrown was performed on the databases of PubMed (Medline), Scopus and Google Scholar. A total of 60 articles were retrieved by using the keywords out of which 18 articles were included based on the inclusion criteria: 1) Studies evaluating at least one of the following factors about endocrown: Intra-coronal depth of pulp chamber, crown thickness, type of material used for fabrication, form of finish line and shape of the preparation; 2) Studies performed in vitro, in silico, or in vivo; 3) Case reports; 4) Systematic reviews.

**Results:** Eighteen studies were identified and included in this narrative review, based on these studies it can be inferred that the intra-canal extensions decrease the marginal and internal adaptation of the endocrowns, the increase in crown thickness leads to stress and deformation of the restoration. Incorporation of shoulder finish line and certain grooves helped to enhance the fracture resistance and survival of the endocrown and among the materials used for fabrication Lithium Disilicate is considered superior due to its excellent esthetic property, low plaque retention and good biocompatibility.

**Conclusion:** Endocrowns appear to be a valuable option for endodontically treated posterior teeth with extensive loss of coronal structure and a thorough knowledge of the factors influencing the strength of endocrown helps the clinician to decide the best possible restoration that would enhance the overall clinical performance.

#### Abstract 676

### Denigrating the canal demon: *Enterococcus faecalis* – A review

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*Enterococcus faecalis* (E.faecalis) is the predominant bacteria responsible for the failure of root canal treatment and persistent infections. Thus eliminating the pathogen pertains to the greater success of treatment outcome. There are different irrigants that

Abstract

are being used in the devastation of the E.faecalis. It spans from the common irrigant sodium hypochlorite to the modern day advanced irrigants which incorporates nano- particles in them and also the development of traditional herbal formulations to be used as irrigants. The complex root canal anatomy which makes the endodontic instruments unreachable is compensated by the use of irrigants. These irrigants have the property of penetrating even the minute anatomical defect that may be enlacing pathogens and there by destruction of same. Thus selection of irrigants become crucial in the elimination of E.faecalis which is said to be resistant to most of the irrigants. This review paper focuses on the role that each irrigant play on purging the canal demon – E. Faecalis.

### Abstract 677

#### Conservative access cavity preparations: Boon or bane: A review

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An appropriate access cavity is imperative for a successful endodontic treatment. It is the first step in root canal treatment which helps in efficient cleaning, shaping and obturation of the canal. The access cavity preparation should provide adequate access to the canal and conserve the sound tooth structure. Conventional access cavity preparation can result in loss of dentin and anatomical structures such as cusps, marginal ridges and pulp chamber floor leading to unnecessary weakening of the tooth structure and decreased fracture resistance of tooth. With the recent advances in magnification, endodontic instrumentation, obturation and the emerging concept of minimally invasive dentistry, lead to conservative access cavity designs. These design aim to preserve sound dentin and some part of the pulp chamber roof, thereby increasing the fracture resistance of teeth. However, these access cavity designs possess several demerits which impedes in proper instrumentation of the canal and raising the probability of treatment failure. This review paper describes various conservative access cavity designs, their efficacy, fracture strength, remaining dentin thickness and their influence on the outcome of the treatment.

### Abstract 678

#### Comparative clinical evaluation of efficacy of conventional Ca(OH)<sub>2</sub> and TheraCal LC for indirect pulp capping in deep carious lesion: A randomized, parallel group clinical trial

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**Aim:** To evaluate and compare the efficacy of light cure Calcium Hydroxide and TheraCal LC as Indirect Pulp Capping Materials in patients with deep carious lesion.

**Materials and Methods:** This randomized, parallel group trial. 28 patients were randomly divided into two groups (n=14).

Group A was managed by TheraCal LC(a fourth generation calcium silicate cement) while Group B was treated with light cure calcium hydroxide. Clinical examination was done to check for postoperative pain, tenderness, neural sensibility and radiographical examination was done to check for PDL space widening, presence of calcific barrier and periapical radiolucency at patient recall of 21days, 3 month and 6 months. The primary and secondary outcome variables was based on clinical and radiographical success rates noted from the 6 month follow-up that was conducted.

**Results:** The success rate for light cure CH group(Cal LC) at follow up came out to be 0% at 21days, 85.71% at 3-months and 92.85% at 6-month. And the success rate for TheraCal LC group came out to be 0% at 21days, 92.85% at 3-months and 100% at 6-month. The overall success rate for Indirect Pulp Capping procedure was 89.28% at 3-months and 96.42% at 6-months follow up for both the groups (Chart 1). The difference was statistically non-significant at the end of 3-months and 6-months follow up(P>1).

**Conclusion:** Within the limitations of the study, as per our observation, it was concluded that TheraCal LC can be used alternatively with light cure CH in IPC, with a predictability of similar success outcome in patients with deep carious lesions.

### Abstract 679

#### 3D geometric analysis of second mesiobuccal canal in permanent maxillary first molar teeth

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**Topic:** 3 D geometric analysis of second mesiobuccal canal in permanent maxillary first molar teeth

**Objective:** To establish a correlation between the depth of occurrence of the second mesiobuccal canal (MB2), its position, and root canal configuration (RCC) of the corresponding root in permanent maxillary first molar teeth.

**Materials and Methods:** 330 cone-beam computed tomographic (CBCT) scans (voxel size  $\leq 0.125$ mm) of maxillary first molar teeth with an MB2 canal were included. The sagittal section was used to determine the depth of occurrence of MB2, i.e. the distance between the pulpal floor and the level at which MB2 was first visualized in the axial section. To determine the position of MB2 in relation to the mesiobuccal (MB) and palatal canals (P), the respective inter orifice distances (IOD) were determined. In the axial section, the separation (S) was measured i.e. the perpendicular from MB2 to the line connecting MB and P. RCC was determined according to Vertucci's classification. To determine the correlation between the depth and position of MB2, the Pearson correlation coefficient was applied. The student t-test was used to determine the association between these parameters and RCC (Vertucci's Type II and Type IV).

**Results:** The mean depth of occurrence of MB2 was  $1.69 \pm 0.86$  mm. The average distance between MB-MB2 and P-MB2 was  $2.18 \pm 0.58$  mm, and  $4.63 \pm 1.06$  mm respectively. The separation (S) was  $1.02 \pm 0.37$ mm. No significant association between depth of

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occurrence and MB-MB2 IOD was established. Depth of occurrence had significant correlation with P-MB2 IOD ( $r = 0.696$ ,  $P < 0.001$ ) and S ( $r = 0.174$ ,  $P = 0.001$ ). The predominant RCC was Vertucci Type II (75.5%). The mean MB-MB2 IOD was  $2.12 \pm 0.57$  mm and  $2.39 \pm 0.6$  mm with Type II and Type IV RCC, respectively ( $P = .0006$ ).

**Conclusion:** There is a significant correlation between the depth at which MB2 occurs and its position. There is a strong association between the IOD of MB-MB2 and Vertucci's RCC in the permanent maxillary first molar teeth.

### Abstract 680

#### Reducing the production of potentially infectious aerosols during an endodontic procedure in a dental office during the present COVID-19 pandemic

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Covid- 19 pandemic has changed the functioning of the whole world and the field of dentistry is not exempted from the pandemic as well. The endodontic procedures involve procedural grinding of the tooth. This leads to the production of aerosols contaminated with microorganisms of the patients mouth along with the corona virus in case of covid-19 infected individuals. The corona virus remains airborne for 8 to 14 minutes and for three hours on the surface aerosols. It stays for about four hours on copper, 24 hours on the cardboard pieces, and for 3-4 days on plastic and stainless steel. Maximum amount of splatter and aerosols is produced by high speed hand pieces in a dental office. The particles of size less than  $0.5 \mu$  are produced during an endodontic procedure in greater amounts. Ultrasonic and sonic instruments tend to create the maximum number of particles for transmission when compared to the surgical and prosthetic processes. The ultrasonic instruments can transmit 100 thousand (105) microbial particles per cubic foot. These microbes can reach up to the height of 6 feet in the form of aerosol and remain in the surrounding in the absence of proper air flow for 17 hours. Any particle of size less than  $10\mu$  cannot be filtered by the nose and can easily enter the respiratory tract. As the covid- 19 diseases is often left undetected in many patients due to absence of symptoms, false negative reports of RTPCR and rapid antigen test, the dental office acts as a harbor of the corona viruses. Thus, endodontists need improved and functional options in order to control and limit the spread of the diseases between each other and among the patients. This review paper aims on explaining the possible methods for reducing the amount of airborne microorganisms specially corona virus during a non- surgical endodontic procedure from the dental office other than the traditionally used rubber dams or dental dams.

### Abstract 681

#### Cacao pod and green tea extract as a biocompatible root canal irrigants

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**Background:** Maximum result of the endodontic treatment depends on appropriate instrumentation and effective irrigation as a step of cleaning and shaping of the root canal. Irrigation and selection of its materials is one of the keys to achieve a success endodontic treatment. Reactive Oxygen Species (ROS) is the outcome of a cellular redox process that has a significant role in the tissue inflammation and acute infection. In the cacao pod and green tea, there are antioxidant components such as flavonoids, polyphenols and phenols acid which will arrest various kinds of free radicals and dramatically weaken the production of inflammatory cytokines so that it is expected to be used as a treatment for pulp inflammation. They also have power as a biocompatible intracanal irrigants to support the endodontic treatment achieve an excellence result.

**Purpose:** This study aims to describe and explain the extract of cacao pod and green tea as a biocompatible root canal irrigants.

**Methods:** This study was a laboratory experimental study using a post test only control group design. The antioxidant strength of cacao pod extracts and green tea extracts, as well as the combination of both were tested by DPPH, then the data obtained on the absorbance measurement in the spectrophotometer determined the IC50 value expressed in parts per million (PPM).

**Results:** The IC50 value of the green tea is 9 ppm, the cacao pod extracts is 58.5102 ppm, and the combination of the two extracts is 19.3439 ppm.

**Conclusion:** The best antioxidant strength owned by green tea by inhibiting 50% of DPPH radical at 9 ppm.

### Abstract 682

#### Polymeric scaffolds of dental pulp tissue engineering: A review

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The most desired outcome of endodontic treatment would be when diseased or non-vital pulp is replaced with healthy pulp tissue that would revitalize the teeth through regenerative endodontics. Scaffold, stem cells and bioactive molecules such as growth factors are three essential elements of tissue engineering strategy. Stem cells are a population of undifferentiated cells characterized by the ability to extensively proliferate (self-renewal), usually arise from a single cell, and differentiate into different types of cells and tissue. Scaffolds and biomaterials provide a meaningful approach to better incorporate stem cells and growth factors along with controlled rate of regeneration. Multiple methods of scaffold design exist for pulp tissue engineering that provide a three dimensional structural framework which can support cell organization and vascularization. Injectable scaffolds are appealing for tissue regeneration because they offer many advantages over pre-formed scaffolds. Regenerative endodontics aims to regenerate dental pulp like tissues using

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two possible strategies- cell transplantation and cell homing. The purpose of this review is to describe the evidence based tissue engineering strategies that have the potential of restoring not only dental tissue function but also their biological purposes.

**Abstract 683**  
**Artificial intelligence in endodontics: Current applications and future directions**

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The term “artificial intelligence” (AI) refers to the idea of building machines that are capable of performing tasks that are normally performed by humans. In the last seven decades AI and its applications were regarded both as Boon and Curse to Society. However, during last decade major advancements in AI lead to impact in every part of the society especially Health care systems and Dentistry is one among them. AI has immense capability to replicate human intelligence and performs complex decision making in healthcare, especially in endodontics for precise detection, determination and disease prediction. AI not only contribute to improvement in diagnosis but also in treatment related aspects that can lead to success in Endodontic treatment outcomes. This review article is mainly aimed at verifying the reliability of AI in day to day practice of endodontics & further discuss its potential future applications.

**Abstract 684**  
**Can vertical root fractures be fixed?**

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Traumatic dental injuries have been projected as the fifth most prevalent disease worldwide. In a global systematic review by Petti et al., the estimated number of individuals, from 7 to 65 years of age, with injured permanent teeth was approximately 900 million. Crown fractures and luxations of these teeth are the most commonly occurring of all dental injuries. Proper diagnosis, treatment planning, and follow up are important for achieving a favorable outcome. Guidelines should assist dentists and patients in decision making and in providing the best care possible, both effectively and efficiently. Root fracture involves dentin, cementum and the pulp. They can be further classified based on the type of displacement of the coronal fragment. VERTICAL ROOT FRACTURE can present difficulties in diagnosis. these are, however many specific clinical and radiographical signs which, when present, can alert clinicians the existence of a fracture. As the tooth presents poor prognosis, the most common treatment modality is extraction. One can save the tooth from extraction by the reconstruction of fracture fragments followed by intentional reimplantation. In this review presentation, the diagnosis of vertical root fractures will be discussed in detail, and examples are presented of clinical and radiographic signs associated with these fractured teeth. Treatment alternatives for both anterior and posterior are discussed.

**Abstract 685**  
**Management of subgingivally fractured maxillary tooth by multidisciplinary approach: Case report**

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Dental trauma is very common. Crown fractures represent the majority of dental trauma in the permanent dentition. Complicated crown-root fractures require a multidisciplinary approach, for long-term success. The major challenge in traumatic injuries is the management of subgingival fracture of anterior teeth. Orthodontic extrusion is a suitable approach for these teeth as it provides both a sound tissue margin for final restoration and creates a periodontal environment (biological width) which is easy for the patient to maintain. Restoration after orthodontic eruption may present a more conservative treatment choice in patients compared with the prosthetic restoration after extraction. This paper reports a case of the fractured maxillary anterior tooth at the subgingival level that was managed by orthodontic extrusion after endodontic therapy followed by aesthetic rehabilitation. The pulp was widely exposed and therefore endodontic treatment was necessary. Orthodontic extrusion was decided and it was achieved using bracket and elastics. This was followed by crown lengthening procedure to maintain level of gingival zenith, followed by fiber post placement and PFM crown. Patient is kept under clinical and radiographic follow up.

**Abstract 686**  
**Single file Ni-ti rotary systems: Boon or bane: A review**

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In the published literature, the concept of single file rotary systems remains controversial. Cleaning and shaping the root canals, being the utmost important step for successful root canal treatment, has caused an outstanding display of files for negotiating and shaping canals. The shaping of root canals was conventionally achieved with the use of carbide steel hand files. Endodontics witnessed the first change in shaping instruments for root canal treatment with the introduction of stainless-steel hand files. However, procedures using stainless steel hand files have a lot of drawbacks. As stainless-steel hand files are repeatedly used, it requires repeated sterilization. Hand instrumentation using stainless steel hand file is time-consuming and tiresome, has high chances of canal transportation and cross-contamination and is challenging in teeth with less accessibility. Nickel Titanium rotary shaping files have been a game-changer in endodontics as the procedure of shaping the root canals in root canal treatment has become a lot easier and a lot less tiring. These are very time effective and reduces the chances of cross-contamination. Single file Ni-Ti rotary systems have been introduced that claim complete shaping of the root canal with a single file. Recently introduced Single file Ni-Ti rotary systems are: (1) Wave-One Gold; (2) Self Adjusting File [SAF]; (3) Reciproc Single Files; (4) T File; (5) One Shape; (6) F 360. The purpose of this article is to review the recently introduced Single File Ni-Ti Rotary Systems.

### Abstract 687

#### Nonsurgical endodontic retreatment of anterior teeth with large canal followed by anatomical fiber post and lithium disilicate bridge: Case report

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The incidence of initial endodontic treatment failure is about 14 – 16%. Endodontic retreatment is considered when there is a persistent of periradicular infection from previous treatment. Non-surgical endodontic retreatment is the first treatment choice to overcome a nonhealing periradicular lesion of unsuccessful initial endodontic treatment, because it is a minimal invasive procedure that can cause fewer traumas than surgical treatment. Reintroduction of microorganism to the canal is primarily caused by coronal leakage. In cases of endodontic treatment failure due to coronal leakage where the previous treatment was still in good standard and there were no signs of significant periradicular abnormalities, a non-surgical endodontic retreatment and planning for a new definitive restoration were highly recommended and had a high success rate. This case report discusses about a non-surgical endodontic retreatment of anterior teeth with large canal followed by anatomical fiber post and lithium disilicate bridge as the new definitive restoration.

### Abstract 688

#### Comparison of apical debris extrusion by several heat-treated endodontic nickel-titanium reciprocating instrument systems

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**Aim:** To evaluate the amount of apical debris extrusion during the instrumentation with three heat-treated single reciprocating file systems with and without preceding engine-driven glide path instrumentation.

**Materials and Methods:** Sixty distobuccal roots of maxillary molars with a single canal and curvature of 0 to 20 degree were collected. The roots were randomly divided into three groups of reciprocating file systems. Each group was subdivided into 2 groups of with and without its preceding glide path instrumentation (n = 10). Three reciprocating file systems for the canal preparation were Reciproc® blue file and its path file, R-Pilot™, WaveOne® Gold and its path file, WaveOne® Gold Glider and EdgeOne Fire™ and its path file, EdgeOne Fire™ Glide Path. During canal preparation, apically extruded debris was collected in the pre-weighted Eppendorf tube according to the Myers & Montgomery method. After canal preparation, the tubes were dried by using an incubator at 70°C for 5 days and weighed by an electronic balance. The amount of apically extruded debris was statistically analyzed using Kruskal-Wallis test with multiple comparisons test from the window-version SPSS was performed to analyze the result of this study and the statistically significant level was set at  $P < 0.05$ .

**Results:** All groups showed certain amount of extruded debris.

There was no significant difference in the amount of debris among three reciprocating file systems without preceding path file instrumentation ( $P > 0.05$ ). There was no significant difference in the amount of debris among three reciprocating file systems with preceding path file instrumentation either ( $P > 0.05$ ). However, there was statistically significant difference between the grouped average of without preceding path file and the grouped average of with preceding path file instrumentation ( $P < 0.05$ ).

**Conclusion:** The amount of extruded debris in groups with preceding path file instrumentation was less than that of groups without path file. When heat-treated single reciprocating file systems are used, it can be recommended to prepare the root canal after preceding path file instrumentation to reduce apical extrusion of debris.

### Abstract 689

#### Comparative evaluation of pH and solubility of three root perforation repair materials at 24 h and 7 days: An *in vitro* study

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**Background:** MTA, Biodentine and BioRoot RCS are used for repair of iatrogenic perforation made during non surgical endodontic treatment. According to the ANSI/ADA specification number 57 and ISO standardization number 6876, an ideal root canal sealer should demonstrate a weight loss of less than 3% mass fraction after immersion in water for 24 hours. An alkaline pH inhibits the growth of microorganisms and facilitates the deposition of calcium and phosphate ions.

**Objective:** Evaluation of pH and solubility of MTA, Biodentine and BioRoot RCS at 24 hours and after 7 days.

**Methodology:** Samples of 4mm height and diameter (measured with digital caliper) were prepared using a template of polypropylene mold from each of MTA, Biodentine and BioRoot RCS. The weights were recorded using a precision balance with accuracy of .001 gram. The experimental samples so prepared were immersed in deionized water maintaining 100% humidity in incubator at 37°C.

Experiment 1:-

The pH of the samples were measured after 24 hours and 7 days. Same samples were used throughout the study.

Experiment 2:-

Fifteen samples of each of MTA, Biodentine and BioRoot RCS were taken out, dried with absorbent paper, dehumidifier and desiccator, and were weighed at 24 hours and after 7 days. Fresh samples were taken for the two time intervals. The percentage of solubility were determined by

$(IM - FM) \times 100 / IM$  (Initial weight = IM Final weight = FM)

**Results:** of the data and statistical analysis: - Sample size estimation was done by using GPower software (version 3.0). Datas were statistically analyzed by F test and ANOVA ( $P < 0.001$ ). MTA showed highest pH at 24 hours and after 7 days. BioRoot RCS showed highest solubility at 24 hours and Biodentine showed highest solubility after 7 days.

**Conclusion:** In this study, MTA showed highest pH after 24 hours.

Abstract

BioRoot RCS had highest percent solubility after 24 hours. After 7 days, MTA showed highest pH. Highest percent solubility after 7 days was shown by Biodentine.

**Abstract 690**

**Management of deep carious lesion in permanent teeth**

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Management of carious lesion involves removing soft demineralized dentin, but there are chances of iatrogenic exposure of pulp during caries removal. As per the current recommendation, stepwise caries removal has been recommended for permanent teeth with a deep carious lesion to overcome this. Stepwise caries removal involves a two-step procedure for carious tissue removal before the final restoration is placed. Stepwise caries removal can be considered in the deep carious lesion in permanent teeth to preserve the pulp vitality.

**Abstract 691**

**Radical method of fiber-post cementation: A pushout bond strength analysis**

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**Aim:** To analyze and compare the pushout bond strengths of two different core buildup materials in cementing two fiber posts.

**Materials and Methods:** Forty single-rooted mandibular premolars were decoronated, endodontically treated, post space prepared, and randomly assigned to one of the following four groups: Group I: RelyXTM 3D Glass fiber post luted with LuxaCore Z Dual Group II: RelyXTM 3D Glass fiber post luted with CosmeCore Group III: Tenax trans fiber post luted with LuxaCore Z Dual Group IV: Tenax trans fiber post luted with CosmeCore Pushout bond strength was evaluated in a universal testing machine for each of the  $2 \pm 0.5$  mm sections obtained from the samples (total 80 sections).

**Statistical Analysis:** One-way ANOVA and post hoc tests were used for statistical analysis.

**Results:** RelyXTM 3D Glass fiber post cemented with LuxaCore Z Dual group showed the maximum pushout bond strength. Tenax trans fiber posts cemented with CosmeCore showed mean pushout bond strength almost equivalent to RelyXTM 3D Glass fiber posts cemented with LuxaCore Z Dual. The lowest mean pushout bond strength was exhibited by Tenax trans fiber posts cemented with LuxaCore Z Dual. However, there was no statistically significant difference between the groups.

**Conclusion:** Both Luxacore Z Dual and CosmeCore, Dual cure resin based core buildup materials, are equally effective as luting agents and can be used for cementation of fiber posts simultaneously when used as core buildup materials to create a true monobloc effect.

**Abstract 692**

**Effect of negative pressure irrigation on the postoperative pain in the teeth with symptomatic irreversible pulpitis: A systematic review and meta-analysis**

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**Objective:** The present systematic review aimed to compare the effect of irrigation delivery methods using apical negative pressure preventing the apical extrusion of the irrigant compared with methods using positive pressure and the severity of postoperative pain in mandibular molar teeth with symptomatic irreversible pulpitis after root canal therapy. The systematic review and meta-analysis have been registered in the PROSPERO with registry number: CRD42020221285.

**Materials and Methods:** An electronic search was conducted from January 2000 to October 2020 in PubMed, PubMed Central (PMC), EMBASE, Scopus, EBSCO Dentistry, Cochrane Library, DOAJ, LILAC, Ovid medicine, Web of medicine along with manual search. A total of four clinical trials that met all inclusion criteria were included in the systematic review. The primary outcome is the reduction in postoperative pain after negative apical pressure irrigation techniques. Postoperative pain evaluation carried using pain scales like VAS at different time intervals [from 6 hours till the seventh day] after root canal therapy.

**Results:** In the included four trials, three studies were judged as medium risk and one as low risk of bias using the Cochrane risk of bias tool. The included articles concluded that the use of negative apical pressure resulted in significant reduction of postoperative pain levels compared to conventional needle irrigation. The meta-analyses showed a statistically significant ( $p < 0.0001$ ) difference in the reduction of postoperative pain with negative apical pressure with a standard mean difference at a 95% confidence interval was  $-0.67 [-1.03, -0.32]$ .

**Conclusion:** This systematic review and meta-analysis is scientific evidence emphasizing that apical positive pressure irrigation caused greater postoperative pain after endodontic therapy of mandibular molar teeth with symptomatic irreversible pulpitis compared with the apical negative pressure irrigation system.

**Abstract 693**

**Potential association of serum vitamin D levels with nonsurgical periapical healing: A cross-sectional study**

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**Introduction:** Vitamin D is required for normal bone metabolism. Its deficiency is a global public health issue that has a negative impact on osseous healing. The study aimed to assess the serum vitamin D level in patients undergoing nonsurgical endodontic therapy (NSET) and observe its potential association with periapical healing.

**Methods:** Records of subjects who underwent a standard two visit NSET between January to December 2019 in mature permanent anterior teeth and completed one-year follow-up were identified.

## Abstract

A total of 189 subjects were enrolled. The radiographic healing was evaluated using pre and post-PAI scores. Biochemical estimation was performed for serum vitamin D, intact parathyroid hormone (iPTH), calcium, inorganic phosphate, and alkaline phosphatase levels. The scores and the corresponding biochemical data were statistically analyzed.

**Results:** The serum vitamin D level was deficient in 77.25% of the total subjects. (n=146). Among vitamin D deficient subjects, 10.96% (n=16) had severe, 33.5% (n=49) had moderate, and 55.48% (n=81) had mild deficiency. The percentage of healed teeth were 58.9% (n=86), 38% (n=13), and 44% (n=4) in Vitamin D deficient, insufficient, and sufficient subjects, respectively (p=0.07). Vitamin D deficient subjects had significantly higher serum iPTH levels (p=0.01). No significant difference was established in the levels of serum calcium (p=0.22), inorganic phosphate (p=0.5) and alkaline phosphatase (p=0.84).

**Conclusions:** Vitamin D deficiency has a high prevalence rate in subjects who underwent NSET. No association was established between serum Vitamin D level and periapical healing at one-year follow-up.

### Abstract 694

#### A novel approach for vital pulp therapy

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Vital pulp therapy is an important alternative to root canal treatment. It mainly helps in preservation of pulp and its functions and hard tissue. Materials are invented from conventional calcium hydroxide to newer materials like bio dentine. But every materials has its own challenges in vital pulp therapy and its success rate. Platelet rich fibrin is used in regenerative procedures because it contains rich number of the growth factors like transforming growth factor beta 1, platelet derived growth factors and vascular endothelial derived growth factor Which mainly helps in stimulation of stem cells for formation of odontoblasts, fibroblasts and cementoblasts which in terms leads into formation dentin, cementum and pulpal tissue. Because of this properties it may be used in vital pulp therapy for dentine bridge formation and also helps in healing of pulpal tissue. For this further histological studies are required. This is a case report of 18 years old patient compliant of carious tooth, upper left back quadrant. asymptomatic, on clinically examination –class 1 deep caries lesion in relation to 26, radio graphically shows caries proximity to pulp, planned for deep excavation and with adding PRF followed by bioactive material-MTA and restored with GIC done follow up done tooth was asymptomatic and vital. Therefore we conclude that within the limitation of study PRF application in operative dentistry considered as an inexpensive alternative to recent available materials in pulp capping treatment during vital pulp therapy.

### Abstract 695

#### Comparative evaluation of smear layer removal efficacy of three different types of irrigating solutions with single file system: An *in vitro* scanning electron microscope study

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**Aim:** To compare the effectiveness of three different irrigating solutions (NaOCl+ EDTA, REMIX 2 IN 1, TWIN KLEEN) on the removal of smear layer with single file system (XP-Endo Shaper) in mandibular premolars using a scanning electron microscope.

**Materials and Methods:** Thirty-three human single rooted mandibular premolar teeth were selected and decoronated to a standardized length. Biomechanical preparation was done with a single file system (XP-Endo Shaper) using 3% NaOCl as an irrigant during instrumentation. Teeth were randomly divided into 3 experimental groups, with eleven teeth in each group (n=11) and final irrigation was carried out with a 30-Gauge side vented needle. In Group I - (control group) 5.25% Sodium Hypochlorite (NaOCl) and 17% ethylenediaminetetraacetic acid (EDTA), Group II - REMIX 2 IN 1 solution (Neelkanth healthcare, India), Group III - freshly prepared TWIN KLEEN (Maarc dental, India) solution. The teeth were split into two halves and the half containing the greater part of the apex was selected. Observed under a scanning electron microscope at 3mm, 6mm, and 9mm from the apex to analyze the amount smear layer in 1000X. Scoring was done using a 5-grade scoring system given by Hulsmann et al. Data obtained were analyzed using the Kruskal–Wallis test and Mann–Whitney U test.

**Results:** On comparing the three different irrigating solutions, there was no statistically significant difference found in terms of the ability to remove smear layer from the coronal and middle third (P>0.05). Group I (1.14±0.68) and Group II (1.18±0.40) showed significantly higher smear layer removal in the apical third when compared to Group III (1.81±0.60)

**Conclusion:** Sequential use of 5.25% NaOCl + 17% EDTA and REMIX 2 IN 1 solution were found to be the most efficient than TWIN KLEEN solution in the removal of smear layer in the apical third of root canals instrumented with single file system (XP-Endo Shaper).

### Abstract 696

#### Various anaesthetic techniques to deal with hot tooth

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A tooth that is difficult to anaesthetize is known as hot tooth. The term “hot” tooth generally refers to a pulp that has been diagnosed with irreversible pulpitis, with spontaneous, moderate-to-severe pain. Symptoms of a hot tooth might include dull ache, extreme sensitivity to hot or cold lingering pain after removal of a stimulus, spontaneous pain, or referred pain. The hot tooth appears when the chronic inflammation of the pulp progresses into an acute exacerbation (flare up). This results in edema and increased pressure on the nerve fibres, which show symptoms like discomfort and pain. Why is it difficult to anaesthetise a hot tooth-the most accepted and recent theory for this is the TTX-resistant channels theory. According to this theory, in case of inflammation, neuroinflammatory reactions start and sodium channel expression

Abstract

on C fibers shifts from TTX sensitive to TTX resistant creating inflammatory hyperalgesia. One of the clinically significant characteristics of these Na<sup>+</sup> channels are relatively resistant to lignocaine. Researchers found these channels to be five times more resistant to anesthetic than TTX- sensitive channels. After a nerve block, a patient may describe profound anesthesia of soft tissue where no inflammation is witnessed. However, entering the vital pulp chamber may initiate pain. Achieving profound pulpal anaesthesia is not only a helping hand to patients to overcome their fears and irritations towards dentistry but also supports the dentists who will be less worrying about the patient's reaction. But, achieving satisfactory anaesthesia in patients with a hot tooth, which is a tooth with irreversible pulpitis, can be a problem. Management of hot tooth includes predications, change of anaesthetic agents, change of injection techniques including intraligamentary, intrapulpal, infiltration, and intraosseous anesthesia.

**Abstract 697**  
**Minimal access cavity designs – A review**

**HIMANSHI TEHLAN**

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In the last decade, several access cavity designs involving minimal removal of tooth tissue have been described for gaining entry to pulp chambers during root canal treatment. The concept assumes that maximum preservation of pulp chamber roof during access preparation would maintain the fracture resistance of teeth following root canal treatment. Trials of more conservative access cavity designs such as contracted (a small conservative cavity on the occlusal surface that allow the clinician to access all the canal orifices), truss (a direct access from the occlusal surface to expose the mesial and distal canal orifices and leaving the intervening dentin intact), and ninja (ultraconservative approach) access cavity preparation methods have been previously reported to improve fracture resistance of endodontically treated teeth. This paper reviews the various conservative access cavity designs focusing mainly on the pros and cons of it.

**Abstract 698**  
**Guidance: A futuristic tool**

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The digital revolution is changing the world, and dentistry is no exception. The introduction of digital devices and processing software along with powerful manufacturing tools are radically transforming dental profession. Navigation is an important example of technological advancement, when applied in dentistry it is known as guided dentistry, same when applied to endodontics is called as guided endodontics. Guided endodontics allows a more predictable treatment outcome. In this 3D imaging data are used to plan an optimized minimally invasive access cavities preparation, to locate root canals and for negotiation of calcified root canals by

preservation of a significant amount of tooth substance. Though these advantages must be carefully balanced against a larger dose of radiation and higher costs.

**Abstract 699**  
**Geriatric endodontics – An overview: Diagnosis and treatment planning**

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General and oral health is a fundamental right of every human being. Oral health of patient determines the general health, and general health determines happiness in life, that brings smile. Good health is achieved by assimilation of healthy diet and this is guided by maintaining health of oral hard (teeth) and soft tissues. To lead a quality life in old age, one needs teeth for the enjoyment of food and also for proper nutrition and esthetics. There is also evidence that oral diseases impact cardiovascular, endocrine and pulmonary health particularly in the elderly, which will certainly provide additional stimuli for the elderly to seek dental care. Clinical management in elderly patients is becoming increasingly challenging as older people are aware of their health and related ailments. The challenges include biological and psychological differences from the younger patients as well as treatment complications in older population. Older adults now prefer saving their teeth at any cost. Over the years, the preservation of the natural dentition has been so successful that tooth loss is no longer accepted as inevitable. Geriatric endodontics (geroendodontics) is a branch of endodontics and gerodontology to provide elder people good-quality endodontic therapy to ensure them a better quality of oral health and overall to improve their life quality by saving teeth through endodontic treatment. It is mainly about the effect of aging on diagnosis of pulpal and periapical disease and successful root canal therapy. Endodontics treatment is less traumatic than extraction especially in older patients. This review paper describes the challenges posed upon diagnosis, treatment planning and treating the elderly endodontic patient.

**Abstract 700**  
**An everyday challenge: Endodontic management of four different types of aberrant root canal anatomy – A case series**

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Anatomical characteristics of the different types of teeth and their possible variations are challenges routinely faced by practitioners performing endodontic treatment. Studies on the internal and external anatomy of teeth have shown that anatomic variations can occur in all groups of teeth and can be extremely complex. Endodontic anomalies like middle mesial canal is sometimes present in the developmental groove between mesiobuccal and mesiolingual canal of mandibular first molar and the incidence ranges from 1 to 15%. Incidence of three canals in mandibular second premolar has

been reported to be 0.46-0.5%. Vertucci had reported an incidence of 1% of maxillary second premolars with three canals while Pecora et al reported 0.3%. The frequency of a dental anomaly like four-rooted maxillary second molar was reported by Libfeld and Rotstein to be 0.4%. Inability to locate and fill a root canal can lead to post-treatment disease. Variations of root canal morphology, especially in multirooted teeth, are a constant challenge for diagnosis and successful therapy. Therefore it is imperative that aberrant anatomy be identified prior to and during root canal treatment of teeth. This presentation of four cases discusses the management strategies for different types of aberrant root canal anatomy like presence of mid-mesial canal in mandibular first molar, maxillary second premolar with three canals, three canals in mandibular second premolar, and maxillary second molar with four roots.

### Abstract 701

#### A beacon of hope for the hopeless: hemisection: A systematic approach of tooth preservation

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Patients are becoming more educated in the available treatments and will ask for services by name. In modern dental era every person wants to preserve and retain his dentition for longer periods. As practitioners of the art and science of dentistry we owe to our patients to be able to provide a wide range of treatment options based on, the clinical situation, age, economical considerations of the patient and the best available clinical evidence of successful treatment modality. So it is necessary for us to provide an alternative way to maintain a functional dentition even for a severely decayed or compromised tooth. The loss of posterior molar can result in several undesirable sequelae including shifting of teeth, collapse of the vertical dimension of occlusion, super eruption of opposing teeth, loss of supporting alveolar bone and a decrease in chewing ability. The treatment options to replace severely damaged and possibly unrestorable teeth include removable partial denture, fixed partial denture and dental implants. A guiding principle should be to try and maintain what is present. Advances in dentistry, due to increased desire of patients to maintain their dentition, have led to development of treatment modalities that end up saving teeth that otherwise would have been removed. One such treatment option is HEMISECTION of a tooth, more specific, of a mandibular molar. The word hemisection is derived from hemi - meaning half, and sect - meaning cut. Hemisection usually denotes removal of half the tooth done in two procedures: tooth sectioning, followed by removal of one root. Hemisection of the affected tooth helps to retain the tooth structure, surrounding alveolar bone, and may also facilitate the placement of fixed prosthesis. This case series shows that hemisection can be performed as a successful treatment method to save mandibular molars that otherwise would have been removed.

### Abstract 702

#### Complications and malpractice in endodontic treatment

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The aim of this study was to help dentists to avoid harm in disputes such as malpractice cases. Nowadays, doctors can find different treatment solutions for the same diseases in their medical practice. Doctors have many responsibilities, such as law and ethics. A significant increase in the number of treatment administrations, along with an increase in the ability of access of patients to medical information that also led to evaluate the quality of the treatments. However, malpractice lawsuits filed against physicians are also increasing day by day. In dentistry, especially in the Endodontics, medical interventions include both aesthetics, operative and surgical procedures with using a wide range of drugs and different techniques. A complication is damage that may be predicted to occur before treatment, so precautions can be taken, but possibility that may not be avoided. Malpractice, on the other hand, is the practice of a doctor whose apply is incorrect medically. It is possible that the situation encountered is an error or non-detailed examination of the medical procedure. For example, it is possible that perforation of the tooth when searching for a canal after cleaning the caries with the device may be an example of malpractice, but if the same perforation occurred as a result of the sudden turning of the patient's head while precautions have been taken, it is possible that it may be considered as a complication. There is always risks in medical procedures, but reducing it is possible with preventions. Such as a careful Rubber-dam application, careful administration of anesthesia, using clean and new tools also constitute the medical standard in treatment and evaluations are made according to these standards. For this reason, complications that may occur during medical intervention or after the procedure should be well evaluated, care should be taken and precautions should be taken to prevent patient dissatisfaction or failures in the treatment process. As a result, the doctor should act within the medical standards and the medical education and ethical framework. Also should know how to intervene in a possible undesirable situation.

### Abstract 703

#### Impairment of the angiogenic process may contribute to lower success rate of endodontic treatments in diabetes mellitus

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PAULO, CATARINA CARVALHO, EUNICE CARRILHO,  
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**Objective:** To investigate the association between root canal treatment outcome, diabetes mellitus, and alterations of the angiogenic process.

**Methodology:** A retrospective observational study was conducted in healthy (control group, CG) and diabetic (type II diabetes mellitus group, DG) patients after root canal treatment. The follow-up appointments were performed to clinically and radiographically observe symptoms, the healing of periapical lesions, and the quality of root filling. In the animal model study, diabetic Goto-

Abstract

Kakizaki (GK) rats and control Wistar rats were used. After 21 days of pulp exposure and the development of apical periodontitis (AP), the mandibles were removed for scintigraphic, radiographic, histopathological and molecular analyses. Chi-square tests were performed to examine the variables related to endodontic outcome and differences between animal groups were assessed using the Student's t-test.

**Results:** The group of patients with diabetes had a significantly lower rate of success following root canal treatment than the CG ( $p < 0.001$ ). Logistic regression suggested that diabetes is a risk factor for success of root canal treatment. In the animal study, GK rats had significantly higher fasting glycemia at t0 and t21 ( $p < 0.001$ ) and triglycerides levels ( $p < 0.05$ ) and area under the curve (AUC) during the insulin tolerance test at t21 ( $p < 0.001$ ). AP area was significantly greater in GK rats ( $p < 0.05$ ). Histologically, diabetic rats had increased signs of periodontal ligament inflammation 21 days after the induction of apical periodontitis, with fibro-hyaline matrix filling and vessel with undefined walls. Wistar rats had significantly increased vascular endothelial growth factor (VEGF) levels and VEGF/Ang-2 ratio 21 days after AP induction ( $p < 0.08$ ;  $p < 0.07$ ). GK rats had intrinsically lower levels of VEGF than control rats ( $p < 0.05$ ), which did not change after AP.

**Conclusion:** Diabetes mellitus should be considered as an important factor in the prognosis of root canal treatment and its outcomes over time. Future strategies to improve angiogenesis and tissue repair should be pursued to achieve better root canal treatment outcomes in diabetic patients.

#### Abstract 704 Endodontic diagnosis

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Diagnosis is probably the first and arguably the most important step in the management of a problem. In other words, diagnosis is the keystone upon which the entire treatment plan is based. Pulp is a complex neurovascular bundle that lies at the center of each tooth. No single diagnostic tool is enough to describe the exact state of pulpal health. Correct Diagnosis is seldom based on a single observation but is the amalgamation of a good case history, in-depth clinical examination, and relevant investigations along with diagnostic tests. Time and again, various diagnostic tests have been implemented to diagnose pulpal health correctly. Unfortunately, all have failed to live up to the accuracy of histologic examination which is considered the gold standard for diagnosis. But this method is not a viable option in clinical practice. Conventional sensibility tests rely on the patient's response to a stimulus. The response is subjective and can lead to both false positive and false negative responses. The advent of new technology in dentistry has helped to shape not only new treatment modalities but has also ushered in a new era of minimally invasive diagnostic procedures. These tests are based on the tooth's own condition (e.g., vascularity) rather than the patient's response to it. This review paper gives an overview of the fundamental shift in the concept of pulp vitality and provides an insight into both traditional and new diagnostic methods.

#### Abstract 705 Maximize, to minimize - Omnipresence of magnification in modern-day dentistry

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In the world of contemporary dentistry, what sets a clinician apart is his holistic approach to the problem the patient presents to him with, which includes how well the tooth has withstood the treatment, it is provided with. An essential aspect of that is respecting the healthy tissue just as well as dealing with the diseased tissue, which will ultimately work towards providing a better quality of care to our patients. That approach has given rise to the idea of incorporating minimally invasive techniques in every aspect of treatment, be it at the diagnostic level or at the level of handling an iatrogenic complication. Since the endodontic surgical field is measured in terms of millimeters, the key to correctly carrying out the concept of minimally invasive dentistry is the use of magnification and illumination. By providing both intensely focused light as well as a high degree of magnification, devices like dental loupes and operating microscopes have developed into becoming an important part of the armamentarium for the modern Endodontist. This Review Paper delves into the close association of the concept of minimally invasive dentistry in various facets of treatment, with the aid of magnification and illumination.

#### Abstract 706 Management of dens invaginatus by using an ultrasonic device under the microscope

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Dens invagination is a developmental anomaly of teeth with unclear etiology. Endodontic treatment of teeth with dens invaginatus may have limits due to the unusual anatomy and relative inaccessibility of the necrotic pulp tissue. For successful root canal therapy, the invaginated hard tissue needs to be removed carefully. This case report presents the treatment of dens invaginatus by removal of invaginated hard tissue with the use of ultrasonic device under the microscope. Accurate diagnosis and precise treatment are important in dealing with dens invaginatus. Case Presentation An 18-year old woman visited the dental hospital with a chief complaint of pain when she pressed her gingiva on the left maxillary lateral incisor. Although gingiva swelling and palpation pain were observed during clinical examination, percussion and mobility tests were negative. The pulp vitality tests showed negative results on the cold and the electric pulp tests. Radiographic examination revealed apical radiolucency on the left maxillary lateral incisor and tooth-within-tooth appearance of dens invaginatus. Pulpal diagnosis was pulp necrosis, and periapical diagnosis was chronic apical abscess. Nonsurgical root canal treatment was initiated. A large amount of pus was discharged

Abstract

and root canal disinfection was performed after invaginated hard tissue was removed using an ultrasonic device under the microscope. After clinical symptoms were disappeared, the root canal was obturated, and apical healing was observed in regular follow-up checks. Discussion and conclusion: One of the difficulties for successful root canal treatment on dens invaginatus is the obstruction caused by complex internal anatomy of invaginated hard tissue. Enamel lining of the invagination which makes endodontic instrumentation difficult needs to be properly removed for efficient root canal irrigation and obturation. In the present case, invaginated hard tissue was removed by using an ultrasonic instrument under the microscope, which provided better access and in turn allowed complete disinfection and obturation. Also, CBCT was essential to understand the anatomical complexity of the invaginated tooth and to establish the treatment plan.

### Abstract 707

#### Evaluation of root canal morphology in central and lateral mandibular incisors using cone-beam computed tomography

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**Aim:** This study aimed to assess the root canal morphology of Mandibular central and lateral incisors with Cone-beam computed tomography in Mahabubnagar region of Telangana.

**Introduction:** Endodontic treatment must be preceded by a thorough knowledge of the anatomy of both pulp chamber and root canal system because access to the complete anatomy of the root canal system allows the eradication of microorganisms and their byproducts, therefore enhancing the treatment outcome. CBCT has been found to be useful for diagnosis of root canals morphology.

**Materials and Methods:** 100 CBCT records of patients reported to oral and maxillofacial radiology, mahabubnagar were randomly evaluated from the previous data.

The following information are be recorded

1. Age and sex of the patient
2. Number of roots
3. Root canal configuration
4. Bilateral /unilateral diversity in root number and configuration of the root canals.

The configuration of root canals were categorized using vertuccis classification.

**Results:** Distribution of single canals in both Central and Lateral Incisors was 153 which accounted for 38.25% and two canals were found in 247 which accounted for 61.75%. And based on vertuccis classification percentage of type I is 38.25%, type II is 10%, type III is 41%, type IV 1.25%, type V is 1.5%, type VIII is 8%.

**Conclusion:** Within the limitation of this study, Permanent mandibular incisors presented with two canals in about 61.75% of cases. Mandibular Central and Lateral Incisors had no significant difference between genders with regard canals Configurations. Slight bilateral asymmetries were present in both mandibular incisors which could be of Clinical significance in case of treating contralateral teeth in the same individual.

### Abstract 708

#### Knowledge, attitude and practice of general practitioners and endodontists, towards the management of acute apical abscess: A cross sectional study

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**Aim:** The aim of this study is to evaluate knowledge, attitude and practice of dental postgraduates, general practitioners, academicians, endodontists in the management of apical apical abscess.

**Methods:** The present study is a cross sectional, multiple choice questionnaire study conducted among general practitioners, academicians, and endodontists and post graduates. A total of 17 questions in the questionnaire included demographic data, assessment of knowledge and treatment protocol of Acute Apical Abscess cases. Data is gathered into spreadsheets and the form assured that the participant's identity and information given would remain anonymous and confidential. Statistical analysis is performed with SPSS 21Version software.

**Results:** Within the limitations of this study the following can be concluded:

- 1) Clinicians showed clear trend towards preserving teeth involved in Acute Apical Abscess.
- 2) Only access opening was done by majority of dentists in the first visit.
- 3) Aqueous based calcium hydroxide was preferably used by both endodontists and general practitioners.
- 4) A combination of sodium hypochlorite and saline was used for irrigation by both endodontists and general practitioners.
- 5) There is urgent need for clear guidelines that are based on scientific evidence because clinicians, especially GDPs, relied on their own experiences in managing cases.

### Abstract 709

#### "Double trouble": 3D-guided non surgical endodontic management of a complex Type III "double invagination" dens invaginatus of maxillary lateral incisor with large periapical lesion

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Dens Invaginatus is a morphological abnormality of the tooth in which the coronal tooth enamel and dentin folds inwards towards the pulp cavity. Dens Invaginatus Type III (Oehlers 1957) is characterized by infolding of the enamel and dentin as far as the root apex. Navigation and tackling of complexities which accompany cases of dens invaginatus (DI) can summon any clinician to hustle. Optimizing the boon that our technology has developed into, the field of Guided Endodontics simplifies our paths through such complex cases. This Case report presents 3D Guided Non-Surgical Endodontic Management of a Complex Oehlers Type III Double Invagination Dens Invaginatus of a Maxillary Left Lateral Incisor with an extensive periapical lesion

Abstract

with the help of a 3D- Printed Access Guide. A 36 year old male reported with a chief complain of pus discharge from upper front tooth region since 3 months. After initial radiographic examination a diagnosis of Type III Dens Invaginatus with pulp necrosis based on pulp sensibility tests was made. CBCT scans revealed to us there were 3 separate opening, with the invaginatus portion engulfed between the mesial and distal canals confluent at the apex as one single exit giving the tooth a 'Tooth-in-Tooth Appearance'. Decision to fabricate a 3D Guide was made to avoid adding any iatrogenicity and facilitate precise access to this otherwise complex anatomy. Meticulous biomechanical preparation along with chemical debridement using Ultrasonic irrigant activation helped achieved complete asepsis of this complex root anatomy. Orthograde MTA Filling in apical third was followed by thermoplasticized obturation of the remainder of the canal of tooth #22 was performed. Successful advent of healing was visible clinically as well as radiographically within a span of 15 days of post operative follow-up.

### Abstract 710

**"A nano-revolution" comparative evaluation of gold nano particles and pola office in bleaching procedures: An *in-vitro* study**

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**Aim:** To compare the efficiency of a new revolutionary material- the Gold nano particles with a commonly used clinical bleaching procedure -Pola office bleaching technique.

**Materials and Methods:** Thirty single rooted teeth are selected and divided into two groups (n=15). The teeth are stained using a standardized tobacco solution for 3 days to vita shade guide C4. The stained specimens are bleached with Pola office bleaching kit and Gold Nano particles along with hydrogen peroxide suspended in a colloidal solution. Each Specimen is bleached for a number of sessions with one session being defined as 3x10min exposure and is photo activated at a wavelength of 310nm. The visual vita shade guide is used to compare the results before and after of the two groups to determine the material that has a higher bleaching efficiency. Chi Square test is used to compare the shades of the teeth before and after bleaching procedure between the 2 groups. Marginal Homogeneity test is used to compare the shades of the teeth before and after bleaching procedure in each study group. The level of significance [P-Value] is set at P<0.05.

**Results:** Chi Square test was used to compare the Tooth shades between Pola office bleach and bleaching with Gold Nanoparticles after bleaching. Marginal Homogeneity test was used to compare the tooth shades between before and after bleaching in each study group. Out of the 15 teeth stained with tobacco 3 out of 15 teeth showed a shade change from C4-A1 in the Pola office bleaching group and 11 out of 15 teeth showed a shade change from C4-A1 in the Gold Nanoparticles group which indicates that gold nanoparticles gave a better bleaching effect compared to Pola office bleaching.

### Abstract 711

**How to deal with short clinical crown and open apex in nonvital teeth: A case report**

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Open apex commonly arises secondary to pulpal necrosis as a result of caries or trauma in an immature tooth with incomplete root formation. One of the golden choice in cases of open apex is apexification with Mineral Trioxide Aggregate (MTA). MTA is a material with excellent biocompatibility and sealing ability. This case report describes the apexification treatment using MTA on a maxillary central incisor with pulp necrosis and open apex. A 12-years-old female patient came to Dental Hospital of Hasanuddin University for treatment of a central incisor with a history of composite restoration. On examination, there were no complaints of pain. Objective examination of tooth 11 revealed a short clinical crown with fracture of old restoration till the cervical area. Tooth 21 had a discoloured old composite restoration. Radiographic examination showed a wide root canal with an open apex. A multi-visit endodontic treatment was performed with Calcium hydroxide as an intra-canal dressing followed by the application of 4 mm MTA. Restoration was done with fiber post composite crown. After follow-up there were no complaints either clinically or radiographically. This case report shows fiber post composite crown and apexification with MTA is an effective treatment for maintaining teeth with short clinical crown and open apex.

### Abstract 712

**Bioactive glass based sealers in endodontics – An overview**

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In endodontic treatment, obturation plays a very important role for the success of the treatment. The success of the endodontic treatment is largely dependent on the sealing achieved by root canal obturation. The primary functions of root canal sealer are sealing off voids between root canal walls and gutta-percha, embedding residual bacteria and filling imperfections and increases adaptation of the root filling to the canal walls of the root canal system, including small lateral canals and isthmus. If the tooth is re-infected as a result of a poorly obturated root canal, periapical periodontitis may set-in due to invading bacteria. To both avoid any re-infection and improve the success rate of endodontic retreatment, a treated root canal should be three-dimensionally obturated with a biocompatible filling material. To achieve this, a good root canal sealer should be used which has tissue tolerance, no shrinkage with setting, slow setting time, adhesiveness, radiopacity, absence of staining, insolubility to oral and tissue fluids, bacteriostatic properties and ability to create a seal. However, conventional root canal sealers based on zinc oxide eugenol, calcium hydroxide or resins, might have sealing problems due to solubility or polymerization shrinkage after setting, and hence lead to microleakage. In addition, these traditional root canal sealers

Abstract

fail to promote tissue regeneration, or even irritate periapical tissues inflammation. Bioactive glass (BG) one type of bioceramics, shows similar or better characteristics. It has displayed capabilities to form hydroxyapatite-like precipitations, biocompatibility, sealing ability, and removability. It is known to possess great ability to inhibit biofilm formation within the sealer dentin interface, reduce cytotoxicity, and improve sealability. These sealers exhibited less microleakage in comparison with ZOE, and has higher bioactivity potential which has been regarded as a promising root filling material in endodontics. This review shows the potential application of bioactive glass-based cement as a root canal filling material to facilitate the development of a new root canal sealer for endodontics. Iling material to facilitate the development of a new root canal sealer for endodontics.

### Abstract 713

#### Effect of Er:YAG laser on intrapulpal temperature changes and its efficacy upon restoration removal: An ex-vivo study

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**Objective:** The aim of this study was to assess and regulate intrapulpal temperatures produced by a high-speed handpiece and an Er: YAG laser at three different power settings and compare their efficacy during restoration removal.

**Materials and Methods:** Composite resin restorations were placed in eighty class-I cavities (Remaining Dentin Thickness= 2mm) prepared in human mandibular molar teeth, and the specimens were randomly assigned to 4 groups with two subgroups each (n=10). Restoration removal was done in Group-I (controls): high-speed handpiece with diamond bur; Group-II: Laser at 2W; Group-III: Laser at 5W; Group-IV: Laser at 8W; the subgroups involve A= Glass-ionomer cement restoration; B= Composite restoration. Thermocouples were introduced inside the pulp chamber through the furcal opening created on the samples and fixed to the vestibular wall using thermal paste. These were supported by a customized glass box with water at 37°C simulating the oral cavity, connected to a data logger and computer software for recording temperature variations. After restoration removal, the samples were assessed using a stereomicroscope.

**Results:** The data were submitted to Two-way ANOVA and Tukey's statistical test. The recordings showed that the intra-pulpal temperature increased upon using a highspeed handpiece (G-I) and Er:YAG laser at 8W (G-IV). The mean temperature rises were: 0.41°C (±0.25) for Group-I, 0.39°C (±0.26) for Group-II, 0.36°C (±0.20) for Group-III, 0.44°C (±0.31) for Group-IV; however, there is no significant difference between the groups (p>0.05). Among the subgroups, the mean temperature rises were: 0.41°C (±0.25) for subgroup-A, 0.39°C (±0.26) for subgroup-B; however, there is no significant difference among the subgroups (p>0.05). All groups tested did not have a change of temperature that exceed the threshold of 5.5°C.

G-I showed nonselective removal of restoration (A, B) along with dentin and enamel upon magnification. In contrast, laser G-II, G-III, G-IV showed selective removal of restorations. Few Glass

ionomer restorations showed carbonization of the material in G-III and G-IV.

**Conclusion:** All the above groups showed acceptable intra-pulpal temperature changes invitro. Much precise and efficient removal of restorations with minimal intrapulpal temperature change was found with Er:YAG laser at 5W.

### Abstract 714

#### Nanomaterial based photodynamic therapy against oral biofilm: A literature review

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Oral diseases such as tooth caries, periodontal diseases, endodontic infections and much more are prevalent worldwide. Biofilm growth is known to contribute to secondary caries. This heavy burden of oral infections and their impact on quality of life indicates a strong need for developing effective therapies. One of the most recent ways to counteract dental biofilm is by photodynamic therapy. The application of antimicrobial photodynamic therapy has attracted tremendous interest in the recent decade. The mechanism of action of photodynamic therapies involving chemical agents as photosensitizers, light of specific wavelength and generation of oxygen radicals and reactive oxygen species have shown to be effective against various microorganisms, however photodynamic therapy has a minimal effect on viability of organised biofilm due to its hydrophobic nature, therefore new methods have been implemented to overcome this limitation, one of those methods is to use nanoparticles and their unique attributes to combat infection have received considerable attention within a range of diverse fields, including dentistry so using nanomaterials as a mode of delivery for hydrophobic photosensitizers into microorganisms have been proven to be effective. Novel bioactive nanomaterials have demonstrated great potential to serve as carriers for photosensitizers to enhance its effect and wide range in other fields too. This review focuses on the use of nanomaterial photodynamic application against endodontic infections emphasizing on nanomaterials, photosensitizers, mechanism of action to improve understanding of nanomaterials and need for its application in dentistry.

### Abstract 715

#### Irreversible pulpitis management with one visit root canal treatment: A case report

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One visit root canal treatment has some advantages might be minimize the risk of complication. This treatment is defined as complete biomechanical cleansing, shaping, and obturation carried out in one visit. The advantage of this treatment is to reduce appointment and decrease bacterial recontamination. Irreversible pulpitis without periapical lesions, pulp necrosis with

## Abstract

asymptomatic apical periodontitis, and normal root canal anatomy can be treated with this treatment. This case report describes one visit root canal treatment on tooth 46 with diagnosis irreversible pulpitis. A 15-year-old male patient came to the Conservative Dental Clinic, Hasanuddin University Dental and Oral Hospital with a chief complain of discomfort while chewing. Objective examination revealed that the vitality test positive (+), percussion and palpation negative (-). Pre-operative radiograph showed radiolucency reached the pulp chamber and root canal appeared normal. This case was completed in one visit root canal treatment. Following one-month evaluation, there was no clinical symptoms and no abnormalities on radiographic examination. The one visit root canal treatment in irreversible pulpitis case can be successful therapy if proper diagnosis and treatment procedures are carried out.

### Abstract 716

#### Apexification with mta in anterior tooth with external resorption: A case report

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Apexification is one of the treatment procedures for young permanent teeth that undergo necrosis and open apex. This treatment is carried out by inducing the formation of an apical barrier. Natural barrier formation can be induced with Ca(OH)<sub>2</sub>, but it takes a long time and decrease root fracture resistance. Apexification by creating an artificial barrier at the apical using materials such as MTA, Biodentin, or Calcium Enriched Mixture (CEM) is currently more desirable. This case report aims to provide information about the treatment of teeth with open apex using MTA as an apical barrier. A 29-year-old woman came to the dental conservation of dental hospital Hasanuddin University, with chief complaint a fracture in her maxillary anterior teeth due to trauma when she was ±9 years old, and the discoloration of the teeth appeared. After clinical and radiographic examination, periapical lesions were found, the apex was exposed with external resorption. Root canal treatment and artificial barrier with MTA are the operator's treatment options. Control after 3 months of treatment showed periapical tissue healing and resorption did not continue. Apexification treatment with MTA in patients with open apices gave positive results, this may be due to the ability of MTA to stimulate tissue repair at the apical.

### Abstract 717

#### Apexification of left maxillary central incisor with mineral trioxide aggregate: A case report

**MUSTAKIM MUSTAFA, CHRISTINE ANASTASIA ROVANI**

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Treatment of necrotic immature teeth with open apex is a challenge for dentists. Apexification is a treatment that is carried out to induce an artificial apical barrier in the open apex area with an affective agent. MTA (mineral trioxide aggregate) is one of the best materials to cover the apex area and has good biocompatibility. The

purpose of this case report is to describe the case management of maxillary central incisors with open apex with a combination of root canal treatment, apexification, and direct restoration. A 23 years old female patient came to the Hasanuddin University Dental Conservation Clinic with complaints of discoloration of the teeth. Clinically, it appears that the tooth has been treated with composite restoration. Radiographs show an open apex. The management of the case was to perform apexification treatment with MTA material and then direct restoration with composite resin. From this case, it can be concluded that apexification treatment using MTA can form a calcification barrier with a shorter visit time with satisfactory results.

### Abstract 718

#### Irreversible pulpitis, make it simple with one visit endodontic: A case report

**ESFANDIARY EFFENDY, NOOR HIKMAH**

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Traditionally, root canal treatment is done in several visits. However, along with the times, patient comfort, time efficiency and effectiveness of treatment are the main considerations in treatment, supported by technological developments, there has been a shift in root canal treatment from multi visit to one visit endodontic. One visit endodontic is root canal treatment which includes cleaning, shaping and obturation which is done in the same visit. One endodontic visit was carried out by taking into account the selection of cases and adhering to standard endodontic procedures. This case report describes a one-visit endodontic with direct composite restoration using incremental layering technique in a female patient, aged 14 years, who came to RSGMP Hasanuddin University with complaints of cavities and pain in her lower left back tooth several months ago. Based on subjective and objective examination, the tooth was diagnosed with irreversible pulpitis. One endodontic visit was performed, root canal preparation using Protaper Next rotary instrument, irrigation with 5.25% NaOCl and 17% EDTA. Obturation with single cone technique and direct composite restoration with Incremental Layering technique. Subjective and objective examination when the control had no complaints, negative palpation and percussion, radiographic examination showed hermetic obturation and no periapical radiolucency. The prognosis in this case is good. One visit endodontic treatment with direct composite restoration with the Incremental Layering technique is an effective, efficient treatment method with a high success rate in restoring natural function and tooth morphology.

### Abstract 719

#### A multi-dimensional analysis of root canal transportation and centering ability of three single file retreatment systems: A cone beam computed tomography study

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K MADHU VARMA, R KLAYAN SATISH,  
GIRIJA S SAJJAN, VENKATA KARTEEK VARMA**

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**Objective:** To compare the Transportation and Centering Ability of M two R (Mt), Neoniti (Nn) and WaveOne Gold (Wg) systems during

## Abstract

retreatment procedure using Cone Beam Computed Tomography. **Materials and Methods:** Forty freshly extracted single rooted mandibular premolars were selected. Teeth were decoronated and were standardized to a tooth length of 15 mm from the root apex. The root canals were instrumented using Protaper rotary files. All the teeth were embedded in soft putty blocks, post-instrumentation Cone Beam Computed Tomography (CBCT) imaging was done at levels 3, 6 and 9 mm from the apex. Root canals of all the specimens were obturated with gutta-percha by warm vertical compaction technique using AH Plus sealer. Teeth were randomly divided into four groups (n = 10) for retreatment. Group I - retreatment was done using Hand instrumentation (Hi), Group II - retreatment was done using Mtwo R (Mt), Group III - retreatment was done using Neoniti (Nn), Group IV - retreatment was done using WaveOne Gold (Wg). CBCT imaging of all the teeth was repeated after the completion of retreatment procedures at same position. The centering ability and canal transportation were calculated at 3, 6, 9 mm from apex in both mesiodistal and buccolingual directions. The mean and standard deviation were calculated, and ANOVA and Post Hoc Tukey tests were used for comparative analysis.

**Results:** Significant difference for canal transportation was observed mesiodistally at 9 mm from apex ( $P < 0.05$ ) where the Hand instrumentation (Hi) removed more dentin in one direction compared to WaveOne Gold (Wg). A significant difference for centering ability was observed buccolingually at 9 mm from apex ( $P < 0.05$ ) where Hand instrumentation (Hi) was less centered in the canal compared to Neoniti (Nn) and WaveOne Gold (Wg).

**Conclusion:** Within the limitations of the present study, the tested file systems Mtwo R (Mt), Neoniti (Nn), WaveOne Gold (Wg) resulted in minimal canal transportation and the files remained relatively centralized within the root canal compared to hand instrumentation (Hi). Hence, they can be used with a minimal risk of procedural errors during retreatment in straight canals.

### Abstract 720

#### Knowledge and practice of pulp sensibility tests among general dental practitioners and endodontists

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**Aim:** The aim of this survey was to evaluate the knowledge and practice of Pulp Sensibility Tests among General dental practitioners and Endodontists

**Materials and Methods:** A cross-sectional Knowledge and practice survey was conducted for data collection. An online questionnaire was created using the "Google Forms" platform, consisting of 13 questions including multiple choice and closed ended questions. Quantitative data on clinician demography, and the knowledge and practice of Pulp Sensibility Tests was summarized. Statistical analysis was applied to determine associations.

**Results:** There were 113 respondents to the survey. The majority of participants were GDPs(71.7%) and Endodontists were 28.3%. knowledge of the majority of Endodontists was good(65.6%) with score ranging from 9-11. Knowledge of the majority of GDPs was

fair(67.9%) with score ranging from 5-8. There was a statistically significant difference in knowledge between Endodontists and GDPs ( $P = 0.00^{***}$ ), Highly significant. Participants with 10-20 years of experience are having good knowledge with score ranging from 9-11. From this study it was determined that the years of experience was significantly associated with Knowledge ( $P < 0.05^*$ ). Majority of Endodontists (65.6%) practice PSTs to assess the pulp status prior to restorative procedures. Whereas only 38.2% of GDPs practice PSTs prior to restorative procedure. There was a statistically significant difference between Endodontists and GDPs in practicing PSTs( $P < 0.05^*$ ).

**Conclusion:** From the present study, it was concluded that, only few GDPs practice Pulp Sensibility Tests in assessing the pulp status prior to the restorative procedures and knowledge was good among Endodontists and fair among General Dental Practitioners towards Pulp Sensibility Tests.

### Abstract 721

#### Human amniotic membrane in endodontics: Hype or hope?

**SRINKHALA**

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Uttar Pradesh, India

**Aim and Objective:** The aim is to review and discuss the outcome of using a bioactive resorbable membrane (Human Amniotic membrane) in regenerative endodontic procedures and as an allograft in periapical surgeries.

**Background:** Human amniotic membrane (HAM), a placental based scaffold has been extensively used in the medical field due to its cell proliferation and regeneration ability. HAM constitutes the innermost layer of placenta, composed of a single epithelial layer, thick basement membrane and avascular stroma. HAM is extensively used in the reconstruction of ocular surface, skin reconstruction, endothelial cell cultivation, local drug delivery as well as graft material after vestibuloplasty. Current research has expanded its use in the field of tissue engineering due its ability to enhance epithelization, antiscarring, and anti-inflammatory effects. The presence of collagen, elastin, laminin and fibronectin makes this membrane an excellent scaffold in tissue engineering. Contrasting to the other barrier membranes, HAM is biologically active due to the presence of growth factors (GF) that aids cell migration and facilitates wound healing. The advantage of HAM as a scaffold is its lack of immunogenicity and irradiation to remove any potential contamination. Amniotic membrane has been used clinically for guided tissue regeneration in endodontic surgery to restore the attachment apparatus of the tooth. Recent research has brought to light that HAM can be used as a cell delivery vehicle in tissue engineering.

**Review Results:** The electronic search yielded 853 results from the PubMed database; in light of inclusion and exclusion criteria, only case reports, clinical preliminaries on human amniotic membrane utilized in the field of endodontics were extracted and 7 articles met the inclusion criteria. Then, by pooling extricated information and analyzing the outcome of treatment, the reviewed information was synthesized.

Abstract

**Conclusion:** Human amnion/chorion membrane loaded with growth factors can be used to promote regeneration of healthy tissue in resolving dual endodontic problems; 1. At the time of apical surgery, when the root has lost attachment apparatus, 2. Intrapulpally, to promote revascularization of the pulp space. With the additional advantage of anti-scarring, speedy healing reduced post-operative pain.

**Abstract 722**

**Minimal invasive endodontics: A review**

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Sibar Institute of Dental Sciences, Guntur, Andhra Pradesh, India

Preserving the natural tissue for the long term survival of tooth is the principle of minimally invasive dentistry. Minimal invasive endodontics aims at salvaging the tooth structure during the endodontic treatment and its post endodontic restoration phase. The dentist needs to preserve the tooth structure during access cavity preparation, cleaning and shaping of the canal, post space preparation, and post endodontic restoration of the teeth. The concept of minimally invasive endodontics involves the preservation of healthy coronal, cervical and radicular tooth structures during endodontic procedures. These procedures can be incorporated in various phases of endodontic treatment and surgical endodontics. As Devan stated that "Our goal should be perpetual preservation of what remains rather than meticulous restoration of what is missing" which is achieved by the shift of traditional endodontics from extension for prevention to the minimal invasion with the intent to preserve healthy tooth structure. Minimally invasive approach requires knowledge of root canal anatomy, diagnosis and decision making, preservation of structural integrity of tooth, alternate access designs, image-guided endodontic access, dynamically guided endodontic access, micro-guided endodontic access, modern bur designs, cleaning and shaping, 3d irrigation, disinfection, and root strengthening. Diagnostic aids like radiographs, cone-beam computed tomography, and magnification aids such as loupes and surgical operative microscope play a pivotal role in minimal invasive endodontics. This review article discusses various procedures that can be incorporated at each step of endodontics to achieve minimal intervention, which is the primary goal of the new-age endodontics.

**Abstract 723**

**Nonsurgical management of split tooth: A case series**

**AAKASH SAHAI, AMRITA CHAWLA, AJAY LOGANI, NAVAS MOIDU, AMAL RANA**

All India Institute of Medical Sciences, New Delhi, India

A tooth is considered to be a split tooth if it contains a fracture line extending from the occlusal surface through marginal ridges. Currently, the only treatment option for a split tooth is extraction. The present case series describes a novel therapeutic strategy for the preservation of a split tooth with a fracture in the mesiodistal direction. A non-surgical procedure involving visualization and slight widening of the fracture line is described in the two cases. This procedure facilitates sealing of the fracture gap with composite resin stabilization and cuspal coverage

restoration of the tooth. This presentation of two cases discusses the management strategies for split tooth. On follow-up, clinical and radiographic examination showed satisfactory outcome. This concept, presents an alternative treatment option for preserving a crack tooth thus restoring the aesthetics and its function.

**Abstract 724**

**Effect of body temperature on the cyclic fatigue resistance of the nickel-titanium endodontic instruments – A systematic review and meta-analysis of *in vitro* studies**

**SELVENTHRA SAVITHA, SIDHARTHA SHARMA, PERUMAL VANAMAIL, VIJAY KUMAR, AMRITA CHAWLA, AJAY LOGANI**

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**Aim:** The purpose of the systematic review was to investigate the effect of body temperature (I) in comparison to room temperature (C) on the cyclic fatigue resistance (O) of nickel-titanium (NiTi) endodontic instruments (P).

**Methods:** The study was conducted following the Preferred Reporting Items for Systematic Review and Meta-analysis statement and registered in the PROSPERO database (CRD42020204286). A systematic search in the English language was conducted until June 15, 2021 in the following electronic databases: PubMed, Scopus, Web of Science, Google Scholar, Cochrane, and Open Grey. In vitro studies comparing the cyclic fatigue resistance of NiTi instruments at body ( $35\pm 2^{\circ}\text{C}$ ) and room temperature ( $20\text{-}25^{\circ}\text{C}$ ) were included. The risk of bias was assessed. Due to the lack of standardization among the cyclic fatigue testing methods, the meta-analysis (STATA version 16 software) was performed for studies that included size 25 instruments and similar testing conditions (a static stainless-steel model with  $60^{\circ}$  angle and 5 mm radius filled with water). Effect size (mean difference) and 95% confidence interval (CI) was estimated using the random-effect model with restricted maximum likelihood (REML) method. A subgroup analysis was carried out based on the instrument motion (rotary or reciprocating).

**Results:** The search resulted in 343 studies, out of which 23 studies met the inclusion criteria. The meta-analysis was performed in six studies (= 17 groups). The overall effect sizes (2001.8; 95% CI: 847.8-3155.9) were highly significant ( $P<0.001$ ), indicating that the mean values were significantly ( $P<0.001$ ) higher at the room temperature. The sub-group analysis by motion showed that the overall effect size of rotary instruments (mean difference: 1616.7; 95% CI: 77.9-3155.6) and reciprocating instruments (mean difference: 2707.3; 95% CI: 1033.2-4381.4) were statistically significant ( $P<0.001$ ).

**Conclusion:** Cyclic fatigue resistance of a NiTi endodontic file is significantly reduced at body temperature compared to room temperature. Future cyclic fatigue testing of NiTi files should be conducted at simulated body temperature.

**Abstract 725**

**New international classification of orofacial pain: What is in it for endodontists?**

**MACHERLA KRANTHI KUMAR, JAHNAVI JAVVADI, KANCHETI CHAMINI**

Abstract

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The assessment, diagnosis, and management of orofacial pain (OFP) disorders is often a complex, multifactorial, and multidisciplinary process. Pain experienced before, during, or after endodontic therapy is a serious concern to both patients and endodontists, and the variability of discomfort presents a challenge in terms of diagnostic methods, endodontic therapy, and endodontic knowledge. Pain symptoms often challenge the clinician's diagnostic acumen, for it is well known that a correct diagnosis implies correct treatment. Its origin is mostly odontogenic, but several other conditions may mimic dental pain or present themselves as such. The new International Classification of Orofacial Pain (ICOP) is the first comprehensive classification that uniquely deals with orofacial pain in order to facilitate the process of better diagnosis. The purpose of this review is to describe how diagnosis of pain can be of use to general dentists and endodontists with special attention to differential diagnosis of tooth pain.

### Abstract 726

#### Root canal treatment of obliterated tooth: A case report

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Obliteration is one of pulp responses due to dental trauma. It can occur in the root canal either partially or completely. This can be challenging the dentist to perform the root canal treatment. If there were clinical symptom or periapical lesion, the obliteration could be treated by conventional root canal treatment or endodontic surgery. Conventional root canal treatment is commonly performed on cases which have an accessible root canal on radiograph. This case report describes root canal treatment procedures in obliteration case with conventional technique. A 37-years-old woman complaint the discoloration on maxillary right central incisor. The tooth had trauma approximately at 14 years old. Clinical examinations showed discoloration and no responses to vitality test, percussion and palpation. Radiographic examination revealed obliteration in two third coronally of root canal. It was diagnosed as pulp necrosis. Root canal treatment performed utilized C+ file with chelating agent then continue with crown down preparation technique (protapen next). The treatment result of obliterated teeth can be obtained favorable with proper diagnosis and instrumentation.

### Abstract 727

#### Endodontic treatment on permanent first maxillary molar with MB2 canal during COVID-19 pandemic situation – A case report

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Universitas Trisakti, Jakarta Barat, Indonesia

Outcomes of nonsurgical and surgical endodontic procedures are highly influenced by variations in canal configuration and cross sectional shaped and by the presence of canal irregularities and

curvatures. To achieve excellent result in endodontic treatment, clinicians need to have knowledge about dental anatomy and its variations. The clinician should pay more attention to maxillary first molar, especially the mesiobuccal root. The mesiobuccal root often wide buccolingually and has an accessory canal named MB2. However, during Covid-19 pandemic situation, clinician had to improvise to examine the root canals because periapical radiographs could not be taken as usual. This case report demonstrates the management of a maxillary first molar having two canals at the mesiobuccal root during a pandemic situation.

### Abstract 728

#### Outcome of intentional replantation of endodontically treated teeth with periapical pathosis: A systematic review and meta-analysis

**FAIZAN JAVED, KAMIL ZAFAR, FARHAN RAZA KHAN**

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**Objective:** The purpose of the present review was to evaluate success, survival and failure following intentional replantation of endodontically treated teeth and to determine the factors that might affect the outcome of replantation in these teeth.

**Methods:** PubMed NLM, CINAHL Plus, and Wiley Cochrane Library databases were systematically searched for articles that were published between January 1966 and February 2021. Clinical trials, longitudinal studies, case series with >10 cases, atleast one year follow-up, and published in the English language were included. Data were extracted to analyze success, survival and failure. Meta-analysis was performed using random-effects computation model employing MedCalc software. Risk of bias was assessed using Newcastle-Ottawa Scale.

**Results:** A total of 189 articles were obtained in the electronic and hand search. Thirteen articles were included in the final systematic review. Most studies carried low risk of bias.. The average rate of success following intentional replantation was 77.3%. Inflammatory root resorption was the most frequent complication found in 8.1% of total cases. Meta-analysis revealed the mean weighted survival to be 85.9%.

**Conclusions:** Intentional replantation has acceptable success and survival. Common complications include inflammatory root resorption and ankylosis. The long term success and survival rate of intentionally replanted teeth are found to be dependent upon short extra oral time, reduced pocket depth, type of tooth, type of root-end filling material, and the prevention of iatrogenic tooth root damage during replantation.

### Abstract 729

#### Prototype cryotherapy unit and its application in full pulpotomy performed in mandibular molar teeth with symptomatic irreversible pulpitis- A series of two cases

**VS AKHIL**

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**Introduction:** Cryotherapy is the therapeutic method of utilizing low temperatures for hemostasis, anti-inflammatory and analgesic effects by modulating the circulatory and neural response.

Abstract

Cryotherapy has been applied in endodontics to reduce post-operative pain after root canal treatment.

**Objective:** To develop a cryotherapy unit for continuous delivery of irrigant at a constant temperature of 2.5°C and apply it to achieve hemostasis in full pulpotomy performed in mandibular molar teeth with symptomatic irreversible pulpitis.

**Methodology:** A portable cryotherapy unit was developed for chairside use in dental clinic. It consisted of a container, compressor, microcontroller and delivery tip comprising of 10ml syringe with a 21-gauge needle. 0.9 % normal saline was used as an irrigant. The microcontroller and compressor relay were used to maintain the temperature inside the container at -0.15°C. An 135mm long insulated tube delivered the irrigant solution at a flow rate of 8ml/min and maintained constant temperature of 2.5°C when operated at ambient temperature of 27°C. A mathematical equation was used to solve the heat loss problem. Full pulpotomy was performed under local anesthesia and aseptic conditions. Coronal pulp was removed and the cryotherapy irrigation was done till hemostasis was achieved. The time required to control the bleeding was noted. The radicular pulp was capped with Mineral trioxide aggregate and restored with composite restorative material in the same visit. The postoperative pain was measured up to 72 hours using the Numeric Rating Scale.

**Results:** Pulp haemostasis was achieved in both the teeth within 4-8 minutes. The postoperative pain score gradually came down to 0 within 72 hours. During follow-up, both teeth were clinically asymptomatic without any radiographic evidence of periapical pathology.

**Conclusion:** A portable cryotherapy unit was successfully developed and tested for achieving haemostasis in teeth with symptomatic irreversible pulpitis.

### Abstract 730

**"A post on time saves dime": A clinical case series on anatomical posts**

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Endodontically treated teeth with loss of crown structure may require posts for reinforcement and rehabilitation. A wide range of posts are available at clinicians choice including cast metal posts, fiber posts, anatomic posts, Digi posts, etc. Abnormally flared and wide root canals pose a challenge in placing conventional posts. Custom made anatomic posts are mandated in such scenarios due to custom fit, minimum material interfaces, improved bonding to root dentin and cost effectiveness. A clinical case series on anatomical posts is presented here.

### Abstract 731

**Evaluation of change in working width before and after canal preparation using Pro taper universal file system under cone beam computed tomography – An *in-vitro* study**

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**Aim:** To evaluate the working width of single-rooted premolar teeth before and after canal preparation using Protaper universal file system under Cone-Beam Computed Tomography (CBCT).

**Materials and Methods:** 10 roots from intact extracted premolars with fully formed roots without any visible signs of external resorption or fracture were selected. None of these teeth had undergone prior root canal therapy. Preparation of teeth: The cusps of the teeth were levelled to provide a well-defined stable reference plane. Pre-operative CBCTs were taken to estimate the working length. The access cavities were prepared, the first reference length of the root canal was measured by inserting a size 10 hand file into the root canal until the file tip was visible under a magnifying loupe, at the apical foramen. The final working length was determined by subtracting 1mm from the first reference. Using CBCT images maximum and minimum width of the canal was measured at 1 mm, 2mm, and 3mm short of the external foramen and named 1ref, 2ref and 3ref. Canals were prepared using crown down technique upto size F2 (ProTaper Universal). Throughout the preparation, irrigation was done using 1% sodium hypochlorite. Following instrumentation, CBCT images were taken for measuring both maximum and minimum dimensions at all three levels. The data collected were analysed using a statistical package for social sciences (SPSS), version 17.0 (SPSS Inc, Chicago IL). Descriptive statistics were calculated. Paired t-test was applied to see the association within and between groups to compare the difference in the diameter between pre and post instrumentation at all three levels. Using this method, the variables selected showed a significant difference at the 95% level ( $p < 0.05$ ).

**Results:** There was a significant increase in the working width at all three levels (mesiodistally and buccolingually) following preparation using ProTaper universal file system.

**Conclusion:** There was a significant increase in the working width mesiodistally and buccolingually at all three levels following preparation using ProTaper universal file system.

### Abstract 732

**Photoactivated disinfection: Illuminate to eliminate**

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The success of endodontic treatment depends on how well the pathogenic microflora are eliminated from the root canal system and allows for periapical healing. The main objective of a successful root canal treatment is the complete removal of pulpal tissue, elimination of bacteria and prevention of recontamination after treatment. In addition to mechanical preparation, the use of disinfecting irrigants is highly recommended, in order to promote successful root canal disinfection and debris removal. It is well established that complete debridement and thorough elimination of bacteria from the root canal is quite challenging, because of the complexity of the root canal system. Thus, in addition to mechanical preparation, it is highly recommended to use disinfecting irrigants such as Sodium Hypochlorite, EDTA, Chlorhexidine, Citric Acid, etc. due to their ability to dissolve organic and inorganic tissues, lubricate the root

Abstract

canal and eliminate microorganisms and their by-products. Recently a novel method of disinfection has been introduced known as Photo-activated disinfection (PAD) (aka photodynamic therapy, PDT) which is used both in caries removal and root canal treatment as an adjunctive procedure to kill residual bacteria in the root canal systems after standard endodontic root canal preparation. This therapy involves the use of different photoactive dyes (photosensitisers) that are activated by exposure to light of a specific wavelength resulting in the formation of reactive oxygen species (ROS). ROS reacts strongly and destroys the microorganisms instantly and effectively. The advantage of PAD is that it selectively eliminates bacteria, it does not affect any other normal tissue and causes no damage to the surrounding tissues. There is no staining on the gingiva or restorations. Application of PAD has shown to be successful in the eradication of multi-drug-resistant microorganisms such as *E. faecalis*, *A. israelii*, *F. nucleatum*, *P. gingivalis*, *P. intermedia*, *P. aeruginosa*, *S. salivarius* etc. This review presentation aims to illustrate PAD discussing the various types of photosensitisers and light sources available and to incorporate this novel technique in routine clinical practice.

### Abstract 733

#### Comparative evaluation of micro cracks formed during root canal preparation by five rotary file systems in mandibular molars under stereomicroscope - An *ex vivo* study

**AYUSHI BANGARI**

Seema Dental College and Hospital, Rishikesh, Uttarakhand, India

**Aim:** The aim of this study was to select the Rotary Instruments which causes Minimum Cracks in Dentin.

1. Mani Silk
2. Hyflex EDM

**Materials and Methods:** 40 Freshly Extracted Human Permanent Mandibular First Molars were collected. All the roots of the extracted mandibular molars were sectioned perpendicular to the axis at 3mm, 6mm and 9mm from the apex. All the mesial canals of prepared samples were separated randomly into two groups (N=20) where Group A was prepared with Mani Silk file system and Group B was prepared with Hyflex EDM file system. After the canal preparation and horizontal sectioning, the root apex was stained with 1% methylene blue dye and images were recorded after instrumentation by using stereomicroscope at 100x magnification for evaluation of cracks. To define crack formation, 2 different categories were made (i.e., no cracks or cracks). Cracks were observed as stained lines extending either from the root canal lumen to the dentin or from the outer surface into the dentin were considered as cracks and the number of cracks seen on experimental tooth varied as some of the tooth showed more than one crack.

**Results:** Mani silk showed more number of defects as compared to Hyflex EDM.

**Conclusion:** Within the limitation of this study, it could be concluded that NiTi Instruments tend to induce various degree of dentinal damage during root canal preparation. Hyflex EDM showed minimum defects when compared to mani silk

### Abstract 734

#### Comparative evaluation of various MMP inhibitors as final irrigants on the fracture resistance of root filled teeth: An *in vitro* study

**NUREEN SHAFIYA**

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**Aim:** The objective of this study was to evaluate the effect of chlorhexidine and coffee arabica extract on fracture resistance of roots

**Methodology:** 30 extracted single rooted teeth was sectioned below the cemento-enamel junction to standardize the length of teeth to 12 mm.

The canals of the specimens was instrumented till F3 protaper and randomly divided into 3 groups

Group 1: Irrigation was done with chlorhexidine

Group 2: irrigation was done with coffee arabica extract

Group 3: irrigation was done with saline (control group)

All the root canals were filled with gutta percha using single cone technique and the specimens were embedded in self curing acrylic resin, and the fracture resistance of all the groups were evaluated by universal testing machine.

**Results:** One way anova was used to determine the significance difference among groups and p value less than 0.05 was considered as significant. i.e. 0.003 and coffee arabica was more significant compared to chlorhexidine when used as an irrigant.

**Conclusion:** Coffee arabica extract as an irrigant has shown the highest fracture resistance than the chlorhexidine.

### Abstract 735

#### Comparative evaluation of smear layer on the canal walls prepared with different rotary endodontic files under scanning electron microscope: An *ex vivo* study

**ARYAMA BALODI**

Seema Dental College and Hospital, Rishikesh, Uttarakhand, India

**Aim:** To compare the clinical efficacy of two files on smear layer formation, under scanning electron microscope (SEM).

1. Edge Taper Encore Files (EdgeEndo, Albuquerque, New Mexico)
2. Hyflex CM (Coltene Whaledent)

**Materials and Methods:** Forty freshly extracted single rooted mandibular premolars were selected and divided into two groups (n=20). Teeth were decoronated at the cemento-enamel junction. The working length was determined subtracting a millimeter when a size 15 K-file was visible through the apical foramen. All specimens in a group were treated by a single operator and split in longitudinal sections and then sent for Scanning Electron Microscopic study where Group 1 was prepared with Edge Taper Encore File system and Group 2 was prepared with HyFlex CM File system. After completion of the study, all the data were collected and subjected to statistical analysis.

**Results:** The smear layer produced by HyFlex CM (Coltene

Abstract

Whaledent) was lesser as compared to the smear layer produced by Edge Taper Encore ( Edge Endo Albuquerque, New Mexico) HyFlex CM produced significantly lesser smear layer as compared to Edge Taper Encore.

**Conclusion:** It is concluded that under the conditions of this study HyFlex CM (Coltene Whaledent) produced less smear layer than Edge Taper Encore File (EdgeEndo, Albuquerque, New Mexico).

### Abstract 736

#### Apical plug of nonvital tooth with wide open apex: A case report

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This case report illustrates the treatment of maxillary anterior teeth with a diagnosis of pulp necrosis with an open apex. A 26-year-old man came to the RSGMP Hasanuddin University complaining the discoloration in his upper right front tooth. The patient had a history of trauma to the tooth  $\pm$  17 years ago. Radiographic examination revealed that the apex was wide open. Cleaning and shaping were performed by placing calcium hydroxide as an intracanal medicament. Mineral trioxide aggregate (MTA) was applied into the root canals with a thickness of 4-5 mm. Obturation was performed with thermoplastic gutta-percha. Apical plug using MTA gives satisfactory results and shorter treatment time.

### Abstract 737

#### Dentronics: A new era in endodontics!

**PRIYA KOSARE**

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Dentronics is the hypernym of a wide field of modern dental technologies, such as medical robot system and specialized artificial intelligence including hardware, software, human-machine interaction, robot safety and assistive functions. Dentronics has played a vital role in endodontics as the goal of endodontic treatment is to provide the best quality treatment with an intention to retain tooth in its functional state and at the same time to prevent any further complications. In order to increase the clinical ease, efficiency and the performance of the clinician, it is very necessary to have a best clinical picture of endodontic disease and therapy. Even with the availability of various treatment modalities the success rate was found to be 60-80% for endodontic treatment, so in order to achieve the best result, accuracy in diagnosis, clinical decision making and planning a best therapy is utmost important. Artificial intelligence is a newer technology that has been widely used in dentistry. It is mainly composed of a neural networks architecture similar to human brains and which in turn mimics the human thinking. This neural architecture is made up of neurons that have strong interconnections it have been applied for the diagnosis of dental disease, treatment planning, clinical decision making, and prediction of prognosis. Robotics is an emerging field in dentistry. Robotics in dentistry will be the upcoming future with all necessary

equipped technology which could be further developed and easily adopted. This advancement from the traditional technique to digital world uses technology to increase the quality and safety of variety of tasks. In endodontics, this robots perform automatic drilling, cleaning-shaping and three dimensional filling of root canal system and at same time decrease the overload to dentist. However, artificial intelligence may never replace the human dentists. As technology improves it will help dental professionals to perform at a higher level by making their jobs much easier without human error. The future of dentistry is very bright with artificial intelligence and robotics. These poster review the Dentronics system which include the artificial intelligence in dentistry as well as in endodontics as they go hand in hand.

### Abstract 738

#### Push out bond strength of resin-based sealer to the radicular dentin treated with antioxidants and diode laser

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**Aim:** To compare and evaluate the push out bond strength of resin-based sealer to the radicular dentin treated with antioxidants and diode laser to decrease oxidizing effect of sodium hypochlorite.

**Methods:** Sixty single rooted permanent teeth were selected and decoronated at the level of CEJ standardizing the root length of 15mm. All the teeth were prepared with ProTaper Universal rotary system up to F3 according to manufacturer instruction and canals were irrigated using 3 mL of 5.25% sodium hypochlorite during instrumentation. The canals were flushed with sodium hypochlorite as a final irrigating solution. After final irrigation with sodium hypochlorite samples were treated with antioxidants and diode laser according to following group: Group I – Cocoa bean extract (irrigated for 10 min), Group II – 10% Sodium ascorbate (irrigated for 10 mins), Group III – 1.5W Diode laser (continuous mode for 30 sec), Group IV – 5ml Saline (control). All samples were obturated with Gutta percha and AH Plus sealer. Samples were placed in 100% humidity for 48 hours to ensure complete setting of the sealer. Samples were sectioned approximately from 5 mm coronally obtaining disc thickness of 2mm. Push out bond strength was performed using universal testing machine. The data was analysed using one way ANOVA and post hoc Tukey test.

**Results:** Concerning the push-out bond strength, Cocoa bean extract and sodium ascorbate showed significantly higher bond strength values compared to control group ( $P < 0.05$ ) even so, Diode laser showed equivalent bond strength. Adhesive failures were predominant in all groups.

**Conclusion:** Cocoa bean extract and sodium ascorbate showed equivalent bond strength when compared with diode laser. Both antioxidants and laser increase the adhesion of resin sealer to root dentine.

### Abstract 739

#### Novel technique for treatment of immature permanent teeth with apical periodontitis and tooth discoloration: A case report

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**Introduction:** Traumatic injuries are most common in children particularly anterior teeth are most frequently involved it leads to pulp necrosis and tooth discoloration. In case of an immature tooth, that will lead to an interruption of the root development leading to open apex and fragile dentinal walls that are difficult to manage with further endodontic treatments. Among the defined treatment protocol, treatment of immature open apex tooth is endodontically challenging procedure, traditionally 'apexification' procedure were treated using calcium hydroxide. However, the disadvantages of this technique include delayed treatment, improper apical seal and increased risk of root fractures. Novel technique with PRF and Biodentine collectively rendered an apical plug that provides suitable alternative to commonly used materials. Biodentine provides good interfacial adhesion and sealing with dentin attributed to its property of hydroxyapatite crystal deposition at the material-dentin interface. Also, because of its bioactivity, it likely promotes the conversion of adjacent PRF into a calcific barrier, thus reinforcing the apical seal. Additionally, host-modulating responses of PRF contribute in expediting the healing process.

**Material and Methodology:** In this case report a 13-year-old boy with Ellis class IV fracture of a maxillary permanent central incisor 21 with crown discoloration and apical periodontitis with open apex. Novel technique of treatment with PRF as matrix and biodentine was placed. Endocrown was fabricated with Lithium disilicate ceramic and cemented.

**Results:** Follow-up at 3rd, 6th, 9th & 12th month was done. Subjective and objective examination revealed satisfactory response with adequate periapical healing.

**Conclusion:** The promising clinical and radiographic outcome in this case demonstrated that novel technique with PRF as scaffold & Biodentine as calcific barrier may be an successful alternative to immediate conventional apexification materials and endocrown can be a conservative alternative to post and cores in such cases.

### Abstract 740

#### Cryotherapy in endodontics: A review

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Pain management during and after root canal treatment is one of the most important aspects of endodontic practice. Postoperative pain is unpleasant and often leads to distress to both the patient and the clinician and is often considered a parameter by the patient to evaluate the clinician's skills. It has been reported with a variable incidence rate ranging from 3-58%. Various strategized protocols have been implemented to decrease post-operative

pain, including the use of long-lasting anesthesia, intracanal medications, occlusal reduction, and pharmacologic management. Cryotherapy is a novel promising methodology to render an optimal anti-inflammatory and post-operative analgesic effect by using cold saline as a final irrigant contributing to improved patient compliance after endodontic treatment. Few studies done using intracanal cryotherapy have been assessed and a significant reduction in pain was seen after the use of cold saline as an intracanal irrigant. Cryotherapy has been recommended as a safe and well-tolerated strategy to minimise postoperative pain with few-to-no side effects. This review paper will discuss the application of cryotherapy during endodontic treatment and its efficacy in minimizing post-endodontic pain.

### Abstract 741

#### Poly-ether ether ketone whether it's a boom over other traditional endocrowns?

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Rehabilitation of endodontically treated teeth with extensive coronal destruction still remains a challenge for most dentists. The biomechanical principles of retention and resistance are deteriorating. The biomechanical changes due to root canal therapy and the degree of lost dental tissue lead clinicians to restorative treatment planning. For teeth heavily damaged by dental caries or fractures, treatment with a full crown supported by a cast metal core has been suggested. Yet, may result in root perforation or thinning of the root canal walls due to over preparation. Moreover, the limitations to the use of intraradicular posts, such as calcified root canals, narrow canals, or a fracture of an instrument, have led dentists to think of other alternatives, as the use of endocrowns. An adhesive endodontic crown "endocrown" is a one-piece ceramic construction. This crown would be fixed to the internal walls of the pulp chamber and on the cavity margins to improve macromechanical retention and the use of adhesive cementation would also improve microretention. Recently, CAD/CAM technology with the development of restorative materials and adhesive methods have made the conservative endocrowns constitute a reliable promising restorative approach. Poly-Ether Ether Ketone (PEEK) is a semi crystalline, synthetic, aromatic, thermoplastic material. Different PEKK-based polymers for CAD/CAM have been introduced as alternate intra-radicular post-core material. This PEKK material is considered an attractive novel material for endocrown systems especially with the fabrication versatility including pressing and milling. There are various applications in endodontics, Viz., PEEK posts and PEEK endocrowns are used for teeth with extensive tooth structure loss and aesthetic requirements.

### Abstract 742

#### Fracture resistance and stress distribution simulation of endocrown restoration post-endodontic with different materials and types of luting cement: Finite element analysis

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**Aim:** The purpose of this finite element analysis (FEA) was to compare and evaluate the fracture resistance and stress distribution of endodontically treated teeth restored with different material of endocrowns and types of luting cement.

**Material and Methods:** Four endodontically treated teeth first mandibular molar restored with an endocrown was modeled by using CAD software and imported into an FEA software. The study was performed using finite element analysis (FEA). Models were duplicated and first model received restoration in lithium disilicate with Rely X (3M ESPE USA) cement, second model in lithium disilicate with Panavia F 2.0 (Kuraray Noritake), third model in zirconia with rely x (3M ESPE USA) and fourth model in zirconia with Panavia F 2.0 (Kuraray Noritake). Total deformation, equivalent elastic strain, and equivalent stress under axial and non-axial force were analyzed. The mechanical properties of each structure were reported, and the material were considered isotropic, linearly elastic, and homogenous. Results were determined by colorimetric von mises of maximum total deformation, equivalent elastic strain and equivalent stress on tooth, cement, and restoration.

**Results:** The results indicated that zirconia endocrown with Rely X and Panavia F.20 cement has better fracture resistance than the other model. During masticatory simulation, the highest maximum total deformation was on model 1 and 2 with 0o angle and 600 N static force (0.18274 mm), the highest maximum equivalent elastic strain arisen on model 4 with 0o angle and 600 N static force (0.020046 mm) and the highest equivalent stress arisen on model 3 with 0o angle and 600 N static force (110.3 MPa). The critical area of total deformation and equivalent elastic strain were on the occlusal and the equivalent stress was in the cement-dentin interface.

**Conclusion:** This study suggested that material with high modulus elasticity play an essential role in the fracture resistance. Endocrown fabricated with zirconia exhibited higher fracture resistance and lithium disilicate exhibited more uniform stress distribution. The maximum stress distribution in the cement-dentin intrerface, this happens both at 225 N and 600 N loads.

**Abstract 743**

**Effect of pressure changes on fracture resistance of endodontically treated teeth with short fiber reinforced composite restoration during simulated dives and flight**

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**Aim:** To compare the fracture resistance of MOD restorations of endodontically treated teeth with direct short fiber reinforced composite resin restorations undergoing pressure changes, simulating SCUBA diving and flight.

**Materials and Methods:** Thirty extracted maxillary premolars were selected and divided into three groups (n=10). All the teeth had endodontic treatment and MOD cavity design with short fiber

reinforced composite resins as the final restoration. Samples in this study were divided into 3 groups. Group 1 for simulating SCUBA diving pressure (2 ATA), group 2 for flight simulating pressure (0.37 bar) and the group 3 as control group (atmospheric pressure). All samples were treated for 1 month and fracture test was performed using a universal testing machine (UTM). Data were statistically analyzed with one-way analysis of variance (ANOVA) (P<0.05).

**Results:** There were statistically significant differences in the results of the fracture strength among the groups. The control group had the highest fracture strength 4140,58 N ± 70.33 N compared to flight simulating group 3891.80 N ± 88.43 and SCUBA diving group 3720.76 N ± 43.27 (P<0.05).

**Conclusion:** This study showed that diving pressure cycles demonstrated adverse effect on fracture resistance of endodontically treated teeth restoration. The impact may due to the higher range of pressure change in dive group compared to flight and control group. Short fiber reinforced composite restoration is suggested in divers and air crew members to increase the fracture resistance of endodontically treated teeth restoration.

**Abstract 744**

**Dynamic navigation: Now a reality in guided endodontics**

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The introduction of digital devices and processing software together with new aesthetic materials and powerful manufacturing tools are radically transforming the dental profession. With only two-dimensional X-ray data available, making a correct diagnosis and an appropriate treatment plan could be difficult. 3D guided endodontics helps not only in diagnosis and treatment planning but can also be used as an efficient tool in executing the treatment. Data or image acquisition is the first operational phase of digital dentistry. Guided Endodontics is also known as Targeted Endodontic Treatment used in cases of calcified canals and endodontic microsurgery. Guided endodontics can deliver more predictable treatment outcomes compared to conventional treatment. Guided approach can be static or dynamic. Dynamic navigation system is in some way the same as a commonly used navigation system in a car. Dynamic guidance is based on computer aided surgical navigation technology and analogous to global positioning systems or satellite navigation. Attempts to localize or determine a position in space in the context of its surroundings. The actual localization technology, however, differs as surgical navigation does not use triangulation like a global positioning system with the help of several geostationary satellites. For the basic setup, the requirements are a stereoscopic camera, a computer platform with screen, and the respective navigation software. During the surgery, the marker spheres are attached to patient and at surgical instruments to enable an exact localization in space and, hence, navigation in the operating room. Implant positions and root canal locations can be designed and correlated with reference points with preoperative CBCT data with the help of computer software programs. Dynamic navigation system is empowered by a motion tracking technology,

Abstract

which tracks the dental drill and patient position throughout the procedures by integrating surgical instruments, 3D images, and optical positioning devices. This technology allows smaller and more accurate access opening preserving pericervical dentin. Dynamic navigation system makes exact root apex localization and accurate apicoectomy possible in a minimally invasive manner. Improvement of targeted surgical navigation systems facilitates surgical maneuvers and decreases the risk of iatrogenic harm.

**Abstract 745**

**Radicular cyst of the anterior maxilla: An insight into the most common inflammatory cyst of the jaw**

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The maxillofacial region is affected a greater number of cysts than any other part of the body. The prevalence of radicular cyst ranges from 15-20% of all endodontic periapical osteolytic lesions. Infected radicular cysts of inflammatory origin are formed in apical area of tooth having an infected necrotic pulp. Because the radicular cysts are caused by root canal infection, it is believed that pocket type of radicular cysts (6%) can be treated by conventional root canal therapy, however true type of radicular cysts (9%) may have to be managed surgically. This case report presents the successful surgical management of infected radicular cyst. The lesion showed progressive resolution and bone regeneration of cystic cavity over a short period of time.

**Abstract 746**

**One visit endodontics treatment of mandibular first molars with asymptomatic irreversible pulpitis (case report)**

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One-visit endodontic treatment is a non-surgical endodontic treatment consisting of biomechanical preparation, medication and root canal obturation which is completed in one visit. One of the indications for this treatment is a tooth with asymptomatic irreversible pulpitis. The advantage of one-visit root canal treatment is that the risk of microorganism contamination is minimized, saving time without compromising the quality of treatment results. The purpose of this case report was explain the successful one visit endodontics treatment in the management of teeth with asymptomatic irreversible pulpitis. In this case report, a 25-year-old female patient came to endodontic clinic of dental hospital with chief complaints of her left mandibular teeth has deep caries and pain. Clinical examination: vitality (+), percussion (-), palpation (-), a preoperative periapical radiograph was taken to support the diagnosis of asymptomatic irreversible pulpitis. Stages of treatment: DHE, informed consent, anesthetic infiltration, fixing rubber dam, the root canal preparation using Rotary files (ProTaper Next), and irrigated using 5.25% NaOCl, 17% EDTA and aquadest. Obturation was done single cone technique and final restoration with onlay restoration.

**Abstract 747**

**Retrograde management for the retrieval of broken endodontic file in maxillary first premolar: A case report**

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One of the most frequent mishaps during root canal procedure is the separation of an endodontic instrument during biomechanical preparation. It prevents proper debridement of the canal apical to the fragment and compromises the success of the treatment. Development in techniques and armamentarium has led to successful retrieval of separated instrument from the root canal. Separation of endodontic instruments impede cleaning and shaping procedure and affect long-term prognosis of tooth. Adequate knowledge, good clinical skill, and experience enable good management of instrument fractured in the root canal. In this report, the case of separated instrument was managed by surgical retrieval of fractured endodontic instrument using Stieglitz forceps in maxillary premolar. Separation of endodontic instrument in the root canal is one of the most unfortunate occurrences and may impair the success of the root canal procedure. Factors contributing to fracture of endodontic instruments are root canal curvatures, instrument design and manufacturing process, dynamics of instrument use, instrumentation techniques, and operator skill. Management of separated endodontic instrument includes (a) bypassing the broken fragment, (b) debriding and obturating at the level of separated instrument, and (c) removal of the separated instrument. Various techniques have been suggested to retrieve the separated instrument which includes ultrasonic technique, Masseran kit, and instrument removal system. Studies have shown that use of ultrasonics with magnification has led to high success rate of retrieval of the separated instrument. This report describes the case in which the separated instrument was managed by surgical retrieval of fractured endodontic instrument using Stieglitz forceps in maxillary premolar.

**Abstract 748**

**Managing endodontic emergency during and before COVID-19 lockdown: A retrospective comparative study**

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**Background:** The entire world has witnessed a huge crisis in the form of a massive pandemic since 2020. Covid-19 has imposed a sense of insecurity regarding the well-being of the health care workers and patients. Endodontists, like other front-line workers are primarily concerned about averting the transmission of the virus in the workplace.

**Aim and Objectives:** To determine the emergency for immediate endodontic intervention for final treatment outcome. To compare treatment with emergency access opening before Covid-19 lockdown

## Abstract

with that only with medicine for pain, after 3 days of follow up. To find the endodontic success rate due to delayed treatment during COVID-19 emergency.

**Materials and Methods:** retrospective study was conducted with two groups of patients. Group A: patients who appeared for not more than 1 sitting of endodontic treatment just before the COVID-19 lockdown and completed/ followed up after the phase II of lockdown was over. Group B: patients who either reported or consulted via video-calling for acute dental pain during lockdown, but only medical treatment was given and followed up after 3 days. Result was considered successful when they turned up after lockdown phase II to start and complete endodontic treatment. Patients who were not relieved of pain were either suggested to get extraction or get the RT-PCR test done for emergency access opening.

**Results:** 22(75.86%) out of 29 patients from group A were considered successful. In contrast only 11(47.82%) out of 23 patients were considered successful in group B. P-value was 0.029 and the result was significant. Among the failures, 2 patients from group A and 5 from group B went elsewhere for treatment, 3 from group A and 4 from group B underwent extraction of tooth, 2 from group A had failed endodontic treatment and 3 from group B had RT-PCR test done for emergency access opening.

**Conclusion:** Management of most of the endodontic emergencies required the use of aerosol-generating procedures. However, adequate precautions should be undertaken to ensure both the HCWs and patients' safety.

### Abstract 749

#### Iatrogenic perforation repair: on time, done right: A case report

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Root perforations are characterized by a communication between the root canal system and the external tooth surface. A diseased condition or iatrogenic accidents are the most common causes. These root perforations can trigger an inflammatory response leading to damage supporting tissues; they should be detected and treated as soon as possible. Depending on the degree of the damage it may lead to inflammatory reaction which results in the formation of granulomatous tissue, epithelial growth, and, eventually, the formation of a periodontal pocket. Timeline, size and location are major clinical parameters that influence the prognosis and healing of root perforations. It also necessitates a thorough understanding of the various materials that are employed in order to ensure the long-term success of treatment. MTA has proven a reliable material to for such repair. This presentation presents successful management of two iatrogenic root perforations, one at supracrestal and another at middle third of a central incisor with MTA followed by placement of fiber post and esthetic rehabilitation.

### Abstract 750

#### The pounce of corticosteroids on pain following single visit endodontic treatment

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**Aim:** The aim of the present investigation was to study the effect of local infiltration of corticosteroids on postoperative pain and quality of life (QOL) in teeth with irreversible pulpitis after single-visit endodontic treatment.

**Materials and Methods:** The subjects consisted of healthy individuals with an age range of 20–50 years. The subjects had not taken any analgesics, except for ibuprofen for 2 days before the study. The vitality of the teeth was confirmed. Preoperative pain severity was determined using visual analog scale. Each tooth was anesthetized with the use of lidocaine. The teeth underwent single-visit endodontic treatment. At the end of treatment, the subjects were randomly assigned to 3 groups to receive 0.7 mL dexamethasone, 0.7 mL LA betamethasone, or 0.7 mL sterile saline as a placebo. The severity of pain and QOL of the subjects were recorded before treatment, and they were asked to record their severity of pain and QOL using a checklist at 6-, 12-, 24-, 48-, and 72-hour and 7-day postoperative intervals. Postoperative pain severity was determined using a visual analog scale (VAS), and QOL was determined using postoperative QOL (POQOL) numerically from 0–10.

The Friedman test was used to evaluate and compare the severity of pain at 6-, 12-, 48-, and 72-hour and 1-week postoperative intervals. The Kruskal-Wallis test was used to compare the severity of pain among the 3 study groups.

**Results:** After endodontic treatment of vital teeth, local infiltration of corticosteroids has a significant effect on alleviating pain.

**Conclusion:** Therefore, it is recommended that these injections be performed routinely for the treatment of the current status of patients who are likely to have moderate to severe pain after treatment. In addition, in the present study, none of the complications of the local injection of corticosteroids were observed.

### Abstract 751

#### Management of intracanal separated instrument: A case series

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Separation of endodontic instrument is one of the common iatrogenic errors that happens in endodontics. The separated fragment often hinders proper cleaning and shaping procedures, thereby negatively impacting the prognosis of the endodontic therapy. Proper management of separated instrument does not adversely hamper the final outcome of the treatment. Adequate knowledge, good clinical skill, as well as experience helps the clinician to manage such a situation. Various treatment modalities are available for managing separated instrument which include treating the rest of the portion of the canal with the broken instrument left in the place; bypassing the broken fragment; retrieval of the broken fragment or retrieval of the separated fragment using surgical approach. Any of the above modalities along with the use of ultrasonics and magnification provide good results. In the present case series of intracanal separated instruments, the cases were managed by three different techniques: instrument bypass,

Abstract

instrument retrieval and leaving the fractured instrument extending beyond apex in place and achieving non-surgical healing.

### Abstract 752

#### Post endodontic flare-up: A review

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Post endodontic flare-up is an extremely undesirable phenomenon in routine dental practice. It consists of acute exacerbation of an asymptomatic pulpal and/or periradicular pathologic condition. Adequate knowledge of mechanisms that cause inter-appointment pain in endodontics is of utmost importance for the clinician because preventing as well as managing this condition will improve patient satisfaction. The etiology behind flare-ups comprises of mechanical, chemical, and/or microbial injury to the pulp or periradicular tissues. While mechanical and chemical injuries are often associated with iatrogenic factors, microbial injury, precipitated by microorganisms and their products has been proven to be the most common cause of inter-appointment flare-up. During situations like apical extrusion of debris; incomplete instrumentation leading to changes in the endodontic microbiota or in environmental conditions; and secondary intraradicular infections, microorganisms and their products participate in accelerating inter-appointment pain. It has been exclusively seen due to the development of acute inflammation at the periradicular tissues in response to an increase in the intensity of injury coming from the root canal system. Therefore, proper measures and appropriate guidelines need to be followed during endodontic procedures in order to prevent the development of any flare-up. This review article discusses the causative and predisposing factors behind its occurrence and various treatment modalities for the prevention and relief in such situations.

### Abstract 753

#### Comparative evaluation of sodium hypochlorite and calcium hypochlorite influence on dentin composition with and without use of DMSO

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**Aim:** To evaluate the changes in root dentin composition after using sodium and calcium hypochlorite with and without the use of DMSO.

**Materials and Methods:** 50 single rooted premolars extracted for orthodontic and periodontic reasons were collected. They were decoronated i.e cut at CEJ and then they were split longitudinally with diamond disk. Dentin disks of dimensions 8\*8\*1 mm were prepared by an Arkansas stone. The dentin bars were randomly allocated to 5 groups.

Group I: sodium hypochlorite group

Group II: sodium hypochlorite group with DMSO as final irrigant

Group III: calcium hypochlorite group

Group IV: calcium hypochlorite group with DMSO as final irrigant

Group V: control group (saline)

sodium hypochlorite 3% commercially available was used.

Calcium hypochlorite was prepared by adding purified powder to distilled water.

DMSO commercially was available as 99% this was added with distilled water to dilute it to 5%.

The solutions are replaced every 10 minutes.

The samples were then subjected to FTIR ANALYSIS.

**Results:** The collagen and phosphate peak heights at 1640 and 1000 cm<sup>-1</sup>. the samples treated with dimethyl sulfoxide after sodium hypochlorite had greater collagen phosphate ratio almost similar to the untreated dentin.

**Conclusion:** Using DMSO as a final irrigant positively influenced the dentin composition.

Collagen/ phosphate ratio was maintained to a good extent almost comparable to normal dentin.

### Abstract 754

#### TruNatomy – Rotary Files with regressive taper but progressive performance: An overview

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TruNatomy (TN; Dentsply Sirona, Ballaigues, Switzerland) is a newly introduced rotary file system consisting of 5 specific instruments with the following characteristic design parameters: a maximum fluted diameter of 0.8 mm and a new post-manufacture heat-treated NiTi alloy with 3 shaping files that have a regressive taper and an off-centered parallelogram cross section. The typical shaping sequence is to use the Orifice Modifier and then the rest of the instruments to the working length (WL) as follows: Glider followed by Prime. Small (for small and/or curved canals) and Medium (for larger canals) are also available. The slim NiTi wire design is 0.8 mm instead of up to 1.2 mm of the most other variable tapered instruments. TN was manufactured as a novel type of special NiTi heat-treated wire that claims to increase the flexibility and strength of the instrument by enhancing the arrangement of the crystal structure. It also reduces the internal stress and surface defects due to the grinding process. One of the claimed advantages of the TN files is that it has a reduced risk of separation due to the increased flexibility and cyclic fatigue resistance. Rotary instrument intracanal separation could be a serious mishap since the separated segments can limit the irrigation solution access to the canal system that may result in preventing sufficient microorganism elimination. The double curvature canals (S-shaped) created more stress on NiTi rotary instruments than in single curvature canals, and consequently, the instruments fractured due to cyclic fatigue. The S – shaped canal is one of the most challenging conditions in clinical situations during root canal instrumentation with NiTi rotary instruments. This review paper highlights the properties of TruNatomy and how it can be better than already established file systems.

### Abstract 755

#### Recent advances in metallurgy of rotary endodontic files

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Abstract

With the advent of technology in endodontic instrumentation over the past few years, the introduction of rotary files has resulted in a paradigm shift towards efficient as well as proficient treatment. Over the past decade, instrument design has been repeatedly modified to better suit clinician's preferences as well as to improve the modality of treatment outcome. Considerable progress has been made pertaining to manufacturing and alloy processing of these files, from rigid stainless-steel instruments to flexible Ni-Ti with shape memory. With the working parameters being continuously modified, the clinician needs to stay up to date with the advancements. Not every instrument system is suitable for every clinician, and not all cases lend themselves to rotary preparation, mainly because of varying degrees of complexity of the root canal anatomy and the expertise of the clinician employing it. The metallurgical aspect of rotary files continues to be poorly understood by some. The understanding of the effect of various parameters affecting the alloy characteristics is critical in the selection of an appropriate file system and more importantly, to the success of the entire treatment. This review paper discusses and elaborates the metallurgical properties of latest Ni-Ti endodontic rotary instruments, their development, mechanical properties and design features.

#### Abstract 756

##### Regenerative endodontics: A review

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Regenerative endodontics is defined as "biologically based procedures designed to replace damaged tooth structures, including dentine and root structures as well as cells of pulp-dentine complex". Stem cells and growth factors from an induced periapical bleeding and scaffolds using blood clot, platelet rich plasma (PRP) and platelet rich fibrin (PRF) have been used in regenerative endodontics. This treatment approach has been described as a 'paradigm shift' and considered the first treatment option for immature teeth with pulp necrosis. There are few favourable treatment outcomes of regenerative endodontics; 1) Absence of clinical signs and symptoms; 2) Root maturation; and 3) Regaining neurogenesis. This review includes the biological basis and clinical protocols which are used currently in regenerative endodontic procedures (REPs) and discuss future directions in pulp regeneration approaches. Clinically, REPs involve disinfection of the root canal system without damaging the endogenous stem cell potential present in the apical papilla and other tissues. These stem cells are introduced into the root canal space by inducing a blood clot followed by placement of a barrier to prevent micro leakage. The biological concept of REPs involves the triad of stem cells, scaffold and signaling molecules. Currently, repair rather than true regeneration of the 'pulp-dentine complex' is achieved and further root maturation is variable. Many clinicians consider the treatment of teeth with REPs as the optimal treatment approach for immature teeth with pulp necrosis.

#### Abstract 757

##### Trailblazing for calcified canals: An *in vivo* study

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India

**Aim:** To check accuracy of guided endodontic and conventional endodontic in calcified canal.

**Materials and Methods:** This clinical study for calcified teeth have been divided into two group that is conventional endodontic and guided endodontic . In these cases, preparing an adequate access cavity and identifying the canal orifice can be challenging and may create a massive loss of tooth structure that is associated with a higher risk of fracture and a high failure rate with conventional endodontic . For guided endodontic treatment preoperative cbct to check accurate level of calcification, impression of jaw manually or digital impression are required . This data were then used to design and three-dimensionally (3d) print a stent with a sleeve . Stent or guided planning have done in software blue sky version 4 . Template printed with clear resin that would guide the access opening and facilitate the location of the actual canal in the tooth. **Results:** The attempt to locate root canals through a traditional approach result in higher substance loss compared with guided endodontic . Study shows that guided access with template results in successful location and negotiation of canals, conserved as much tooth substance as possible.

**Conclusion:** The presented guided endodontics approach seems to be a safe, clinically feasible method for locating root canals and preventing root perforation in teeth with pulp canal obliteration that cannot be predictably accessed via traditional/conventional endodontic therapy.

#### Abstract 758

##### Clinical and radiographic characteristics of longitudinal root fractures in endodontically and non endodontically treated teeth: An *in vivo* study

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India

**Aim:** To evaluate the clinical and radiographical features of various longitudinal tooth fracture cases in both endodontically treated and non endodontically treated tooth.

**Materials and Methods:** 30 cases of longitudinal tooth fractures (fractured cusp, vertical root fractures (VRF), cracked tooth and split tooth ) are divided in to 2 groups ( n= 15 ). Teeth were evaluated thoroughly for swelling (Y/N), sinus tract (Y/N), Periodontal probing depth (measured in mm), prosthesis (Y/N) and occlusal discrepancies (Y/N). Intra oral periapical radiographs (IOPA) is used to categorize the various radiographic features. Straight, mesial and distal angulation radiographs were taken. Radiographic features categorized under presence of periodontal bone loss(Y/N), apical bone loss (Y/N), periodontal ligament widening(Y/N), Pattern of bone loss ( Horizontal /Vertical ) and presence of Post (Y/N).

**Results:** Cusp fracture was reported highest in both endodontically

Abstract

and non endodontically treated tooth, followed by cracked tooth, split tooth and VRF. Cusp fractures are not usually visible radiographically. Swelling and sinus tract associated with VRF is located more gingivally compared to those associated with split tooth. Clinical VRFs in both groups presented with a periodontal probing depth >5 mm, periodontal bone loss, apical bone loss and periodontal ligament widening. In the non- endodontically treated group, the VRFs occurred more frequently in older patients and in the teeth without a prosthesis, exhibiting attrited occlusal surfaces. Fractures are associated with vertical bone loss rather than horizontal.

**Conclusion:** This study highlighted and elucidated some clinical or radiographic and diagnostic features to facilitate the identification and categorization of longitudinal root fractures.

### Abstract 759

#### Management of nonvital maxillary canine with crown discoloration after trauma: A case report

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DIAN AGUSTIN WAHJUNINGRUM**

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Trauma involving anterior tooth needs to be treated properly and correctly to produce favorable and satisfactory results in aesthetic for long term. Complications of dental trauma that can be occur, for examples, are discoloration and loss of vitality of the tooth. This happens because of a minor injury on the vein at the apical. The venous micro circulation to the tooth cut off after injury, while the artery continues to supply blood to the pulp. The blood then decomposes gradually and appears a darker color change. Tooth discoloration can cause aesthetic problems that can reduce self-confidence of the patient. The use of restorations for the treatment of internal discoloration is an invasive procedure by reducing the tooth structure and is not cost effective. Internal bleaching is a treatment method for discoloration of non-vital tooth with a minimally invasive approach, preceded by root canal treatment, by placing strong oxidizing agents in the pulp chamber. 30%-35% hydrogen peroxide is the most commonly used materials for non-vital whitening for endodontically treated teeth. Tooth stains consist of compounds that have color or darker shades that are accumulated in the tooth. Hydrogen peroxide works by breaking apart the chemical bonds of the compounds that hold the stains, resulting in tiny molecules. This cause tooth color become lighter. This presentation discusses successful treatment of non-vital maxillary canine with discoloration by endodontic treatment followed by internal bleaching.

### Abstract 760

#### Single-visit endodontic treatment of mandibular first molar with pulp necrosis: A case report

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Indonesia

The goal of endodontic treatment is to preserve the teeth. This

treatment involve endodontic Triad Principles (cleaning, shaping and obturation). One visit endodontic treatment can be an option to achieve this principle. The advantages of the treatment are preventing bacterial recontamination in the root canal system, reducing the number of visits and eliminating the use of intracanal medicament. In addition, this treatment can be chosen by many considerations, such as open pulp cases due to iatrogenic trauma, irreversible pulpitis, asymptomatic apical periodontitis, apical abscess with sinus track and normal root canal anatomy. This report presents the case of an endodontic one visit on a mandibular first molar with pulp necrosis. A 19-year-old female patient visited Dental Hospital of Hasanuddin University with a chief complaint of tooth 36 decay. Vitality test, percussion and palpation showed a negative response. Radiographic investigation revealed periapical lesion. The diagnosis is pulp necrosis with asymptomatic apical periodontitis. The treatment was performed with crown down technique (proteper next file). one visit endodontic treatment provides good results if it is based on case selection and proper root canal preparation procedure.

### Abstract 761

#### Comparative study of the influence of instrument taper on the fracture resistance of endodontically treated teeth: An *in vitro* study

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**Objective:** The Objective of this study was to examine the influence of Instrument Taper on the Fracture Resistance of Endodontically treated roots under in-vitro experimental conditions.

**Methods:** In total, 40 mandibular first Premolar were sectioned at approximately 15 mm from the apex. The roots were will be randomly distributed into 3 experimental groups (n = 10) and 1 control group (n = 10). The roots in group 1 will be instrumented with hand files up to file (40/.02), groups 2 with Hyflex EDM Rotary File (40/.06), Group 3 with Neoendo Neohybrid rotary File (40/.04) and Group 4 acted as un-instrumented control. After mechanical preparation, the roots were obturated with gutta-percha and sealer. A vertical load will be applied to each specimen using a universal testing machine until the roots fractured.

**Statistical Analysis:** Data will be collected and statistically analyzed.

**Results:** The mean fracture load was  $357.47 \pm 110.54$  N for the control group,  $338.86 \pm 105.23$  N for group 1,  $297.74 \pm 77.31$  N for group 2, and  $280.10 \pm 68.51$  N for group 3. However, only the difference between group 3 and the control group was statistically significant ( $P < .05$ ).

**Conclusions:** After instrumentation using hand files up to file 40/.02 and rotary files up to files 40/.04 and 40/.06, only the last appeared to change the fracture resistance of endodontically treated roots.

### Abstract 762

#### Endodontic treatment and aesthetic management of multiple traumatic dental injuries in maxillary anterior teeth: A case report

**AMANDA AMANDA, RATNA PUSPITA HADI,  
DIAN AGUSTIN WAHJUNINGRUM**

Abstract

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Esthetic problems in anterior teeth usually caused by trauma and caries lesions, it is one of the reason patients seek for dental treatment to restore the function of the tooth and to get a better esthetic smile. The aim of this case report is to report the treatment of traumatized anterior teeth aesthetically. A 26 years old male came to Department of Conservative Dentistry, Faculty of Dental Medicine of Airlangga University, complaining about the traumatized maxillary anterior crown fractures. Clinical examination showed a crown fracture with exposed pulp chamber on right maxillary central incisor. Radiographic examination showed a radiolucent area in the periapical region of left maxillary lateral incisor. Root canal treatments were performed on 11 and 22. Crown lengthening without bone reduction was carried out after root canal treatments, and followed by placing of prefabricated fiber post. Lithium disilicate crowns were made on teeth number 11, 12, 21, and 22. Traumatic injury and caries lesions in the anterior teeth can be restored aesthetically with combination treatment between endodontic and periodontic.

### Abstract 763

#### Comparative evaluation of fracture resistance of teeth obturated with gutta-percha using two calcium silicate sealers and a resin sealer: An *in vitro* study

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**Aim:** The aim of this *in vitro* study was to evaluate the fracture resistance of three root canal sealers AH Plus, Endosequence BC, and Endoseal MTA, in conjunction with gutta-percha obturation using Universal testing machine.

**Methodology:** Fifty-five extracted human single-rooted mandibular premolar teeth (effect size  $f = 0.62$ ) were decoronated to a standardized length of 13 mm and instrumented using crown down technique with the ProTaper gold rotary file system to apical file size F3. The roots were randomly allocated into three experimental groups and two control groups ( $n = 11$ ). Group I - Negative control (neither instrumented nor obturated), Group II - Positive control (only instrumented, but not obturated), Experimental groups were instrumented and obturated as follows: Group III – (GP + AH Plus sealer), Group IV – (GP + Endosequence BC sealer) and Group V – (GP + Endoseal MTA sealer). Coronal 1mm of gutta-percha was removed and all the canal orifices were sealed with Cavit-G. All the samples were stored in artificial saliva and incubated for one week at 37°C and 100% humidity in an incubator to allow the complete setting of sealers. PDL simulation was done for all the specimens and embedded in self cure acrylic resin. Using an Universal testing machine, samples were subjected to a slowly increasing vertical force (1 mm/min) and the point at which fracture of the roots occurred was recorded. The data obtained were subjected to statistical analysis using SPSS statistical software (version 22.0).

**Results:** Endosequence BC showed better fracture resistance among the sealer groups ( $579.945 \pm 85.7541$  N). On comparing Group III with Group IV and V there was no statistically significant difference

found ( $p = 0.499$  and  $p = 0.755$ , respectively). While comparing Group IV and Group V, result showed the mean difference value ( $p = 0.05$ ), which was found to be statistically significant.

**Conclusion:** All the experimented groups in this study showed an acceptable fracture resistance. However, Endosequence BC sealer group showed a superior fracture resistance compared to the two other sealers used in this study using gutta-percha obturation technique.

### Abstract 764

#### Comparative evaluation of horizontal depth of penetration of sodium hypochlorite, chlorhexidine, ozonated water into the dentinal tubules with and without sonic irrigation

**VIMALA MUDDANI**

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**Aim:** To evaluate and compare the penetration depth of sodium hypochlorite, chlorhexidine, ozonated water penetration into the dentinal tubules with and without sonic irrigation

**Methods:** A comparative study regarding the penetration depth of the irrigating solutions into the dentinal tubules using two methods, 1) conventional irrigation 2) sonic irrigation. Fifty six extracted single rooted teeth are taken and decoronated 13 mm from the root apex, working length is determined and the apical foramen sealed with putty silicon. The root canals are prepared upto protaper F3 rotary file by using saline for irrigation during preparation. To study the penetration depth of the irrigants, smear layer was eliminated in all samples by using 17% EDTA. Dentinal tubules were stained with crystal violet and after longitudinal sectioning of teeth. Then, the samples were distributed into 7 experimental groups.

Group 1- 2.5% sodium hypochlorite with conventional irrigation

Group 2- 2.5% sodium hypochlorite with sonic irrigation

Group 3- 2% chlorhexidine with conventional irrigation

Group 4- 2% chlorhexidine with sonic irrigation

Group 5- ozonated water with conventional irrigation

Group 6- ozonated water with sonic irrigation

Group 7- control group (saline with conventional irrigation)

**Results:** The  $p$  value was significant ( $P < 0.05$ ) The mean depth of penetration of Group 2 (2.5% sodium hypochlorite with sonic irrigation) was more (0.71) followed by Group 4 (2% chlorhexidine with sonic irrigation 0.69).

Group 6 (ozonated water with sonic irrigation 0.69).

**Conclusion:** The mean depth of penetration of 3 irrigants (Ozonated water, 2.5% sodium hypochlorite, 2% chlorhexidine) is almost same into the dentinal tubules. The sonic irrigation technique enhances the penetration of the irrigant into the dentinal tubules. So, chlorhexidine and ozonated water can use as a substitute irrigants to sodium hypochlorite.

### Abstract 765

#### Clinical management of endodontic failure in central maxillary incisor with persistent periapical abscess: A case report

Abstract

**WEES KAOLINNI, ENDANG SUPRASTIWI**

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The objective of root canal treatment is to perform complete debridement of the root canals and subsequent obturation to facilitate healing of periapical pathosis. However, endodontic treatment failure may occur due to different causes such as persistence of bacteria, root canals that are poorly cleaned and obturated, improper coronal seal (leakage), and untreated canals (missed canals). The purpose of this article is to report successful endodontic retreatment of a central maxillary incisor caused by poor cleaning, poor obturation, and improper coronal seal. This case report discusses the clinical management of a previously root filled central maxillary incisor with endodontic failure and persistent periapical abscess. The post-treatment radiographs show complete healing in periapical area. This case report highlights the importance of optimal cleaning and preparation of root canal to get successful result in endodontic retreatment.

**Abstract 766**

**Regeneration arena: A promising future in endodontics**

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Regenerative endodontic procedures can be defined as biologically based procedures designed to replace damaged structures, including dentin and cells of the pulp-dentin complex. The objectives of these procedures are to regenerate damaged coronal dentin, such as following a carious exposure; and regenerate resorbed root, cervical or apical dentin, periapical tissue repair with increasing root length, thickening of the root walls, and apical closure in young patients. Regenerative endodontic procedures require the use of appropriate scaffolds to provide a spatially correct position of cell location, regulate differentiation, proliferation, or metabolism of the stem cells. Platelet-rich fibrin is one such scaffold which is currently gaining popularity in the field of regenerative endodontics. To ensure a successful and predictable outcome of regenerative endodontic procedure, it is of vital importance to have thorough and precise knowledge about the scaffolds used. The proposed therapies involving stem cells, growth factors, and tissue engineering, all require pulp revascularization. This is itself an enormous challenge. One of the most challenging aspects of developing a regenerative endodontic therapy is to understand how the various component procedures can be optimized and integrated to produce the outcome of a regenerated pulp-dentin complex. The future development of such procedures will require a comprehensive research program directed at each of these components and their application. These developments in the regeneration of a functional pulp-dentin complex have a promising impact on efforts to retain the natural dentition, the ultimate goal of endodontic treatment. This case report series provides an insight and an update about the use of platelet-rich fibrin in regenerative endodontic procedures, its benefits and limitations. The following case series describe the treatment of an immature permanent tooth with periapical lesion

which was treated with regenerative approach using platelet rich Fibrin (PRP).

**Abstract 767**

**Mend the broken-fracture reattachment a boon in dentistry!**

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Coronal fractures of the anterior teeth are a common form of dental trauma that mainly affects children and adolescents. The most affected teeth are upper incisors due to their anterior position and protrusion caused by the eruptive process. One of the options for managing coronal tooth fractures, especially when there is no or minimal violation of the biological width, is the reattachment of the dental fragment when it is available. Tooth fragment reattachment offers a conservative, esthetic and cost effective restorative option that has been shown to be an acceptable alternative to the restoration of the fractured tooth with resin-based composite or full-coverage crown. Reattachment of fractured tooth fragments can provide good and long-lasting esthetics (because the tooth's original anatomic form, color, and surface texture are maintained). It also restores function, provides a positive psychological response, and is a relatively simple procedure. Patient cooperation and understanding of the limitations of the treatment is of utmost importance for good prognosis. The management of coronal and coronal-radicular fractures in the maxillary region with these adhesive materials is easier, safer, and more efficacious than the use of traditional treatment alternatives that involve the use of posts and cores and/or other mechanical devices to obtain retention. However, it is important to note that the reattachment option is to be presented only after confirming that the fragment is in good condition and that it fits reasonably well on the fractured tooth. This case series of fracture reattachment demonstrates the successful management of complex crown fracture by multidisciplinary approach cases that are successfully treated using tooth fragment reattachment. These cases portray how beautifully a tooth's own fragment is brought together and re-establishes the original form and function.

**Abstract 768**

**Endodontic retreatment with inadequate obturation on lower second molars: A case report**

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Failure of root canal treatment can lead to reinfection. In general, treatment failure occurs due to inadequate obturation, persistent bacteria in the root canal, and leakage in the final restoration. However, this can be resolved with repeated root canal treatment. This case report evaluates retreatment of posterior teeth with inadequate obturation. A 39-year-old male came to the Hasanuddin University General Hospital with a complaint the lower of right posterior region was uncomfortable when it used for chewing. The teeth have been treated previously. Clinically, 47 was seen with inadequate composite restoration. Radiographic examination revealed inadequate

Abstract

restoration and unhermetic obturation. Based on subjective and objective examination the tooth was diagnosed as previously treated tooth. Retreatment procedure was preceded by removing gutta percha, determining working length, and preparing root canal using crown down pressureless technique. Obturation of the root canal was performed using a single cone technique using gutta-percha and AH-plus sealer and post-endodontic restoration using porcelain onlay. After follow-up, the patient showed no subjective complaints, the surrounding gingiva was normal, and the radiographic examination showed hermetic obturation. This case report shows that endodontic retreatment is an effective alternative for teeth with treatment failure.

### Abstract 769

#### Apex resection treatment on tooth 11 with periapical lesion: Case report

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**Background:** Apex resection is a surgical procedure of endodontic surgery having a high success rate. Treatment indications for apex resection are cases with periapical lesions that cannot be treated with conventional endodontic retreatment. In this case report, it was found that the maxillary anterior incisor had periapical lesion that had failed root canal treatment. Treatment plan of periapical surgery and apex resection was made.

**Objective:** The aim of this case report is to present endodontic retreatment with apex resection of anterior tooth with radicular cyst, with successful treatment outcome.

**Case Report:** A 26-year-old female patient came to the department of Conservative Dentistry of Universitas Airlangga Dental Hospital with complaint of pain, swollen gums and pus coming out of the right upper anterior tooth, the tooth has been treated previously. Diagnosis of reinfection of previously treated root canal with suspected radicular cyst was made. Case management: Root canal treatment followed by periapical surgery and root apex resection was done.

**Conclusion:** Management of root canal treatment and apex resection provides good result and there were no repeated complaint on the maxillary anterior teeth.

### Abstract 770

#### Vital pulp therapy: Various approaches and its outcome: A review

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Pulpal exposures occur under three scenarios, caries, trauma and mechanical causes, with caries being the most common scenario. Irrespective of the medium through which pulp exposure occurs, all the three scenarios permit bacterial insult to the pulp. The aim of vital pulp therapy is to maintain healthy pulp tissue by eliminating bacteria from the dentin-pulp complex. There are divergent treatment options for vital pulp therapy in extensively decayed or traumatized teeth. Pulp

capping or pulpotomy procedures rely upon an explicit assessment of the pulp status, and careful management of the remaining pulp tissue. However, in the last decade exceptional progress was made in terms of maintaining pulp integrity and promoting pulpal repair. Vital pulp therapy (VPT) is defined as a treatment which aims to preserve and maintain pulp tissue that has been compromised but not destroyed by caries, trauma, or restorative procedures in a healthy state. Vital pulp therapy procedures involve removal of local irritants and placement of a protective material directly or indirectly over the pulp. In recent times generous materials have been advocated to be incorporated in vital pulp therapy procedures which encourages pulpal repair, prevents microbial contamination and maintains pulp physiology. One of the most dominant issues in VPT is the status of the pulp tissue. Standard endodontic tests should reproduce symptoms and help distinguish between reversible pulpitis, irreversible pulpitis, and pulpal necrosis and this distinction is paramount since vital pulp therapy is only effective in reversible and irreversible pulpitis and not the latter. Clinical diagnosis of pulp disease should be reassessed because of the poor correlation between clinical manifestations and pulp sensibility testing and the actual histological status of the pulp. VPT is performed to treat reversible pulpal injury in order to promote root development, apical closure and accomplish complete root canal therapy. The purpose of this paper is to review different approaches of vital pulp therapy and the outcomes of various VPT techniques.

### Abstract 771

#### Endodontic management of permanent maxillary incisor with calcified root canal: A case report

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Currently, the advancements in diagnostic aids and instrumentation techniques has enabled management of calcified canals predictably. Calcification of the root canal that commonly referred as pulp canal obliteration, can be so extensive that the entire root canal system is obliterated. As a result, it becomes great challenge to the endodontist to treat the tooth in this condition. In the worst case, it might end up in iatrogenic root perforation. Identification and careful approach of the calcified area increase the successful rate of the treatment. The aim of this case report is to present a clinical case that performed endodontic treatment of a maxillary right permanent incisor with a calcified canal. A 34 year old male patient came to Conservative Dentistry, Department of Universitas Airlangga Dental Hospital reported with a complaint of decayed upper right incisor tooth and poor aesthetic. Tooth #11 was isolated and the caries was removed. Single root canal was negotiated and glide path was achieved with C-Pilot files. The coronal portion of root canal was enlarged and calcified area was removed with with E4D Dental Scaler Endo Ultrasonic Tip (Woodpecker, EMS Type). Working length was determined followed by cleaning and shaping and obturation with single cone technique. Fiber post was placed after preparing post space in the coronal two third of the root canal and core build up was done. Direct composite restoration was chosen as a final restoration. Calcified root canal in single root tooth is manageable with right identification and good approach.

Abstract

**Abstract 772**

**Efficacy of different storage media in maintaining periodontal ligament cell viability of an avulsed tooth: A systematic review**

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**Aim:** The best treatment for an avulsed tooth is its immediate replantation. If this is not possible, a proper storage medium is required for the maintenance of viability of the periodontal ligament cells (PDL) until replantation. The aim of this study was to systematically review the efficacy of different storage media used for the survival of PDL cells of avulsed teeth in an in vitro or ex vivo setting. **Methods:** The search strategy was based on the keywords: "Transport media for avulsed teeth," or "Storage media for avulsed teeth," or "Tooth avulsion," and "pdl cell survival of avulsed tooth," or "pdl cell viability of avulsed tooth," "AND" and "OR" Boolean operators were applied to combine keywords. Each study was evaluated for eight criteria, including use of human periodontal ligament (PDL) cells, in vitro or ex vivo cell culture models, the number of passages, types of storage media, percentages of surviving PDL cells, pH and osmolality of storage media and the type of test used to assess PDL cell viability. **Results:** In 13 selected studies, nine storage media were analyzed at five time periods- 1 hour, 3 hour, 6 hour, 12 hour, 24 hour. Milk was the most suitable medium up to 3 hours. For long-term incubation up to 24 hours Hanks Balanced Salt Solution, Dulbecco's Modified Eagle Culture Media showed superior PDL cell viability compared to milk. However, milk has an advantage because of its commercial availability. **Conclusions:** Milk remains the most convenient, cheapest and readily available solution in most situations with its pH and osmolality lying within ideal range and its capability of keeping PDL cells alive.

**Abstract 773**

**Smart endodontics: Breaking new grounds in dentistry**

**SONALI JAIN**

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A good aesthetic with preservation of teeth appeal occupies a top priority in all fields of dentistry, which leads to an increased quest and concern towards better and more efficient technological perspectives. Conventional materials and methods are lagging because of the risk factors such as failed endodontic treatment, secondary caries, fracture of restoration, fracture of tooth, marginal discrepancies, or wear. Also, it has always been a great challenge which is being continuously rising since time immemorial. Hence it leads to an increased concern and research towards better and more efficient technological perspectives. Traditionally designed materials used in dentistry are passive and had relatively 'neutral' existence in the mouth, that is, they survive without interacting with the oral environment. It is considered that by being passive and inert they will display more stability and have a greater durability. But with advancement in research and evidences in the search for an "ideal material", today, a newer generation of materials

has been introduced. The rapid developments in nanotechnology suggest that by using building blocks at a molecular or even atomic level, smart features can be manufactured into compounds. As our world is progressing towards innovation and improved technology, following 'Smart Endodontics,' in which utilization of all the materials which have smartness by chance and also designing the existing materials to incorporate smartness in them, would shift the trends in the field of endodontics.

**Abstract 774**

**Conceptions on traditional and minimally invasive endodontic access cavity designs**

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There is no clear consensus regarding the shape of access cavity preparation for endodontic therapy. There are plethora of studies regarding the minimal access cavity preparation but one should weigh the benefits against drawback of the same, as there is always a risk of skipping the accessory canal while using the approach of minimal access cavity preparation and unable to do the proper irrigation & disinfection. In addition minimal access cavity preparation is technique sensitive & requires special equipments. I will be presenting a review of literature regarding access cavity preparation, describing both merits and demerits of the same so that, one can decide whether it is advisable to be a minimalist while planning to prepare a cavity.

**Abstract 775**

**Effect of etidronate on the microhardness of root dentin: A review**

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**Objective:** The present narrative review focused to investigate the effect of etidronate on the microhardness of root dentin. **Search Methods:** A comprehensive literature search was performed on PubMed, Google Scholar and Medline databases from 2010 to 2021. The main search terms used were etidronate, HEBP, microhardness, dentin microhardness and root canal dentin microhardness. **Selection Criteria:** Inclusion criteria was based on in vitro and comparative studies that evaluated the direct effect of etidronate as endodontic irrigant on the microhardness of root dentin. Articles in English or those having detailed summary in English, in vitro and comparative studies were included. All the case reports, abstracts, letters to editors, editorials, and in vivo studies were excluded from the present review. **Results:** A total of seven studies were included in the final review. The paper evaluated the effect of HEBP on the microhardness of root dentin based on the irrigant concentration, exposure time and its effect on the location in radicular dentin. The optimal concentration to remove the smear layer and exert antibacterial

Abstract

activity was found to be 9-18%. The effect of the irrigating solution on the microhardness of root dentin increased with exposure time and radicular dentin microhardness value declined from superficial to deep regions.

**Conclusion:** Etidronate a weak chelating agent used as alternative to other chelating agents with a concentration of 9-18% for 5 minutes has optimal effects on dentin microhardness and can be used in association with NaOCl, without interfering its action.

### Abstract 776

#### Barrier placement as a treatment modality in cases of endodontic retreatment with open apex: Case reports

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**Aim:** Endodontic management of open apex using mineral trioxide aggregate / Biodentine as an apical matrix.

**Summary:** The primary reason for an endodontic treatment failure is the persistence or regrowth of different species of bacteria within the root canal system. The root development and closure of its apex in a permanent tooth occurs till 3 years after the eruption. Treatment of traumatic injury of teeth during the development period of root resulting in open apex poses an endodontic challenge. The prime objective is to eradicate bacteria from the root canal with minimum irritation to the periapical tissues. Various materials are used for induction of apical closure and to confine root canal filling within the root canal space. This paper describes two clinical cases of retreatment on the central incisor and premolar with improperly treated root canal with an open apex. On intraoral examination, both the cases revealed the presence of post endodontic restoration with the sinus tract in the periapical region. The teeth were tender on percussion and palpation. The preoperative radiograph revealed a root canal filling, which was overextended beyond the apex and showed voids within and between the root canal fillings and root canal walls. In the first case, multiple visit retreatment of the central incisor was done. Intra-canal dressings of calcium hydroxide medicament were given followed by placing an apical plug of mineral trioxide aggregate (MTA) against platelet-rich fibrin (matrix). In the second case, multiple visit retreatment of premolar was done by placing triple antibiotic paste (TAP) as intra-canal dressing. An apical plug of Biodentine against Platelet-rich fibrin (matrix) was placed. MTA and Biodentine were used to induce apical artificial barriers. The endodontic challenge associated while treating permanent teeth with open apices is preventing the overfilling of the restorative materials that serve as an artificial barrier. This can be performed by using matrix-like PRF.

**Conclusion:** Both the cases showed successful periapical healing and resolution of symptoms. The barrier technique using Biodentine along with PRF matrix act as a dentin substitute while treating cases with an open apex.

### Abstract 777

#### Replantation of avulsed teeth: A case series

**ES AKSHARA**

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Traumatic dental injuries (TDIs) occur most frequently in children and young adults. Avulsion of permanent teeth is one of the most serious of dental traumatic injuries, and is estimated to represent 0.5% to 16% of all dental injuries. Immediate replantation of an avulsed tooth enhances the viability of periodontal ligament cells and results in healing of up to 85% of a mature tooth. Initiation and proper execution of endodontic treatment is another aspect in the management of these cases. Prompt and correct emergency management is the key to attaining the best outcome after this injury. This paper discusses three cases of avulsion and their management strategies along with a six-month review summary.

### Abstract 778

#### Comparative evaluation of smear layer removal by 7% maleic acid and a new endodontic irrigant using three different irrigation techniques: A scanning electron microscopy study

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**Aim:** To evaluate and compare the efficacy of 7% Maleic acid and SmearOFF in smear layer removal when activated with ultrasonic technique, sonic technique, and plastic rotary finishing file at low speed, as observed by scanning electron microscopy.

**Materials and Methods:** Sixty single rooted human mandibular premolar teeth with single canal were collected. After standardization of length, access preparation was done. Working length was estimated and preparation was done using ProTaper Gold rotary files till size F2. Irrigation was performed with 3 ml of 5.25% sodium hypochlorite (NaOCl) between each instrument. Prepared specimens were randomly divided into the following groups and irrigated with 5 ml of the respective test solutions for 1 minute, along with the respective activation techniques.

GROUP I (n=30) 7% Maleic acid

GROUP II (n= 30) SmearOFF

In both groups, the specimens were further divided into three sub-groups (n=10) corresponding to the respective irrigant activation technique, namely Ultrasonic activation, Sonic activation and Activation with plastic rotary finishing file.

After a final rinse with 5 ml of 5.25% sodium hypochlorite solution, the specimens were dried, split longitudinally, mounted on coded stubs and gold sputtered for SEM analysis. The presence of smear layer was observed at coronal, middle and apical thirds and photomicrographs were taken at (x1000) magnification. The smear layer scoring was done according to the system given by Torabinejad et al, 2003.

**Results:** Smear layer was removed in all specimens, but most effective removal was seen in the coronal thirds, followed by middle and apical thirds. At coronal, middle and apical thirds, all the groups examined were equally effective in removing the smear layer without any statistically significant differences.

**Conclusion:** These irrigants along with the activation techniques can be used in effective smear layer removal.

### Abstract 779

#### Endocrown: An approach to conserve and preserve endodontically treated molars

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Restoration is one of the most important things in the field of dentistry. There are two main things that must be considered in a restoration - aesthetic factors and functional factors. A tooth after endodontics treatment requires more complex restoration than normal tooth, because lot of factors needed to be observed first, one of which is tissue residue, root canal anatomy and even the economic condition of the patient. There are multiple options available to restore an endodontically treated tooth. Among this, Endocrowns represent a simple, conservative and aesthetic alternative to conventional crowns. Endocrown is a one-piece restoration, usually indicated in cases with decreased crown height. The preparation comprises 'sidewalk' as the cervical margin and a preparation into the pulp chamber that may or may not extend into the root canals. It prevents interferences with periodontal tissues, due to the presence of supragingival position of the restoration margins. The rationale of this technique is to use the surface area available in the pulpal chamber to assume the stability and retention through adhesive procedures. Principally, endocrowns are full ceramic restorations. A case report is presented here, where an all-ceramic endocrown was fabricated using the similar protocols and clinical procedures.

### Abstract 780

#### 3D printing – Environing the perspective of dentistry

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3D printing is a promising new technology with wide range of applications in dental field. Three-dimensional (3D) printing can be precisely described as additive manufacturing, rapid prototyping, layered manufacturing, or solid-free form fabrication. It is the process in which, a virtual design of the object is created using three-dimensional model which is sliced into multiple thin layers as an additive process, in contrast to the subtractive manufacturing process like CAD CAM. This printing can be combined with oral scanning and CAD/CAM design to produce crowns, bridges, stone models and various orthodontic appliances. 3D printing has successfully been applied to experimental approaches in regenerative endodontics, calcified root canal negotiation, endodontic treatment of dental invagination, apical surgery and auto transplantation, has also provided a new concept and treatment mode for the diagnosis and therapy of endodontic diseases.

### Abstract 781

#### Human dental pulp stem cells: Role in dentin repair

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Dental Pulp is a connective tissue uniquely situated within the rigid encasement of mineralized dentin. The central core of pulp called the pulp proper contains fibroblasts, blood vessels and nerves with undifferentiated mesenchymal cells and defence cells in the perivascular area. The dentine–pulp complex provides strength and resiliency to the tooth and have the ability to regenerate a dentin-pulp-like complex. Mammalian dental pulp stem cells (DPSCs) have the ability to regulate the temperature and oxygen levels to maintain cell homeostasis. However, acute or chronic pulpitis or deep cavity preparation can result in ischemia and hypoxia of the dental pulp. This leads to necrosis and apoptosis of the pulpal stem cells. The response of DPSCs to hypoxia and the temperature change is a complex biological process that includes various molecular and cellular signals. To restore these deep cavity preparations, certain manipulation technique and restorative materials are used which can stimulate the DPSCs. These cells are mechanosensitive, can recognize these mechanical changes and transform this information into cellular responses. Several investigations have also shown that mechanical stimuli including dynamic hydrostatic pressure, cyclic tensile strain, mechanical compression and cyclic uniaxial compressive strain can promote the odontogenic differentiation of DPSCs. Another important factor to consider is the electromagnetic fields (EMF) generated from dental devices, e.g., by electric toothbrushes and curing light sources for light-cured resin. EMF also induces the DPSCs to undergo cellular and molecular changes which includes cell migration, proliferation and expression of growth factors. Hence, to have a quality repair of the dentin, consideration of these factors and their effects on DPSCs are necessary. These cells on stimulation will undergo certain functional changes and activate inflammatory signalling pathways via various mediators. These mediators in turn stimulate repair of the dentin by either inducing mineralization or proliferation and differentiation of the DPSCs into odontoblasts, osteoblasts or cementoblasts as per the need. Thus, this review paper explains about the various stimuli and their role in repair of dentin by directly or indirectly affecting DPSCs.

### Abstract 782

#### Single visit non surgical endodontic treatment on symptomatic irreversible pulpitis – A case report

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**Background:** Endodontic treatment usually performed by clinician in multiple visit and thus required a considerable amount of time to complete the treatment. With the development of an increasingly advanced era and the discovery of supporting tools, a single visit endodontic treatment can be carried out and shows a better result than multiple visits. Single-visit root canal treatment is safe regarding postoperative pain as well as secondary infection as far as many studies and clinical reports are concerned. This treatment is safe in both inflamed and necrotic, and even teeth with periapical pathosis. A thorough understanding of the basic endodontic

Abstract

principles is important in decision making as to whether or not it can be completed in one visit.

**Purpose:** To determine the success rate of single visit root canal treatment (RCT) and thus encourage clinicians to offer this treatment option appropriately. Case: A 55 year old woman came to Universitas Airlangga Dental Hospital complaining her bad fixed partial denture on upper right central and lateral incisor and acute pain on upper left central incisor. The fixed denture was removed first and the residual root below the denture was extracted. Patient wanted to relieve the pain on upper left central incisor and replace with restoration. Management: Endodontic treatment was done in single visit. Patient was given local anesthesia to relief the pain and isolation with rubber dam was done on 21 tooth. Access opening and removal of the pulp tissue then followed by confirming the glide path and working length. Cleaning and shaping was done using VDW Recipro Blue with single length technique and activated irrigation. Single cone was chosen as an obturation technique and sealed with temporary restoration. Fiber post and core preparation was done on the following visit. The final restoration was done using metal based ceramic.

**Results:** Patient was satisfied with the result and no complain on percussion and bite test.

**Conclusion:** Single Visit endodontic treatment on symptomatic irreversible pulpitis can lead to a better prognosis with minimal visit and risk of infection and pain during treatment.

### Abstract 783

**Comparison of sonic and ultrasonic irrigation activation techniques on endodontic biofilm, irrigant penetration, calcium hydroxide and debris removal: A systematic review**

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**Aim:** This systematic review aims to investigate the efficacy of sonic and ultrasonic systems on endodontic biofilm, penetration depth of irrigant into dentinal tubules, removal of calcium hydroxide, and canal cleanliness (debris and smear layer).

**Methods:** The research question was developed according to the PICO strategy. A literature search was performed at general data base PUBMED, Web of science, Embase, Scopus, Cochrane using the keywords and MESH- sonic irrigation, ultrasonic irrigation, Ultrasonic and sonic irrigation, ultrasonic or sonic irrigation, smear layer, endodontic biofilm, irrigant penetration, calcium hydroxide removal, endo activator. A hand search of the reference list of identified articles was performed to isolate relevant articles. The reviewers evaluated the full-text articles to determine eligibility and excluded articles that met any of the following criteria: 1. Studies not treating human permanent teeth with fully formed apices. 2. Studies not evaluating root canal cleaning, disinfection. 3. Studies with different/not standardized instrumentation in the compared groups. 4. Studies not using commonly used irrigants. 5. Studies not comparing ultrasonically

activated irrigation with sonic activated irrigation. 6. Studies measuring the cleanliness in lateral canals, isthmus, artificial grooves were excluded as they were not concerned with the central body of the canal. The data extraction and synthesis were formulated according to Preferred reporting items for systematic reviews and meta-analysis (PRISMA) checklist.

**Results:** After removal of duplicates, 95 articles were excluded as they did not meet the selection criteria. Two systems (sonic, ultrasonic) and four variables of interest (antibiofilm, irrigant penetration, calcium hydroxide removal and debris removal) were evaluated in the thirty eight included articles and the risk of bias of the selected articles was moderate. Results showed that ultrasonics performed better in calcium hydroxide removal, smear layer removal and irrigant penetration in dentinal tubules compared to sonic irrigation. There was no significant difference between sonic and PUI in reduction of bacterial count.

**Conclusion:** It may be concluded that, because of the methodological differences among the studies evaluated, further research is required to produce definitive results.

### Abstract 784

**Apexification using mineral trioxide aggregate, endodontic retreatment and porcelain crown with composite resin posts on right central maxillary: Case report**

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Trauma on teeth in a young age can make non vital immature teeth with open apex. This later makes the dental pulp roots that are not completely formed face the necrosis and apical closure stop later causing the apex wide and open. The opened apex can be coped with the care of apexification. Mineral Trioxide Aggregate (MTA) is the best material of apexification used for the formation of apical barrier. This case report present the treatment use of MTA (Mineral Trioxide Aggregate) as apexification material and all porcelain crown with fiber posts on the maxillary right central incisor, so as to maintain and restore tooth function. A 20 year old female patient came with complaints of loose fillings in her teeth. The right maxillary central incisors which were broken 13 years previously because of falling. The diagnosis was right maxillary central incisor Ellis Class III fractures. The treatment procedure begins with root canal re-treatment using circumferential filling motion preparation techniques, apexification using Mineral Trioxide Aggregate (MTA) followed obturation with gutta-percha. Two week after the apexification treatment was completed followed the installation of fiber post, and after three weeks followed insertion all porcelain crown. Apexification with post and all porcelain are good treatments that can be performed on the immature right maxillary central incisor, without exposing pulp. The patient was satisfied with the care that had been done and also, the function of her teeth could be restored, including aesthetic and phonetic functions.

### Abstract 785

#### Comparison of apical debris and irrigants extrusion using four different thermally treated endodontic file systems: An ex-vivo study

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**Aim:** The aim of this study was to evaluate apical debris and irrigant extrusion of four different thermally treated rotary and reciprocating file systems.

**Materials and Methods:** 60 extracted human mandibular molars were sectioned into two halves and the distal half was discarded. The mesial portion of the root along with the crown was mounted in glass vials with rubber stop and randomly divided into four groups (n=15) depending on the rotary/reciprocating and blue/gold files used – Group A: Reciproc blue files, Group B: Wave One Gold files, Group C: Vortex blue files and Group D: Protaper gold files. The apically extruded debris and irrigant were collected in pre weighed glass vials. The vials were dried and then weighed in electronic weighing machine. The data obtained were statistically analyzed using paired t – test.

**Results:** The reciprocating file systems extruded significantly less debris than the rotary file systems (p<0.05). Reciproc blue extruded the least debris, followed by Wave one gold, Vortex blue, and Protaper gold.

**Conclusion:** All systems extruded the debris during the instrumentation. The reciprocating file system extruded significantly less debris compared to the rotary file system.

### Abstract 786

#### Photobiomodulation therapy in endodontics

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Nowadays lasers became an innovative modern tool in various fields including dentistry also. Laser irradiation can induce a photobiomodulatory (PBM) effect on cells and tissues, contributing to a directed modulation of cell behaviours. Photobiomodulation (PBM), the word actually represents low-level laser therapy (LLLT) only. Photobiomodulation therapy is defined as “A form of light therapy that utilizes non-ionizing forms of light sources, including lasers, LEDs, and broadband light, in the visible and infrared spectrum. It is a nonthermal process involving endogenous chromophores eliciting photo physical and photochemical events at various biological scales. This process results in beneficial therapeutic outcomes including alleviation of pain or inflammation, immunomodulation, and promotion of wound healing and tissue regeneration.” It has many applications in Endodontics and Conservative Dentistry such as post-operative pain control after endodontic therapy, to control dentinal hypersensitivity, to aid in healing associated with endodontic surgeries. It can also be used as an adjuvant to direct pulp capping and for controlling

the post-operative sensitivity after bleaching as well as after placement of composite restorations in deep cavities. In short, photobiomodulation therapy is a specific and effective therapy by the application of light. It can be used as an alternative or adjuvant to specific routine clinical procedure to ensure predictable healing. Apart from the fact that it requires a specific instrument for its implementation, it is a reliable tool which helps in the accomplishment of the success of the specific clinical procedure. This review paper describes the uses of photobiomodulation therapy in Endodontics.

### Abstract 787

#### Nano antimicrobials in endodontics: A review

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A root canal system exhibits a tough environmental condition about the availability of nutrients and oxygen. Conventionally, chemical antimicrobials (topical) are used within the root canals in combination with mechanical instrumentation to achieve “microbe-free” root canals before filling the root canal with an inert filling material. Antimicrobial resistance (AMR) has emerged as one of the principal public health problems of the 21st century. It threatens the effective prevention and treatment of an ever-increasing range of infections caused by bacteria, parasites, viruses and fungi no longer susceptible to the currently used antibiotics. One of the important requirements of endodontic treatment is the ability to eliminate microorganism from root canal system. this antimicrobial effect is achieved by combination of chemical and mechanical disinfection. Due to increasing antimicrobial resistance, efficacy of traditionally used irrigants have been decreased. Owing to this limitation of currently used antibiotics it paves the way for nano antimicrobial based irrigants. It has been highlighted that the addition of antibacterial nano particles in root canal sealers would improve the direct (based on the direct antibacterial assay) and diffusible antibacterial effects (based on a membrane-restricted antibacterial assay) of the root canal sealers. Additionally, nano particles when incorporated into intracanal medicament have shown added benefits. Nanoparticle-based photosensitizers have been considered to potentiate the antimicrobial efficacy of photodynamic therapy (PDT). The antibacterial nanoparticle-based treatment has the potential to improve antibacterial/antibiofilm efficacy. They have distinct advantages when applied in endodontics. The whole concept of nanotechnology in health care should be accepted with positive zeal for future development This review paper describes the scope of nano antimicrobials in endodontics as an irrigant, sealer, intracanal medicament and its role in photodynamic therapy.

### Abstract 788

#### Apexification in immature first permanent incisors after traumatic injury: A case report

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Abstract

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**Background:** Tooth fracture involving the open pulp chamber due to trauma can cause necrosis and require root canal treatment. In case of traumatized immature teeth, it becomes a challenge for dental practitioners. Endodontic treatment of immature permanent teeth without apical barrier leads to failure of treatment due to incomplete sealing of the canal. Apexification is considered to be the treatment of choice for non-vital immature permanent teeth, which involves cleaning the canal and filling it with a medication that stimulates the formation of a calcific apical barrier. In this case report, there is an abscess on traumatized immature first permanent maxillary incisors after trauma 10 years ago.

**Objective:** the aim of this case report is to present a successful treatment regarding apexification procedure of traumatized immature first permanent maxillary incisor with periapical abscess.

**Case Report:** A 19-year-old male patient came to Conservative Dentistry Department of Universitas Airlangga Dental Hospital with complaint of fracture upper right permanent central incisor tooth, had pain and swelling about 2 months ago. Negative pulp vitality under cold testing. Radiographic analysis of the root revealed incomplete apex formation. Case management: tooth 11 with a diagnosis of pulp necrosis with suspect periapical abscess was treated with apexification and root canal treatment.

**Conclusion:** management of apexification and root canal treatment provides good result and there were no repeated complaint on the first permanent maxillary incisors.

### Abstract 789

#### Nayyar technique: An alchemy to a stronger core

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This case report presents the immediate coronal sealing of endodontically treated lower second molar. Endodontic treatment of a tooth may prove unfruitful if it is not restored at appropriate time with an adequate restorative material and technique as well. In order to achieve the above goal a restorative material should be such that it could be placed immediately over the obturated canals and should take retention and support from the canals itself. By using this technique (Nayyar core) the force will be transmitted along the long axis of tooth rather than the on weakened peripheral coronal structure thus providing adequate strength to the tooth. The placement of an amalgam core buildup allows the endodontic seal to be extended from the foramen to the Cavo surface margin. The use of a combined endodontic seal/buildup procedure, combined with an adequate ferrule effect, yield a quantum leap in the long term success of endodontic and restorative care.

### Abstract 790

#### Saving the tooth! With calcium substitutes

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Greatest threats to developing teeth are dental caries and traumatic injury. Successful direct pulp capping of cariously exposed permanent teeth with irreversible pulpitis and incomplete apex formation can prevent need for root canal treatment. An ideal dental material which is used for direct pulp capping should possess certain exclusive properties such as adequate adhesive ability, insolubility, dimensional stability, biocompatibility, bioactivity etc. Wide range of materials are available under this category. The ability to release calcium is a key factor for successful endodontic and pulp capping therapies because of the action of calcium on mineralizing cell differentiation and hard tissue mineralization. Calcium hydroxide has long has several drawbacks, namely, insufficient adherence to dentin, multiple tunnel defects in the dentin bridges, and dissolution over time. Mineral Trioxide aggregate may be used as an alternative to calcium hydroxide. It stimulates faster dentin bridge formation than calcium hydroxide, leading to pulp healing and high success rates in clinical procedures. However it has several disadvantages. Biodentine has been recently introduced in the market to overcome the limitations of MTA as long setting time, poor handling properties, cost, and the potential discoloration of teeth and soft tissue.

### Abstract 791

#### Shaping ability of protaper gold, one curve and self adjusting file systems in severely curved canals: A cone beam computed tomography study

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**Aim:** Aim of the study was to evaluate and compare canal transportation (CT), centering ability (CA) and volumetric changes in severely curved canals prepared using ProTaper Gold (PTG), One Curve (OC) and Self Adjusting File (SAF) systems via CBCT.

**Materials and Methods:** Sixty mesiobuccal canals of maxillary molars were selected. Pre- and post-instrumentation CBCT scans were taken in the same position. CT and CA were calculated at 1 mm, 4 mm, and 7 mm from the apex; change in volume for whole canal was measured and analysed statistically.

**Results:** SAF showed least mean CT at all the levels with no statistically significant differences at 1mm and 4mm when compared to other groups while statistically significant differences were observed at 7mm with PTG and OC. Regarding CA, SAF better maintained canal centricity than PTG and OC at all the levels assessed, though the differences were not statistically significant except at 7mm where statistically significant difference was observed between SAF and OC. SAF removed less volume of dentin followed by PTG and highest removal was shown by OC.

**Conclusion:** SAF showed promising behaviour with least CT, most centered preparation and minimal dentin removal.

### Abstract 792

#### Current strategies in metallurgical advances of rotary NiTi instruments

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Abstract

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A prerequisite of successful endodontic treatment is maintaining the original shape of the root canal system without procedural errors. Previously, the simple hand Endodontic files were made of carbon steel or stainless steel. Hence, while preparing curved root canals using simple hand instruments, some degrees of canal transportation may happen which may also lead to ledge formation and zipping perforation. Nickel-titanium (NiTi) instruments have improved the quality of root canal preparation due to their super elasticity, flexibility and cutting efficacy. This type of instrumentation, eliminates the iatrogenic events, such as ledges, zips, perforations and canal transportation in curved canals. Previous studies suggested that minimally invasive root canal preparation performed using NiTi files with a smaller taper may preserve the root dentin tissue as compared with that of large-tapered NiTi files and increase the fracture resistance of endodontically treated teeth. Today, thermal treatment of NiTi alloys also helps us to optimize the mechanical properties and increase the flexibility of these instruments. New NiTi files manufactured using recently produced heat-treated materials have a martensite-austenite transition temperature close to or higher than that of body temperature. NiTi file rotary systems with small tapered designs have recently been launched for conservative root canal shaping. These files include a variety of taper sizes for the preparation of narrow root canals and a coronal taper designed to protect the root dentin and facilitate canal preparation in narrow endodontic cavities with restricted access. The use of a single file technique is derived from the reciprocating philosophy in cleaning and shaping the root canal systems. Single file concept is requiring a minimum or no glide path and only a single file for complete instrumentation for majority of root canals. Single file rotary systems have advantage of reducing instrument fatigue. Today, the single file NiTi rotary systems have highly improved canal shaping along with reduced chair side time. The purpose of this scientific paper is to review current strategies in Metallurgical Advances of Rotary NiTi Instruments.

### Abstract 793

#### TEMS – Rerouting the root apices

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Endodontic surgery is a facet of comprehensive root canal treatment, which can treat the lesions that cannot be eliminated by nonsurgical techniques. The main objective is to produce a proper seal between periodontium and root canal foramina by eliminating disease at the root end. Endodontic surgery may become a back breaking procedure as the surgeon has to approximate a precise location of various anatomical structures like large blood vessels, mental foramen, maxillary sinus, nerves, etc. and prevent them from iatrogenic damage. The concept of Endodontic microsurgery was introduced in the 1990s as use of enhanced magnification and illumination fathered traditional endodontic surgery. It has been

continuously developing over the years and was further augmented by introduction of TARGETED ENDODONTIC MICROSURGERY (TEMS). TEMS was introduced in 2018; which demonstrates precise osteotomy site, angulation depth and diameter, in anatomically challenging sites. With TEMS, all parameters of osteotomy and root-end resection are expressly defined and if the stent is properly seated, deviation from ideal under clinical conditions is minimized. The precise control offered by TEMS may allow for surgical treatment at sites that were previously inaccessible. Targeted EMS could prove to be an important breakthrough allowing precision-guided surgery in anatomically complex areas for teeth that may have otherwise required extraction. For all its advantages, TEMS is something of a double – edged sword. Surgical phase simplification is achieved and time is reduced, but preoperative preparation requires technical expertise, equipment, and software for merging files and designing and printing 3D surgical guides. This review paper describes about the most recent advancement in the field of endodontic microsurgery and how it justifies its name and all the merits that come along with this technique as well as few of its limitations.

### Abstract 794

#### Endodontic flare up and its management

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India

An endodontic flare up is an acute exacerbation of an asymptomatic pulpal or periapical pathosis prior to initiation, during or post root canal treatment. Endodontic flare up is characterized by pain and / or swelling. The acute endodontic cellulitis exacerbation which can be potentially fatal is one of the definitive entity in endodontic flare ups. Hence endodontic flare up may require an emergency treatment. The causative factors of interappointment pain encompass mechanical, chemical and / or microbial injury to the pulp or peri radicular tissues. Microorganisms participate in causation of interappointment pain in various situations like apical extrusion of debris, incomplete instrumentation leading to changes in endodontic microbiota and secondary intra radicular infection. Thus flare up is a polyetiologic phenomenon. Knowledge of the cause of flare up and mechanism behind interappointment pain in endodontics is of utmost importance for the clinician to properly prevent or manage this undesirable condition. This review article underlines the various etiologic factors that leads to endodontic flare ups. It also highlights the various treatment modalities for relief of pain and swelling in endodontic flare ups.

### Abstract 795

#### Comparative evaluation of fracture resistance of endodontically treated teeth restored with three different restorative materials: An *in vitro* study

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Abstract

**Aim:** To compare the fracture resistance of endodontically treated Maxillary premolars with class II MOD cavities restored with three restorative materials - dental amalgam, dual-cured core build-up composite and sonic-activated bulk fill composite using Universal Testing Machine.

**Materials and Methods:** Fifty human permanent maxillary first premolars extracted for orthodontic purposes were taken as samples for the study and were randomly divided into five groups. Group I (positive control, n=10) specimens were maintained unaltered. In all the remaining 40 specimens standardized Mesio-Occluso-Distal (MOD) cavities were prepared, following which, endodontic procedures were carried out. No further intervention was done in the specimens in group II (negative control group, n=10). In the experimental groups- group III, group IV and group V (n=10 each) the specimens were restored with dental amalgam, LuxaCore Z Dual and Sonic Fill respectively. All the restored specimens were finished and polished and the specimens were stored in distilled water until fracture testing. Fracture resistance of the specimens was evaluated using universal testing machine.

**Results:** The results showed that the highest mean fracture resistance was shown by positive control group (intact teeth) and least mean fracture resistance was shown by negative control group. Among the experimental groups the highest mean fracture resistance was shown by Sonic fill group followed by LuxaCore Z Dual and dental Amalgam. Analysis of variance revealed that there was a statistically significant difference in fracture resistance between the five groups at ( $p < 0.001$ ).

**Conclusion:** Within the limitations of this study, it can be concluded that Sonic fill bulk Fill composite is a better material in terms of fracture resistance for the restoration of endodontically treated teeth with class II MOD cavities, in comparison to LuxaCore Z Dual and dental amalgam.

#### Abstract 796

##### Single visit endodontic therapy of inadequate treated maxillary molar: A case report

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**Background:** Endodontic treatment is frequently preferred by clinicians to be performed in multiple visits, but now this paradigm has changed. At present, root canal treatment can be completed in one visit. Nowadays, root canal therapy has become increasingly automated and can be performed more quickly. Single visit endodontic (SVE) therapy may be defined as the conservative non-surgical treatment of an endodontically involved tooth, consisting of complete chemomechanical instrumentation and obturation of the root canal system accomplished in one visit. It has become common practice which some clinicians are incorporating. Single-visit endodontics therapy has become a main component of contemporary practice and offers several advantages such as high patient acceptance and reduced flare-up rate. The aim of this case report is to present a clinical case of single visit endodontic therapy using crown-down pressureless

technique. A 22-year female patient came to the Department of Conservative Dentistry, Faculty of Dental Medicine of Universitas Airlangga with a chief complaint; The patient complained of throbbing pain in her upper right posterior tooth after being filled 1 month ago. Tooth #27 diagnosed with irreversible pulpitis and treated with single visit endodontic. Patient was given local anesthesia to relieve the pain and isolation with rubber dam was done on 27 tooth. Access opening and removal composite restoration followed by rewalling as pre-endodontic build up. Deep margin elevation using sectional matrix. Confirming the glide path and working length. Cleaning and shaping with crown-down pressureless technique and obturation using single cone technique. Final restoration with fiber post then followed by crown porcelain fused to metal on the following visit. Patient was satisfied with the result and no complaint on percussion and bite test. Single visit endodontic is a viable treatment option for teeth having irreversible pulpitis or apical periodontitis irrespective of tooth type or number of canals. Single-visit root canal treatment is safe regarding postoperative pain as well as secondary infection with minimal visit.

#### Abstract 797

##### Comparative evaluation by sonic activation of EDTA and NaOCl in removing the smear layer from root canal wall: A SEM study

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**Aim:** To compare removal of smear layer on sonic activation of 17% EDTA and 3%NaOCl solution from root canal wall.

**Material and Methodology:** Sixty single rooted premolar selected, decoronated at 16mm from apex and then equally divided into four groups. After instrumentation with protaper gold files upto f3 size the roots in group 1, were treated with final irrigation 17% EDTA and 3% NaOCl with sonic activation of 17%EDTA, in group 2 final irrigation with 17% EDTA and 3% NaOCl with sonic activation of 3 % NaOCl, in group 3 final irrigation done with 17%. EDTA and 3% NaOCl with both 17% EDTA and 3% NaOCl activated and in group 4 irrigation done with 17% EDTA and 3% NaOCl and solution were not activated. The roots were vertically sectioned and observed under scanning electron microscope for removal of smear layer at coronal, middle and apical third.

**Results:** Group 4 had largest number of tubules covered by smear layer in cervical, middle and apical third of roots, Group 2 also show tubules covered with smear layer in all thirds of roots, Group 1 had cervical and middle third were clean while apical third had smear layer on tubules and in Group 4 had cervical and middle third were clean and apical third is cleaner than that of Group 2.

**Conclusion:** Sonic activation of final irrigation solutions 17%EDTA and 3% NaOCl results in cleaner dentinal tubules in cervical and middle third as compare to apical third.

#### Abstract 798

##### Comparative evaluation of the cutting efficiency of heat treated nickel titanium and conventional nickel titanium endodontic files: A systematic review

Abstract

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**Aim:** This systematic review aims to investigate the cutting efficiency of heat treated NITI endodontic files with conventional NITI files.

**Methods:** Research question was developed according to PICO strategy. A literature search was performed using PUBMED, MEDLINE, EMBASE, SCOPUS, COCHRANE and Web of science and subject specific database to identify articles pertaining to cutting efficiency of heat treated NITI endodontic files and conventional NITI files by using keywords and MESH – “Cutting efficiency”, “Heat treated nickel titanium files” and “Conventional nickel titanium files”. The title and abstracts were screened by two independent reviewers and accordingly full text of the article was retrieved. Reference list of selected articles were also searched for any relevant studies. The inclusion criteria include: (a) Articles mentioning cutting efficiency of both heat treated and conventional nickel titanium endodontic files. (b) Studies performed on natural tooth. Exclusion criteria include: (a) Studies performed on models that does not represent natural tooth model. (b) Studies performed on endodontic files other than nickel titanium endodontic files. (c) Article language is not in English. A data was created by tabulating: Author name, publication year, Sample size, methods to evaluate cutting efficiency of both heat treated and conventional nickel titanium endodontic files. The eligible studies were submitted to the methodological assessment and data extraction. This systematic review was done according to the PRISMA guidelines given in PRISMA checklist.

**Results and Conclusion:** within the limitations of our review it can be concluded that heat treated NiTi files can be used with greater safety even in severely curved canals as both the heat treated and conventional rotary files showed similar amount of dentine removal.

**Abstract 799**

**Revascularization in an immature permanent tooth: A case report**

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Dental trauma or carious exposure in young or adolescent patient may arrest ongoing root development and cause pulpal necrosis. Arrested root development gives rise to immature tooth with thin, fragile walls that are prone to fracture. Prior to regenerative endodontic therapy, treatment options for immature tooth were limited to calcium hydroxide or MTA apexification or extraction. A 21 year old female reported with pain in anterior tooth region. Radiographic examination revealed a thin walled immature tooth #21 and tooth #11 and #12 with inadequate root fillings. Owing to the aesthetic demands, revascularization was attempted in tooth no #21. Platelet-rich fibrin was used as the scaffold. 18 months clinical and radiological follow up revealed regaining of pulp vitality, lengthening and thickening of dentinal walls. Platelet-rich fibrin being rich and sustained source of growth factors serves as an ideal scaffold in revascularization.

**Abstract 800**

**Comparative evaluation of postoperative pain with different irrigation agitation techniques in single-rooted teeth with symptomatic irreversible pulpitis**

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**Introduction:** Various irrigation techniques and irrigant delivery devices have been proposed to increase the flow and distribution of irrigating solutions within the root canal system till the apical foramen. This study aimed to compare postoperative pain using manual dynamic agitation(MDA) and modified MDA (GP point 2mm short of working length).

**Methods:** 15 single-rooted teeth with symptomatic irreversible pulpitis were selected. After establishing working length(WL), Biomechanical preparation (BMP) was performed using Protaper file system in continuous presence of 2.5% NaOCl. The patients were divided into 3 equal groups (n = 5) according to the final irrigation activation technique:

Group 1,(control); canals were irrigated with 2.5% NaOCl using a 30 gauge side vent needle and no agitation was done.

Group 2, Manual dynamic agitation (MDA); Canals were filled with 2.5% NaOCl and the solution was agitated manually with a well fitting master Gutta percha cone upto WL.

Group 3, Modified manual dynamic agitation (mMDA). Irrigant was agitated in the same manner as in group 2, except that the apical limit of GP was kept 2 mm short of WL. To ensure this, master GP was cut 2 mm from its tip and verified radiographically prior to agitation. After irrigant activation, all root canals were irrigated with saline, dried and obturated using resin based sealer. Postoperative pain was evaluated after 6, 24 hrs and then daily upto 7 days and data was statistically analysed.

**Results:** At 6 and 24 hrs, patients in mMDA group exhibited least postoperative pain scores ( $p < 0.5$ ). After that, there were no significant differences in pain scores between the groups.

**Conclusions:** Modified manual dynamic agitation seems to be a better agitation technique as compared to conventional MDA or needle irrigation. Further studies are required with higher sample size to achieve definite clinical conclusions.

**Abstract 801**

**The resonation of phoenix**

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Tooth avulsion in children and young adults demands emergency treatment to increase the chances of successful re-implantation. The treatment prognosis depends on intrinsic and extrinsic factors, such as the extra-alveolar time until re-implantation, storage medium, handling, and periodontal ligament condition of the avulsed tooth as well as the patient's general health. The primary goal in treating an avulsed tooth is to preserve and treat the supporting tooth tissues and to replant the avulsed teeth. This case report consists of two cases of re-implantation of avulsed maxillary left central incisors and maxillary right canine due to trauma. In case with avulsed maxillary

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left central incisor the tooth was re-implanted after one hour of trauma and in the case with avulsed maxillary right canine the tooth was re implanted after 3 days using platelet rich fibrin. splinting was done. The teeth were stabilized for 4 weeks and prophylactic antibiotic was prescribed.

**Abstract 802**

**Morphologic wandering -vertucci Type 2 in mandibular canine: Case report**

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The morphologic aberrations of root canals include bifurcation and trifurcation of canals which make it difficult to diagnose and manage. The anatomy of the root canal system determines the parameters under which the endodontic treatment will be accomplished and directly affects the success of the root canal treatment. Hence, a thorough knowledge of the root canal morphology, careful radiographic interpretation and access cavity modifications are essentials for enhancing endodontic procedures. The case presents with mandibular right canine with Vertucci type 2 canal morphology. The tooth was endodontically treated and managed successfully.

**Abstract 803**

**A comparative evaluation of etidronic acid and EDTA irrigating solutions on dentin demineralization and removal of smear layer - A systematic review**

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**Aim:** This systematic review aims to evaluate Etidronic acid and EDTA irrigating solutions on dentinal demineralization and removal of smear layer.

**Methods:** Research question was developed according to PICO strategy. The literature search, was performed in PUBMED, MEDLINE, EMBASE, SCOPUS and COCHRANE using the keywords and MESH – EDTA and Etidronic acid, “dentinal erosion”, “smear layer”. A hand search of the reference list of identified articles was performed to isolate relevant articles. Two reviewers critically assessed the studies against our inclusion and exclusion criteria. The inclusion criteria includes studies performed on human extracted teeth. Exclusion criteria include: (a) studies performed on models that does not represent natural tooth model (b) The studies on animal teeth or plastic blocks (c)previously root filled or open apex tooth (d) article language is not English. The data extraction and synthesis were formulated according to Preferred reporting items for systematic reviews and meta-analysis (PRISMA) checklist.

**Results and Conclusion:** 1) According to Aby et al there was no significant differences in smear layer removal between the two solutions.

2) According to Ulusoy et al NaoCl with Etidronic acid showed highest smear layer removal and highest erosion.

3) According to Emere et al NaoCl with Etidronic acid showed minimal dentinal erosion.

4) There was considerable differences in the studies included. this

differences have led to conflict evidence. hence further research is required to produce definitive results.

**Abstract 804**

**Nonsurgical management of open apex in palatal canal of maxillary first molar**

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It is quite natural to achieve proper canal disinfection, adequate debridement and optimum apical sealing of the root canal in a teeth with closed apex. Whereas achieving these parameters in a tooth having wide open apex is a challenge for an endodontist. Lack of apical stop in cases with open apex puts the clinician in an uncertain circumstance. Starting from working length determination, cleaning and shaping and apical sealing of the root canal. These type of teeth are more commonly associated with periapical pathology. Early necrotized pulp and inflammatory apical root resorption are the most common etiological factors for the formation of open apex in the teeth. Clinicians need to be very careful to avoid peri-apical extrusion of the materials, which may lead to post-operative symptoms like pain and swelling. Besides this, there is an increase in the risk of tooth fracture with intracanal calcium hydroxide dressing for an extended period. Apexification using biocompatible material facilitates 3-dimensional sealing of the root canal along with good adaptation of the obturating materials which will lead to a successful endodontic treatment. This is a case report of successful non-surgical management of open apex in palatal root of maxillary first molar.

**Abstract 805**

**Artificial intelligence in endodontics**

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The goal of an endodontic treatment is to decrease microbial load of endodontic pathogens and also to retain functional state of tooth, with minimum complications. With the advancement in science and technology, a newer technology has been proposed-ARTIFICIAL INTELLIGENCE which can be applied in dentistry. Artificial intelligence is a newer technology composed of neural network architecture which mimics human brain. As we know, stimulus is transmitted to human brain via synapse, in similar way, messages are transmitted to artificial intelligence as input through nodes and output is recieved as pixel image. In the field of endodontics, artificial intelligence is useful in determination of working length, assessment of root morphologies, detection and diagnosis of vertical root fracture, and prediction of periapical pathologies, especially in root filled teeth, since CBCT is unable to provide accurate diagnosis in root filled teeth due to formation of beam hardening artifact and also to predict outcome of regenerative endodontics through neuro fuzzy interference system. Through artificial intelligence one can assess whether one should go for surgical or non-surgical management of separated instrument via virtual treatment and finite element analysis. This review

Abstract

paper describes various applications and effectiveness of artificial intelligence in the field of endodontics.

**Abstract 806**

**Endodontic management of tooth with open apex using MTA as an apical barrier under surgical operating microscope: A case report**

**NEHA VERMA**

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In a tooth with an open apex, absence of natural constriction at the end of the root canal can pose a challenge to the most skilled dental practitioners. Owing to the lack of an apical constriction, an alternative to standard root canal treatment, apexification or root end closure has been advocated. Calcium hydroxide has been routinely used in the past for apexification. Apexification done with calcium hydroxide encounters certain difficulties like very long treatment time, possibility of tooth fracture and incomplete calcification of the bridge which led to the development of newer biocompatible materials which can complete apexification in a single visit. Although different materials are available, but because of its superior clinical properties and demonstrated clinical success, mineral trioxide aggregate (MTA) remains the material of choice for forming an immediate apical barrier. The major advantage of apexification with MTA is that the treatment can be completed in reasonably less time with predictable results and better patient compliance. In the present case report, maxillary left central incisor with open apex was successfully treated using MTA under magnification. After access preparation and working length determination, circumferential instrumentation was done along with irrigation followed by calcium hydroxide intracanal dressing for one week. On the second appointment calcium hydroxide medicament was removed and a hard barrier was formed by placing 4 mm MTA plug in the apical area. The use of operating microscope was very much helpful to place MTA barrier precisely in the apical area and it provided with better depth of field. After confirming the hard set of MTA, obturation was completed using gutta-percha and bioceramic sealer. Access cavity was sealed with composite resin followed by placement of zirconia crown as final restoration. A positive clinical outcome of this case is encouraging for the use of MTA as an apical plug, in immature teeth with open apex and use of surgical operating microscope facilitated the treatment procedure and had a positive impact on the treatment outcome.

**Abstract 807**

**Perfecting the imperfect: Case report on Amelogenesis imperfecta**

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Amelogenesis imperfecta (AI) is a hereditary disorder that causes developmental alterations in the structure of enamel, caused by gene mutations that alter the quality and/or quantity of enamel. In this disorder, the enamel is either hypoplastic, hypomineralized or both which can impact both primary and permanent dentition, varies

among affected individuals, and results in aesthetic and functional complications. It may be autosomal dominant, autosomal recessive, sex-linked or sporadic pattern. The treatment for amelogenesis imperfecta depends on the severity of the condition and age of the patient. It is crucial to diagnose this disorder and plan a proper remedy, which requires collaboration among dental specialties to execute comprehensive dental treatment in order to provide a long-term solution with adequate aesthetics. This case report shows a restorative and aesthetic rehabilitation of a 21-year old male patient affected by a hypoplastic type of amelogenesis imperfecta.

**Abstract 808**

**Auto transplantation: An autologous prosthesis – A case series**

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Tooth auto transplantation is defined as the transplantation of an unerupted or erupted tooth in the same individual, from one site to another extraction site or a new surgically prepared socket. Simple in concept, auto transplantation is the treatment of choice in selected cases. Successful auto transplantation offer many advantages in a growing patient, including proprioception, preservation of alveolar bone volume, greater resistance to occlusal loading, maintenance of surrounding bone, the potential for better aesthetics and an excellent outcome from the cost-benefit perspective. Disadvantages include more surgical involvement than in conventional extraction and difficult predictability of outcome which depends solely on the technique sensitive procedure. Success rate even though is reported to be more in immature than mature teeth, literature do showcase many cases of successful auto transplantations carried out in mature teeth with closed apex too, with reported follow up period being at an average of 10 years. This presentation thus comprises successful management of two auto transplanted molars; the first being a maxillary molar and the second a mandibular molar.

**Abstract 809**

**Reattaching fractured segment of complicated fractures in maxillary central incisor: Case series**

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An injury to the tooth results in damage to many dental and periradicular structures. This, in turn, makes the management as well as consequences of these injuries multifactorial. Most dental trauma occurs in the 7- to 12-year-old age group owing to falls and accidents. It affects the anterior region of the mouth primarily, occurring in the maxilla more than the mandible. 80% of these involve central incisors. A complicated crown fracture is one involving enamel, dentin, and pulp- constituting 0.9% to 13% of all dental injuries. A crown fracture involving pulp will almost always result in pulpal necrosis if left untreated. Treatment options for complicated crown fracture are (1) vital pulp therapy, comprising pulp capping, partial pulpotomy, or full pulpotomy; and (2) pulpectomy. The treatment

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choice will depend on factors like the stage of development of the tooth, the time elapsed between trauma and beginning of treatment, concomitant periodontal injury, and the restorative plan. Crown-root fracture also often proves as a periodontal challenge. Hence, the tooth will also need periodontal treatment to enable a well-sealed coronal restoration, which will highly influence the prognosis. If quick and correct treatment for these teeth is provided after injury, the potential for a successful endodontic outcome is increased. This case series will shed some light on the management of maxillary central incisors with complicated fractures. In the cases to be discussed, endodontic treatment was performed following which post was placed. The coronal segment was modified according to the post placed and then reattached. The reattachment of a tooth fragment is a viable technique that restores function and esthetics with a very conservative approach, and hence was the approach chosen for the management of these cases.

### Abstract 810

#### Nonsurgical retreatment with perforation repair: A case series

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The root canal therapy comprises of various steps and hence, has a multitude of reasons for failure. Iatrogenic perforations are often encountered with failed root canal therapy. Inadequate cleaning and shaping, improper obturation, missed canals, poor coronal and apical seal are also some of the very frequently associated reasons for failed root canals. The following is a case report series of cases with failed root canal therapy due to the above mentioned reasons. The case series highlights management of these failed treatment outcomes with non surgical retreatment and repair of iatrogenic errors using biomimetic materials. The teeth were restored and followed up for healing.

### Abstract 811

#### Platelet rich fibrin as ingenious biomaterial in regeneration: A systematic review and meta analysis

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Platelet-rich fibrin (PRF) described by Choukroun et al. is a second-generation platelet concentrate that allows one to obtain fibrin membranes enriched with platelets and growth factors. It is an autologous biomaterial. Recently, it has been reported that PRF can stimulate cell proliferation of osteoblasts, gingival fibroblasts, pulp cells, and periodontal ligament cells, but suppress oral epithelial cell growth. Platelet-rich fibrin (PRF) enriched with platelets and growth factors serves to accelerate the wound healing of periapical lesion in permanent teeth and also serves as internal matrix to condense biomaterial. The progressive polymerization mode of coagulation in PRF helps in the increased incorporation of the circulating cytokines into the fibrin meshes (intrinsic cytokines) which helps in wound

healing by moderating the inflammation. In a periapical wound, the initial inflammatory process strives to replace the red blood cell clot with a fibrin scaffold. The use of PRF may help to hasten this process by providing a ready-made fibrin meshwork for the ingrowth of granulation tissue and thereby reduce the associated inflammatory response. Due to this, the use of PRF may also contribute towards reduced patient morbidity in terms of pain and postoperative edema.

### Abstract 812

#### The butterfly effect – An overview

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The principle goal of root canal treatment (RCT) is the elimination of disease-causing microbes from the root canal system. The use of a sealer during obturation is important to minimize voids between the core filling material and the canal wall, and to seal dentinal tubules and lateral canals. The penetration and adaptation of a sealer depends on many factors such as its viscosity, the patency and density of the dentinal tubules. Some teeth exhibit an optical phenomenon known as the “Butterfly Effect” and have a significantly higher density of dentinal tubules in the bucco-lingual direction compared with the mesio-distal. The presence of the butterfly effect may impact on the behaviour of sealers inside root canals. Teeth with the butterfly effect could be more prone to developing cracks in this direction due to their significantly higher dentine hardness mesio-distally. This is important during apical surgery, as the use of ultrasonic retrotips for root-end preparation can lead to increased formation of cracks in dentine. Such cracks could promote microleakage and may propagate to form Vertical root fractures. This review paper describes the significance of butterfly effect, its role in sealer penetration and its impact on the prognosis of the tooth post endodontic surgeries.

### Abstract 813

#### Evaluation of effect of diode LASER, biodentine and PRF membrane in direct pulp capping procedure: A case report

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The dental pulp is the most sensitive part of the tooth. Vital pulp therapy is aimed at preserving and maintaining health of pulp in teeth in which pulp exposure has occurred due to caries and restorative procedures. One of the best options for the treatment of a pulp-exposure in permanent teeth is “Direct Pulp Capping”. Direct pulp capping is a procedure in which exposed vital pulp is covered with a protective capping material over the site of exposure in an attempt to preserve pulp vitality. LASER is being used for multiple applications in dentistry, one of which is LASER-assisted repair of pulpal tissue. For this purpose Diode LASER (980nm, 1.5W, continuous wave, fiber diameter 400 micrometer, 2 seconds) is commonly used to expedite the repair of the pulp. 16 Cariously exposed permanent teeth with reversible pulpitis were selected. Sensibility of tooth was assessed using cold test and digital electric

Abstract

pulp tester. Under local anaesthesia and rubber dam isolation caries was removed and they were divided into 4 equal groups. In GROUP 1, Biodentine and in GROUP 2, patients own PRF membrane were placed on pulp exposure site as capping material which was covered with RMGIC and restored with composite restoration. After the LASER application on exposure site, Biodentine was placed in GROUP 3 and patients own PRF membrane was placed in GROUP 4 as capping material which were covered with RMGIC and restored with composite restoration. The patients were kept on regular follow up visits and found that the teeth were functioning normally. The thickness of reparative dentine formed at the exposure site were assessed radiographically and it was found that the LASER assisted pulp capping procedures showed better results than the other groups.

#### Abstract 814

##### Contemporary ways to combat endodontic biofilm

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SHRADDHA CHOKSHI**

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India

The success of root canal therapy depends on adequate cleaning, shaping and three dimensional obturation of the canal. One of the major aims of biomechanical preparation of root canal system is elimination of microorganisms especially residing in the biofilm. However, complete eradication of biofilm is a difficult task. For this purpose, root canal irrigants such as sodium hypochlorite, chlorhexidine, MTAD, Qmix, etc. are routinely used. Owing to certain drawbacks of chemical irrigants various natural products can also be used. Beside these calcium hydroxide, chlorhexidine, and triple antibiotic paste are effectively used as intracanal medicaments for canal disinfection. These therapeutic strategies against microbial biofilm focus on inactivating the structure of resident bacteria and disrupting the biofilm structure. Recently ultrasonic irrigations systems, lasers, photodynamic therapy and ozone therapy have been introduced. Nanoparticles also have good antimicrobial action against biofilms. This review paper will briefly describe the various treatment options and advances in therapeutic strategies in eradication of endodontic biofilm.

#### Abstract 815

##### Diagnosis of vertical root fracture using cone-beam computed tomography: Systemic review

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According to the American Association of Endodontists (AAE) classification, there are five types of cracked teeth and Vertical root fracture is one of them. Radiographic techniques are an important aid in the diagnosis of Vertical root fracture. However, Conventional periapical radiographs can only provide a definite diagnosis of obviously displaced root fractures. Cone-beam computed tomography has been widely used in diagnosis of vertical root fractures in recent

years. Due to the variability and overlapping of the cracks and fractures, some narrow fractures on the roots of VRFs could not be detected by CBCT, and some wide cracks on the crown of cracked teeth could be detected by CBCT. In this review, we discussed about the capability and accuracy of CBCT and its advantages and disadvantages in the diagnosis of Vertical root fractures.

#### Abstract 816

##### Effect of diode laser on penetration of two different bioceramic root canal sealers into dentinal tubules evaluated using confocal laser scanning microscopy: An in-vitro study

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**Objective:** The present in vitro study aimed to evaluate the effect of diode laser on the penetration of two different bioceramic sealers into dentinal tubules using confocal laser scanning microscopy (CLSM).

**Material and Methods:** Eighty human premolar teeth with single canals were decoronated at the level of root length of 16mm. Working length (WL) was determined using #10 K file. The root canals were prepared using ProTaper Gold rotary files operated at 300 rpm, 5ml of 3% sodium hypochlorite solution was used for five minutes followed by 17% ethylenediaminetetraacetic acid gel and saline, the final rinse was carried out with distilled water. The prepared teeth samples were then randomly divided into 4 groups (n=20) according to the laser intervention and type of bioceramic sealers used. Group 1 was obturated with gutta percha using Bioroot RCS without any laser intervention, group 2 was obturated with gutta percha using MTA Fillapex without any laser intervention, group 3 was irradiated using 980nm diode laser followed by obturation with gutta percha using Bioroot RCS and group 4 was irradiated using 980nm diode laser followed by obturation with gutta percha using MTA Fillapex. After 1 week, all the eighty treated teeth were prepared for (CLSM) analysis at 3mm and 5mm from the apex. Results were analyzed using Post Hoc Tukey test and Independent 't' test.

**Results:** Sealer penetration was observed in all the test samples of the study. Maximum sealer penetration depth was observed in group 3 followed by group 4, group 1, and least in group 2 and the difference was statistically significant ( $P < 0.01$ ). Sealer penetration depth was higher in 5mm from the apex when compared with 3mm from the apex.

**Conclusion:** Within the constraint of this study, it can be concluded that sealer penetration of tested bioceramics sealers is enhanced by the irradiation of canal using 980nm diode laser.

#### Abstract 817

##### Direct pulp capping of cariously exposed vital human permanent teeth with biodentine and combination with biodentine and platelet rich fibrin

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Abstract

**Aim:** To evaluate clinical and radiographic outcomes of direct pulp capping using Biodentine and Platelet rich fibrin (PRF) along with Biodentine in cariously exposed vital permanent teeth.

**Material and Methods:** Forty two patients with a diagnosis of reversible pulpitis in the age group of 18-35 years with carious exposure of size upto 2 mm were selected for the study. The subjects were randomly divided into two groups as follows: group 1: Biodentine (N=21) used as pulp capping material and group 2: PRF with Biodentine (N=21) used as pulp capping material. The patients were recalled at 24 hours, seventh day, one month and third month. Clinical and radiographic evidence of pulpal and periapical pathologies and presence or absence of response to tenderness on percussion, mobility, responses to vitality tests with cold and electric pulp tester was evaluated. In addition third month radiovisiographic quantitative evaluation was done for dentine bridge formation.

**Results:** Seventh day evaluation showed significant difference in sensitivity score between groups. Whereas in group 2 experienced less pain compared with group 1 at the end of one month evaluation. Radiographically both Biodentine alone and combination with PRF showed significant dentine bridge formation at the end of three month follow-up period. The mean dentine bridge formation observed in group 2 (0.3056) was higher compared with the group 1 (0.2643) with no significant difference between the groups analysed by student's t test. The overall success rate of direct pulp capping was 83.3%. Over a period of three months, success rate of 76.1% and 90.4% in group 1 and group 2 respectively were observed.

**Interpretation and Conclusion:** Clinical and radiographic evaluation of Biodentine alone and its combination with PRF showed promising results as direct pulp capping material. PRF showed higher potential for dentine bridge formation in vital permanent teeth within 2mm of carious exposure.

### Abstract 818

#### Efficiency of ultrasonography in oral examination and periapical lesions

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**Introduction:** The aim of this study is to compare the findings obtained by ultrasonography (US) with the findings of different examination and two/three dimensional radiographic methods.

**Materials and Methods:** 117 patients that had 120 periapical lesions (PL) were included in this study. After the informed consent forms were obtained from individuals who wanted to participate in this study, extraoral and intraoral examinations were performed detailed and radiographs of the patients with two/three dimensional were evaluated. Following this, a detailed US examination of all patients was performed with both extraoral and intraoral probes. The visibility of the PL on US was assessed by periapical index scoring and the amount of remaining bone obtained in CBCT. PL echogenicity (anechoic / hypoechoic / hyperechoic) was evaluated in terms of cyst and granuloma. Mesiodistal (MD) and superioinferior (SI) measurements of the PL were calculated on all radiographic methods and compared with measurements obtained by US. Independent t-test and chi-square test were used to compare categorical groups.

The Pearson correlation coefficients of the measured were calculated.

**Results:** 49 images obtained with US in 120 PL have a PAI score of 3 and above. There was 33% negative correlation between the amount of bone remaining on CBCT and the PAI score of PL visualized on US. 8 cysts and 41 granulomas were prediagnosed by US during the evaluation of echogenicity. 6 chronic lymphadenopathies (5.11%) detected in the palpation of the lymph nodes could also be visualized by US. 7 sinus tracts routes could be followed by US in the 16 sinus tracts observed with clinical examination of 120 PL. MD measurements of PL detected with US had a positive correlation between MD measurements of periapical (89.9%), panoramic (78.9%) and CBCT (98.9%). In addition, SI measurements of PL detected with US had a positive correlation between SI measurements of periapical (89.9%) and CBCT (99.5%).

**Conclusion:** US is an alternative, non-ionized, three-dimensional and real-time imaging method in oral examination and perforated or thinned cortical bone areas during the examination of PL.

### Abstract 819

#### The difference of antibacterial potency between 6% cocoa (theobroma cacao) peel extract compared to 5% NaOCl against lactobacillus acidophilus as pulp cavity cleanser

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**Objective:** To analyze the difference in antibacterial power between the extract of cocoa peel extract with a concentration of 6% compared to 5% NaOCl against Lactobacillus acidophilus.

**Methods:** this research was conducted with laboratory experimental in vitro study with a post test-only control group design. Using the diffusion method against Lactobacillus acidophilus grown in tubes containing BHIB, then cultured in a petridish which contains a nutrient agar and is divided into 2 parts 6% extract cocoa peel extract and 5% NaOCl, then each petridish given a paper disc that has been poured 10 $\mu$ l by each material, then incubated in the incubator for 2x24 hours at 37oC and observe the diameter of the inhibition zone formed using a caliper.

**Results:** Data from the results of the Independent T-test statistical test showed that the inhibition zone diameter between groups of 6% cacao peel extract compared to 5% NaOCl against Lactobacillus aureus bacteria had a significant difference in results. The mean diameter of the inhibition of Lactobacillus acidophilus formed with 6% cocoa peel extract was 11.8375 mm and NaOCl 5% was 26.0344 mm.

**Conclusion:** This study showed that there was a difference in antibacterial power between 6% cocoa rind extract and 5% NaOCl against Lactobacillus acidophilus, with higher antibacterial value of NaOCl than cocoa peel extract. Funding Source: This work was financially supported by the Government of Indonesia through Faculty of Dentistry, Airlangga University.

### Abstract 820

#### Endodontic treatment and non-vital internal bleaching procedure on maxillary anterior teeth with discoloration teeth: A case report

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SEYTABUDI GOENHARTO**

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**Background:** Tooth discoloration can be extrinsic or intrinsic which can cause aesthetic problems that affect individual appearance and confidence, especially in anterior teeth that can occur due to traumatic injury, caries, or failed restorations. Intracoronal bleeding in the tooth pulp due to trauma is one of the causes of tooth intrinsic discoloration. Internal bleaching is a non-invasive procedure to restore tooth color which is performed after endodontic treatment using a strong oxidator agent in pulp chamber.

**Purpose:** The purpose of this case report is to explain management endodontic treatment post dental traumatic then followed non-vital internal bleaching procedure on maxillary anterior teeth with discoloration teeth. Case: A 40 years old female came to the Airlangga Dental Hospital with a chief complaint of discolored maxillary left central incisor had a traumatic injury about 8 years ago. The patient began to notice that there is a discoloration about 1 year post trauma. The tooth asymptomatic and has never been treated. Case Management: The first is endodontic treatment was performed on tooth 21 using the crown down pressureless preparation technique and obturation with single cone technique followed by internal bleaching procedure using 35% hydrogen peroxide and finally restored with direct composite as a permanent restorations.

**Conclusion:** The treatment combination of endodontic treatment and internal bleaching procedure then followed direct restoration successfully treated tooth discoloration and able to produce good aesthetic results.

**Abstract 821**

**Hemisection as an effort to save tooth with extensive defects involving bifurcation**

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**Background:** In line with the increasing efforts of oral health promotion, people increasingly understand the importance of maintaining dental health and function to preserve the stomatognathic system. Unfortunately, patients often come to the dentist with severe tooth decay even with indications of extraction, but still want to save their tooth. Hemisection which is a procedure of cutting and removing the decayed root and its coronal part and preserving the other healthier portion, becomes one of conservative management to save the hopeless tooth.

**Objective:** This case report aims to describe the endodontic treatment and hemisection procedure on necrotic molars with bifurcation involvement Case: A 23-year-old woman complained of a large cavity in the posterior right mandibular tooth that often bleeds and had dull pain when eats. Clinical examination showed large and deep caries with gingival polip and tooth discoloration. Periapical X-ray showed radiolucent appearance of the mesial

root, perforation in the distal root and bifurcation. This tooth was diagnosed as necrotic pulp with symptomatic apical periodontitis. Case Management: Root canal treatment was performed on the mesial root and fiber post was placed. Then hemisection was performed by cutting and removing the distal root and crown. After healing, the tooth was restored with a porcelain fused to metal crown.

**Conclusion:** With proper case selection, appropriate procedure and careful management, hemisection can be done successfully to save and maintain the hopeless tooth.

**Abstract 822**

**Management of open apex in maxillary central incisors with mineral trioxide aggregate: A case report**

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**Background:** The maxillary anterior teeth in both children and adults are often traumatized. When a tooth gets traumatized and results in necrotic pulpal pathology, the formation of the root is disrupted which leads to an open apex. In those cases, the absence of normal apical constriction of the root canal could make complications to the management of root filling materials. Management of open apex can be done using mineral trioxide aggregate (MTA) which is used for creating an apical plug, repairing root perforation, treating internal root resorption, and can be used as root-end filling material and pulp capping material. Apexification with MTA is the treatment of choice which induces the calcific barrier at the apex which produces a favorable environment for root canal filling.

**Purpose:** This report aims to show the use of MTA to form an apical plug in the open apex followed by complete root canal obturation using thermoplasticized gutta-percha. Case: A 19-year-old female patient came with the complaint of fractured maxillary right and left central incisors. The patient reported that the trauma occurred about 10 years ago and no treatment had been performed. Clinical examination revealed crown fracture exposing pulp of maxillary right and left central incisors. The tooth failed to respond to the vitality test. The radiographic examination revealed the presence of a periapical lesion and the open apex. Case management: Apexification with MTA was decided as the treatment plan and in the same sitting isolation was done and access was made. Working canal length was determined with an apex locator and confirmed by radiography. The canal was shaped with Headstroem #80 with circumferential motion filling and copious irrigation of sodium hypochlorite 2.5%, EDTA 17%, and chlorhexidine 2%. MTA was placed at the next appointment and two days later obturation was done in the third visit using thermoplasticized technique. The patient was reviewed one week later and the patient experienced no symptoms.

**Conclusion:** Apexification using MTA can reduce treatment time by forming an apical plug in the open apex and obturation can be done immediately.

Abstract

**Abstract 823**

**Nonsurgical endodontic management of an atypical mandibular premolars: Rare case reports**

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Mandibular premolars are often considered as Enigma to Endodontist due to presence of atypical anatomic variations

exhibiting combination of multiple roots and root canals. Small anatomical crown with thin roots and multiple canals often complicate the access cavity preparation, cleaning and shaping and obturation. CBCT play an important role in diagnosing the anatomical variations and helps the clinician to prevent endodontic mishaps. This paper reports successful management of mandibular second premolar with two roots and three canals diagnosed with help of CBCT and mandibular first premolar with two roots and Vertucci type I root canal configuration.

This handbook contains structured instructions to recording a case history prepared by using the standard textbooks of Periodontology. It explains in detail the demographics, history recording, clinical examination, diagnosis, prognosis and treatment planning in order to help students in efficiently recording the case of a patient. This book is prepared in interest of undergraduate and post graduate students based on the newer edition of books recommended by the Dental council of India(DCI) and also includes recent advances and technologies in the field of Periodontics.

Case History Recording in Periodontics



Shweta Shivayogi Hugar

# Case History Recording in Periodontics

Handbook of Case history



Dr. Shweta Shivayogi Hugar is an established academician and clinician in the field of Periodontics & Implantology. She has completed her MDS from KAHER's KLE VK Institute of Dental Sciences, Belagavi. She is a life member of ISP and has various Certificate courses, Patents and publications in esteemed journals to her credit. She is presently working at KLE VK Institute of Dental Sciences, KLE Academy of Higher Education and Research, Belagavi.



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**Case History Recording in Periodontics**

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# **Case History Recording in Periodontics**

**Handbook of Case history**

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## **Chapter 1**

### **INTRODUCTION**

Case history taking is the first and the most important step in the treatment of a patient. A correct diagnosis leads us to a correct treatment plan. The case history is a planned professional conversation with the patient that enables the patient to communicate their symptoms. The interest, warmth and compassion exhibited by the clinician during history taking helps in establishing a rapport with the patient and to gain the confidence of the patient. A good clinician starts examining the patient when he/she walks into the clinic. Ideally, the case history should be recorded in a consultation room or a private room, so that the patient is free of the anxiety of dental operator room. The clinical examination is done in the dental operator in a calm and friendly atmosphere.

A proper clinical and radiographical examination can reveal many other findings which help us to associate problems in a particular case, thus helping us to provide a good periodontal health and a functional occlusion to the patient.

## Chapter 2

### **Biographic and demographic information**

This is the first step in history taking where we record the patient's Name, Age, Address, Contact no.

#### **Name:**

It is important to know about patient name as it helps us to establish a good rapport and patient feels free and friendly to explain his/her symptoms to the doctor. Patient also feels comfortable and good when we address them by their name.

Name is also important to identify the patient for future correspondence and patient registration no and date is necessary to keep records for billing purposes and medico-legal cases.

#### **Age:**

It is very important to know the age of the patient because certain conditions are common in certain age group. Such as aggressive periodontitis cases are usually seen in younger age group and chronic periodontitis cases are seen in old patients. It is necessary to know the age for diagnosis, treatment planning and behavioural management techniques.

### **Diseases more commonly present at birth**

- Micrognathia
- Cleft lip and cleft palate
- Pre deciduous dentition
- Teratoma
- Haemophilia

### **Disease present in children and young adults**

- Benign migratory glossitis
- Juvenile periodontitis
- Pemphigus
- Recurrent aphthous stomatitis

- Dental caries
- Dentigerous cyst
- Diphtheria
- Rickets
- Infectious mononucleosis

### Diseases present in adults and older patients

- Attrition
- Abrasion
- Gingival recession
- Periodontitis
- Lichen planus
- Ameloblastoma
- Trigeminal neuralgia
- Fibroma
- Verrucous carcinoma
- Iron deficiency anaemia
- Diabetes
- Hypertension
- Asthma

### Age specific periodontal diseases

Periodontal condition	Age	
<b>Gingival diseases</b>		
Herpetic gingivostomatitis	≤ 6 years	As the condition is contagious, adults would have been exposed to the virus in their childhood and would have developed immunity. Thus it is seen predominantly in children.
Puberty associated gingivitis	11-17 years	Hormonal changes increase; <ol style="list-style-type: none"> <li>1. Tissue response to plaque</li> <li>2. Capnocytophaga , prevotella intermedia and prevotella nigrescens all of which use hormones as nutrients.</li> </ol>
Acute necrotizing ulcerative gingivitis	15-30 years	Seen at any age but most commonly between 15-30 years. Children with Down's syndrome and children from low socioeconomic status are predisposed.
Desquamative gingivitis	40-50 years	It is usually of autoimmune origin. Auto-immune conditions are common in middle aged women. An exception is dermatitis herpetiformis which is seen in males between 20-30 years.

Periodontal disease		
Aggressive periodontitis	≤35 years	The rate of bone loss here is 3-4 times faster than in chronic periodontitis hence the disease manifests at a younger age.
Chronic periodontitis	≥35 years	Though the condition may begin in adolescence due to the slow rate of progression it becomes clinically significant after the age of 35.

Children show more of a T cell response and it is associated with gingivitis, whereas B cell response is associated with periodontitis. Periodontitis is not common in systemically healthy children.

Prognosis of the patient depends upon his age. In two patients with the same level of disease the older patient has a better prognosis. At less age if patient has lost more attachment, then prognosis will be poor.

### **Age – used to calculate the dose of the drug**

Child dose

1. YOUNG RULE = child's age/ age+12 ×adult dose
2. CLARK RULE= child age at next birthday/24×adult dose

### **Sex:**

Certain diseases are common in a particular gender for example; localized aggressive periodontitis the sex predilection depends upon the race. In African Americans it is more common in males while in Caucasians it is more common in females.

Desquamative gingivitis also found more common in females than the males

### **Conditional changes in females**

Due to the hormonal conditions in puberty, pregnancy and oral contraceptives the level of oestrogen and progesterone level increases. Progesterone increases vascular permeability and makes blood vessels more torturous this will result in increased inflammatory response to bacterial plaque.

Apart from this. *Prevotella intermedia* use progesterone as a substitute for vitamin K as a growth factor, these organisms are implicated in both puberty and pregnancy associated gingivitis.

Menopause; oestrogen affects cellular proliferation, differentiation and keratinization of epithelium. Oral changes seen in menopause are thinning of oral mucosa, burning mouth, gingival recession, xerostomia, altered taste sensation, alveolar bone loss and alveolar ridge resorption.

Osteopenia and osteoporosis have been associated with menopausal patients. Osteopenia is a reduction in bone mass due to an imbalance between bone resorption and formation, favouring resorption and resulting in demineralization and osteoporosis.

Osteoporosis is a disease characterized by low bone mass and fragility and a consequent increase in fracture risk. Results of some studies indicate that osteoporotic patients might have a greater bone loss due to periodontal disease than those without periodontal diseases.

### **Occupation:**

#### **Occupational hazards**

Abrasion – notching of incisal edges in tailors because of holding bobby pins and threads between their teeth.

Erosion – people working in factories with acidic environment show eroded teeth, for example; In leather factories where acid is used for tanning leather.

### **Stress:**

Stressful conditions increase the cortisol hormone level which suppresses the immune system resulting in increased susceptibility to infections like periodontitis.

**Low socioeconomic status:**

Periodontal disease is more common in individuals with low socioeconomic status.

**Address:**

Address helps in communication with the patient. It also helps to assess the availability of dental health facilities in the area where the patient resides. Patients follow up visits should be reduced if it is difficult for him to come frequently. Certain diseases have a geographical distribution. For example, fluorosis it is caused by increased fluoride in the water at the time of development of teeth and occurs in the fluoride belts of the country. It causes enamel hypoplasia results in a rough tooth surface which might be hard to keep clean.

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## Chapter 3

### HISTORY TAKING

#### Chief complaint

The chief complaint consists of a brief statement preferably in the patient's own words concerning his reason for seeing the dentist.

#### History of present illness

A detailed description of the patient's current problem in a chronological order is called the "history of present illness". Every symptom and sign have a beginning and a course of development which must be recorded in a chronological order. Usually, a patient reports to a dentist when in pain or has swelling.

**Pain:** There is a set pattern of questions which must be asked in a sequential manner to identify the complete history of pain. These questions can easily be recalled using the word **OLD CARTS** (onset, location, duration, character, aggravating factors, relieving factors, timing and severity).

**Onset:** The patient is asked about the onset of pain. If a patient has come with swelling, its onset should be asked.

**Location:** The patient should be asked to locate the pain. In periodontal problem the pain usually dull and gnawing in nature which is commonly felt deep in bone, which the patient cannot usually localized to a particular tooth but to a region. sometimes the pain is radiated to the temporal region in case of maxillary teeth or towards the angle of the mandible when the mandibular tooth is involved. It should be recorded.

**Duration:** The question to be asked here is "for how long the pain has been there". The patient should be asked when he was absolutely fine.

**Character:** Pain may be sharp or dull in character. Sharp pains are usually associated with endodontic origin, whereas dull pains are usually associated with periodontal origin.

**Aggravating factors:** The patient should be asked about factors which increase the pain. The endodontic pain is aggravated on lying down. Any thermal stimulus usually aggravates endodontic pain whereas it may not have any effect on periodontal pain.

**Reliving factors:** Reliving factors of the pain should be recorded. In periodontal problem patient sometimes is relieved of the pain by forceful clenching of the teeth.

**Timing and severity:** If the tooth has reversible pulpitis the pain should last usually within 30 seconds following a stimulus like thermal changes. In case of irreversible pulpitis, the pain may last for a longer duration. In both cases the pain shall be sharp in nature. The periodontal pain may start on its own without any stimulus, is dull in nature and may last for a variable duration.

Along with the above findings, movement of the pain if any should be noted. Referred, shifting or migrating pain should be recorded in the case history. Sometimes pain may also be accompanied by neurological signs and symptoms. A sensation of hyperesthesia, anaesthesia or dysesthesia should be noted if present.

**Swelling:** The duration of pain should be noted so that it's chronic or acute nature can be determined. swelling associated with periodontal abscess usually has an acute onset and has pain associated with it.

#### Signs and Symptoms of Periodontal Abscess

##### Acute Abscess

- Mild to severe discomfort Localized red,
- ovoid swelling
- Periodontal pocket
- Mobility Tooth elevation in socket
- Tenderness to percussion or biting
- Exudation
- Elevated temperature
- A Regional lymphadenopathy

##### Chronic Abscess

- No pain or dull pain
- Localized inflammatory lesion
- Slight tooth elevation
- Intermittent exudation
- Fistulous tract often associated with a deep pocket Usually without systemic involvement May indicate the need for systemic antibiotics.

Data from Dahlen G: Microbiology and treatment of dental abscesses and periodontal/odontic lesions. Periodontol 2000 28:206, 2002; Meng HX: Periodontal abscess. Ann Periodontol 4:79, 1999; and Sanz M, Herrera D, van Winkelhoff AJ: The periodontal abscess. In Lindhe J, editor: Clinical periodontology, Copenhagen, 2000, Munksgaard.

### **Differential Diagnosis of Periodontal and Pulpal Abscess**

#### **Periodontal Abscess**

- Associated with a pre-existing periodontal pocket.
- Radiographs show periodontal angular bone loss and furcation radiolucency.
- Tests show vital pulp. Swelling usually includes gingival tissue, with an occasional fistula.
- Pain is usually dull and localized.
- Sensitivity to percussion may or may not be present.

#### **Pulpal Abscess;**

- The offending tooth may have large restoration.
- The tooth may have no periodontal pocket or, if present, it probes as a narrow defect.
- Tests show nonvital pulp.
- Swelling is often localized to the apex, with a fistulous tract.
- Pain is often severe and difficult to localize.
- Sensitivity to percussion is noted.

Modified from Corbet EF: Diagnosis of acute periodontal lesions. Periodontol 2000 34:204, 2004.

### **Past dental History**

In this step, we record the patient's attitude towards previous dental treatment previous periodontic, restorative endodontic or oral surgery treatment; the reasons for loss of teeth, fluoride history and radiation or other therapy for oral or facial lesions.

Ask for any complications during previous dental treatments such as syncope, bleeding, hypersensitivity.

### **Complications seen during previous treatment and management**

#### **A. Management of Vasodepressor Syncope**

1. Supine or Trendelenburg position
2. Assess level of consciousness
3. ABC's
4. Calm the patient
5. Loosen uncomfortable clothing
6. Remove drape
7. Cool compress
8. Administer oxygen
9. Aromatic ammonia
10. Monitor vital signs
11. If unconsciousness persists, call EMS

#### **B. Management of Moderate Allergic Reactions**

1. Comfortable position
2. BLS, as needed

3. Monitor vital signs
4. Administer Diphenhydramine (Benadryl) 50 mg IM or IV
  - a. 25 - 50 mg PO tid or qid for 2-3 days
5. Administer Corticosteroid, possibly
  - a. Hydrocortisone Sodium Succinate (Solu-Cortef) 100 mg IM/IV
  - b. Dexamethasone (Decadron) 7.5 mg IM or IV
  - c. PO follow-up doses
6. MD Consultation

### **C. Management of Severe Allergic Reactions**

1. Supine Position
2. BLS, as needed
3. Call EMS
4. Administer Epinephrine (Adrenaline)
  - a. 0.3-0.5 mg (0.3-0.5 ml of 1:1,000) IM or SC
  - b. 0.25 mg for child
  - c. 0.125 mg for infant
5. Administer Oxygen
6. Monitor vital signs
7. Administer Diphenhydramine IM or IV
8. Administer Corticosteroid IM or IV
9. Transport to hospital
5. BLS, as needed
6. Monitor vital signs
7. Transport to hospital

### **D. Potential bleeding problems can be avoided by**

- Effective post operative instruction
- Avoid vigorous rinsing
- Suction
- Ingestion of warm food on the day of surgery

### **Management**

- Identify the exact location of bleeding
- Application of pressure
- Electrocautery

- Haemostatic agents eg. Absorbable sponges, gel foam, surgicel
- Absorbable gelatin sponge (Gelfoam); A porcine derived material that stabilizes the clot and resorbs within 4 to 6 weeks.
- Oxidized cellulose(oxycel); chemically modified form of surgical gauze which resorbs in 1to 6 weeks. The disadvantage of this material is that it is friable and difficult to place.
- Oxidized regenerated cellulose (surgicel); to prepare this, oxidized cellulose is combined with an alkali. The advantages are that it has a more uniform structure, has a bactericidal action and does not impair epithelialization unlike oxidized cellulose.
- Thrombin (Thrombostat); Bovine (from cattle) derived thrombin is used topically to hasten the clotting process.
- Larger vessels when involved can be tied and sutured
- Use of bone wax in case of bleeding from bone

### **Medical history:**

The patient presents with complicating dental and medical factors such as restorative and periodontal needs coupled with a systemic disorder such as diabetes mellitus. It is important to record any medical ailment, treatment or hospitalization for any reason. Any systemic condition for which patient is presently under treatment and the medication he/she is taking should be recorded.

### **Diabetes mellitus**

Periodontal disease has been described as the sixth sign of diabetes by Loe H in 1993. Controlled diabetes shows the same changes as nondiabetic individuals. People with uncontrolled diabetes show an increased prevalence to periodontal disease.

### Oral findings:

- Mucosal drying
- Cheilosis
- Cracking
- Burning mouth and tongue
- Xerostomia

Alteration in flora of oral cavity, with greater predominance of candida albicans, hemolytic streptococci and staphylococci.

Periodontal findings:

**Hirschfeld has mentioned the following periodontal symptoms associated with diabetes**

- Enlarged gingiva
- Sessile or pedunculated polyps
- Polypoid gingival proliferations
- Multiple abscesses – most characteristic finding of diabetes mellitus
- Periodontitis
- Loosened teeth

**Other findings**

Increased gingival bleeding, deep periodontal pockets, rapid bone loss and tooth loss.

Diabetics develop destructive periodontal disease, because of effect of diabetes on bacterial pathogens, function of neutrophils and altered collagen metabolism.

Bacterial pathogens; increase in black pigmented species which includes Porphyromonas gingivalis, Prevotella intermedia, Campylobacter rectus.

Neutrophil function; neutrophils have impaired chemotaxis, phagocytosis and adhesion.

Altered collagen metabolism; regular collagen turnover is necessary to maintain tissue integrity. In diabetics, advanced glycation end products (AGE) attach to collagen and render it less soluble and less likely to be repaired. This damaged collagen remains in the tissues longer and breaks down easily in the presence of periodontal disease.

**Effect of diabetes on periodontium**

The fact that poor periodontal outcome result from hypoglycemia in diabetes has been recognized for a long time. This is due to the

- Change in oral microorganisms – salivary flux reduction and high glucose concentration in saliva and GCF leads to the development of periodontogenic flora. So, increases the susceptibility of diabetics to periodontal disease.
- Change in host response= differences in the immune-inflammatory response to bacteria between people with diabetes and without diabetes.

<p>1. The function of cells including neutrophils monocytes and macrophages is altered with in people with diabetes. The adherence chemotaxis and phagocytosis of neutrophils are often impaired so it prevents destruction of bacteria in the periodontal pocket thereby increasing periodontal destruction.</p>	<p>2. Other immune-inflammatory responses are upregulated in people with diabetes. Monocytes and macrophages often exhibit elevated production of pro-inflammatory cytokines and mediators, such as (TNF<math>\alpha</math>) in the blood and gingival crevicular fluid in response to PDL pathogens, which may increase host tissue destruction suggesting both a local and systemic hyperresponsiveness of this immune cell line.</p>
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- Altered wound healing – the primary reparative cell in the periodontium, the fibroblast does not function properly in high glucose environment. The collagen that is produced by these fibroblasts is susceptible to rapid degradation by matrix metalloproteinase enzymes which are elevated in diabetes. Thus, periodontal wound healing response to chronic microbial insult may be altered in those with sustained hyperglycaemia, resulting in increased bone loss and attachment loss.

- Change in microvascular integrity  
Diabetes with poor glycaemic control have accumulated high levels of irreversibly glycated proteins called advanced glycation end products (AGE's) in the tissues including the periodontium.

These AGE's - Play central role in diabetic complications

- Alter functions of extracellular matrix
- Affects collagen stability and vascular integrity

AGE's formation on collagen- increased cross linking between collagen molecules:

- Reduced solubility
- Decreased turnover rate

**Effect of periodontitis on diabetes**

- In patients with diabetes, hyper-inflammatory immune cells can exacerbate the elevated production of proinflammatory cytokines. This has the potential to increase insulin resistance and make it more difficult for the patient to control his/her diabetes.
- Periodontal treatment that decreases inflammation may help diminish insulin resistance.

**Investigations:**

Levels of fasting blood sugar, blood sugar and post prandial blood sugar help us in diagnosing diabetes, glucose levels greater than 126 mg/dl for fasting and 200 mg /dl for postprandial tests indicate that the patient is diabetic.

Glycated haemoglobin assay is a better test to give an idea about long term glycaemic control. The tests have been called HbA1C assays and they reflect the concentration of blood glucose for the preceding 6 to 8 weeks which corresponds with the lifespan of any erythrocyte. Patients with values greater than 6% are considered diabetic and with values higher than 8% poorly controlled diabetes.

Values of BbA1

46%- normal

≤7%- good diabetic control

7-8%- moderated diabetic control

≥8%- poor control and needs to improve diabetic control

## **Management**

Tetracycline antibiotics in combination with scaling, root planing may positively influence glycaemic control. If surgery is needed in a patient with poor glycaemic control prophylactic penicillin is given.

## **Complications on dental chair**

The most common complication on the dental chair is that of hypoglycaemia. Increased incidence is seen in well controlled diabetics taking insulin or sulfonyl urea agents. It is important to ensure that the patient has had his meal before the dental treatment.

If a patient goes into hypoglycaemia on the dental chair, then the treatment should be discontinued and the patient should be given either some fruit juice or 4 tea spoons of sugar. Unconscious patients can be given 25 ml of 50% dextrose or 1mg glucagon intravenously.

## Cardiovascular problems:

### Hypertension

#### Time of treatment

Blood pressure is usually highest in midmorning. Therefore, it is better to give appointment in the afternoon.

#### Use of adrenaline

Using local Anaesthesia without adrenaline will minimize its anaesthetic action and cause release of endogenous adrenaline. Therefore, adrenaline should be used along with the local anesthetic agent but the concentration of adrenaline should not exceed 1:100,000.

#### Drugs

Calcium channel blockers used to treat hypertension can lead to gingival enlargement. Therefore, it is essential to document drug history in these patients.

Clinically, interdental papillae are affected, and overgrowth is limited to attached and marginal gingiva, which usually is observed on the anterior segments. Nifedipine induced gingival overgrowth can coexist with periodontitis and attachment loss that is different from other forms of Drug induced gingival overgrowth.

Calcium channel antagonists induces blockage of the aldosterone synthesis in zona glomerulosa of the adrenal cortex since this pathway is calcium-dependent, cyclic nucleotide-independent. this may produce a feedback stimulation of an increase in pituitary secretion of ACTH which affects glomerulosa hyperplasia. This hyperplasia is merely related by accumulation of steroid intermediate products. (androgens)that are transformed to testosterone because of an increase in 17-alpha-hydroxylase enzyme activity. Elevated levels of testosterone may act on the gingival cells and matrix to produce gingival hyperplasia.

(ANyska et al. Med hypotheses. 1994 Aug; 43(2);115-8doi;10.1016/0306-9877(94)90061-2. PMID;7990738.)

Classification of Adult Blood Pressure Classification			
classification	Systolic (mm Hg)	Diastolic (mm Hg)	Dental Treatment Modifications

Normal	<120	<80	No changes in dental treatment
Prehypertension	120–139	80–89	No changes in dental treatment Monitor BP at each appointment
Stage 1 hypertension	140–159	90–99	Inform patient of findings Medical consultation or referral Monitor BP at each appointment No changes in dental treatment; minimize stress
Stage 2 hypertension	≥160	≥100	Inform patient Medical consultation or referral Monitor BP at each appointment If systolic BP is less than 180mmhg perform selective dental care (routine examination, restoration, non surgical endodontics and perio treatment ) minimize stress. If systolic BP ≥180 mm Hg or diastolic ≥100 mm Hg, give immediate medical consultation or referral and perform emergency dental care only (to alleviate pain, bleeding, infection),a minimize stress.

### **Myocardial infarction and angina pectoris:**

Patients having suffered from ischemic heart disease should avoid dental treatment for 6 months. Anginal episodes on the dental chair should be treated by administration of nitroglycerine (sublingual) and oxygen.

### **Management of Acute Myocardial Infarction (MI)**

1. Comfortable position- Supine, if unconscious
2. BLS, as needed
3. Call EMS
4. Administer Oxygen
5. Administer Nitroglycerin 0.4mg (1/150 grain) SL, up to 3 doses

6. 325 mg aspirin tablet PO (Chew)
6. Monitor vital signs
7. Morphine Sulfate 2-5 mg IV, or 5-10 mg IM

### **Management of Cardiac Arrest**

1. Supine position
2. Call EMS
3. ABC's
4. CPR
5. Early defibrillation, if indicated

### Patients with cardiac pacemakers

Older pacemakers are unipolar and get disrupted by ultrasonic and electrosurgery units. Therefore, don't use these equipment's in these patients.

However, newer pacemakers are bipolar and unaffected by equipment generating an electromagnetic field.

### **Infective endocarditis;**

Infective endocarditis (IE) is a disease in which microorganisms colonize damaged endocardium or heart valves. Presence of bacteraemia in the blood is called bacteraemia.

The term infective endocarditis is preferred to the previous term bacterial endocarditis because the disease can also be caused by fungi and viruses. The organisms most often encountered in IE are  $\alpha$ -hemolytic streptococci (e.g., *Streptococcus viridans*). However, nonstreptococcal organisms often found in the periodontal pocket have been increasingly implicated, including *Eikenellacorrodens*, *Aggregatibacter actinomycetemcomitans*, *Capnocytophaga*, and *Lactobacillus* species.

This can trigger infective endocarditis in a susceptible patient. Dental procedures can cause bacteremia and prophylactic antibiotics need to be given in patients at risk of infective endocarditis.

Usually, amoxicillin is given at the dosage of 2 g, 1 hour before the procedure and in patients allergic to amoxicillin, azithromycin or clarithromycin may be prescribed at a dosage of 500mg, 1 hour before the procedure.

Preventive measures to reduce the risk of IE consist of the following:

1. Define the susceptible patient. A careful medical history can disclose a susceptible patient. Health questioning should cover the history in all categories of risk. If any doubt exists, the patient's physician should be consulted.
2. Provide oral hygiene instruction. Oral hygiene should be practiced with methods that improve gingival health. In patients with significant gingival inflammation, oral hygiene should initially be limited to gentle procedures (i.e., oral rinses and gentle toothbrushing with a soft brush) to minimize bleeding. As gingival health improves, more aggressive oral hygiene can be initiated. Oral irrigators are usually not recommended because their use can induce bacteremia. Susceptible patients should be encouraged to maintain the highest level of oral hygiene after soft tissue inflammation is controlled.
3. Recommended antibiotic prophylactic regimens should be practiced with all high-risk patients during periodontal treatment. If any doubt regarding susceptibility exists, the patient's physician should be consulted. In patients who have been receiving continuous oral penicillin for secondary prevention of rheumatic fever, penicillin-resistant  $\alpha$ -hemolytic streptococci are occasionally found in the oral cavity. An alternate regimen is recommended instead. If the periodontal patient is taking a systemic antibiotic as part of periodontal therapy, changes in the IE prophylaxis regimen may be indicated. For example, a patient taking a penicillin agent after regenerative therapy can be placed on azithromycin before the next periodontal procedure. Patients with early-onset forms of periodontitis often have high levels of *A. actinomycetemcomitans* in the subgingival plaque. This organism has been associated with IE and is often resistant to penicillins. In patients with aggressive periodontitis who should be given prophylaxis, Slots and colleagues<sup>101</sup> suggested using tetracycline (250 mg four times daily for 14 days) to eliminate or reduce *A. actinomycetemcomitans*, followed by the conventional prophylaxis protocol at the time of dental treatment.
4. Periodontal treatment should be designed for susceptible patients to accommodate their degree of periodontal involvement. The nature of periodontal therapy enhances the problems related to the prophylaxis of subacute IE. Patients are faced with long-term therapy, healing periods that extend beyond a 1-day antibiotic regimen, multiple visits, and procedures that easily elicit gingival bleeding.

The following guidelines can aid in the development of periodontal treatment plans for patients susceptible to IE:

- Periodontal disease is an infection with potentially wide-ranging systemic effects. For patients at risk for IE, every effort should be made to eliminate this infection. Teeth with severe periodontitis and a poor prognosis may require extraction. Teeth with less severe involvement in a motivated patient should be retained, treated, and maintained closely.
- All periodontal treatment procedures (including probing) require antibiotic prophylaxis; gentle oral hygiene methods are excluded. Pretreatment chlorhexidine rinses are recommended before all procedures, including periodontal probing, because these oral rinses significantly reduce the bacteria on mucosal surfaces.
- To reduce the number of visits required and thereby minimize the risk of developing resistant bacteria, numerous procedures can be accomplished at each appointment, depending on the patient's needs and ability to tolerate dental treatment.
- When possible, allow at least 7 days between appointments (preferably 10 to 14 days). If this is not possible, select an alternative antibiotic regimen for appointments within a 7-day period.
- Evidence does not support or refute a need to place patients at risk for IE on extended antibiotic regimens after treatment.<sup>55</sup> Patients who have had periodontal surgery are not usually placed on antibiotics for the first week of healing unless there are specific indications to do so. If patients are placed on these regimens, the dosages are inadequate to prevent endocarditis during ensuing appointments. The standard prophylactic antibiotic dose is still needed. For example, if a patient was placed on 250 mg of amoxicillin three times a day for 10 days after periodontal surgery and was to return to the office for more treatment on the seventh day, the patient would require a full 2.0-g dose of amoxicillin before that treatment. Alternatively, clindamycin or azithromycin could be used at the second appointment.
- Regular recall appointments, with an emphasis on oral hygiene reinforcement and maintenance of periodontal health, are extremely important for patients susceptible to IE.

**Cerebrovascular Accident A CVA (i.e., stroke)**- results from ischemic changes (e.g., cerebral thrombosis caused by an embolus) or hemorrhagic phenomena.

To prevent a repeat stroke, active infections should be treated aggressively,

because even a minor infection can alter blood coagulation and trigger thrombus formation and ensuing cerebral infarction. The clinician should counsel the patient about the importance of thorough oral hygiene.<sup>82</sup> Post-stroke weakness of the facial area or paralysis of extremities can make oral hygiene procedures extremely difficult.<sup>66</sup> The clinician may need to modify oral hygiene instruments for ease of use, perhaps in consultation with an occupational therapist. Long-term chlorhexidine rinses greatly aid in plaque control.

Dental clinicians should treat post-CVA patients with the following guidelines in mind:

1. No periodontal therapy (except for an emergency) should be performed for 6 months because of the high risk of recurrence during this period.
2. After 6 months, periodontal therapy can be performed during short appointments with an emphasis on minimizing stress. Profound local anesthesia should be obtained, using the minimal effective dose of local anesthetic agents. Concentrations of epinephrine greater than 1 :100,000 are contraindicated.
3. Light conscious sedation (i.e., inhalation, oral, or parenteral) can be used for anxious patients. Supplemental oxygen is indicated to maintain thorough cerebral oxygenation.
4. Stroke patients are frequently placed on oral anticoagulants. Previously, it was thought that for procedures entailing significant bleeding, such as periodontal surgery or tooth extraction, the anticoagulant regimen might need adjustment, depending on the level of anticoagulation at which the patient is maintained. However, evidence regarding the risks of altering anticoagulation therapy suggests that it may be prudent to provide treatment without changing it (see Anticoagulant Medications). Any changes in anticoagulant therapy regimens for a stroke patient should be done in consultation with the patient's physician.
5. BP should be monitored carefully. Recurrence rates for CVAs are high, as are rates of associated functional deficits.

### **Ischemic Heart Diseases;**

- Ischemic heart disease includes disorders such as angina pectoris and MI. Angina pectoris occurs when myocardial oxygen demand exceeds supply, resulting in temporary myocardial ischemia.
- Patients with angina may be taking longer-acting forms of nitroglycerin (e.g., tablet, patch),  $\beta$ -blockers, or calcium channel blockers (also used for treating hypertension) for prevention of angina. Restrictions on the use of local anesthetics containing epinephrine are similar to those for the patient

with hypertension. Intraosseous injection with epinephrine-containing local anesthetics using special systems (e.g., Stabident, Fairfax Dental) should be done cautiously in patients with ischemic heart disease because it results in transient increases in heart rate and myocardial oxygen demand

If the patient becomes fatigued or uncomfortable or has a sudden change in heart rhythm or rate during a periodontal procedure, the procedure should be discontinued as soon as possible.

A patient who has an anginal episode in the dental chair should receive the following emergency medical treatment: 1. Discontinue the periodontal procedure.

2. Administer 1 tablet (0.3 to 0.6 mg) of nitroglycerin sublingually.

3. Reassure the patient, and loosen restrictive garments.

4. Administer oxygen with the patient in a reclined position.

5. If the signs and symptoms cease within 3 minutes, complete the periodontal procedure if possible, making sure that the patient is comfortable. Terminate the procedure at the earliest convenient time.

6. If the anginal signs and symptoms do not resolve with this treatment within 5 minutes, administer another dose of nitroglycerin, monitor the patient's vital signs, call the patient's physician, and be ready to accompany the patient to the emergency department.

7. A third nitroglycerin tablet can be given 5 minutes after the second. Chest pain that is not relieved by three tablets of nitroglycerin indicates likely MI. The patient should be transported to the nearest emergency medical facility immediately.

### **Congestive Heart Failure;**

CHF is a condition in which the pump function of the heart is unable to supply sufficient amounts of oxygenated blood to meet the body's needs.

Medical management of CHF can include the use of calcium channel blockers, direct vasodilators, diuretics, angiotensin-converting enzyme (ACE) inhibitors,  $\alpha$ -receptor blockers, or cardiotoxic agents such as digoxin.<sup>27,46</sup> Each medication has potential side effects that can affect periodontal therapy. Because of orthopnea (i.e., inability to breathe unless in an upright position) in some CHF patients, the dental chair should be adjusted to a comfortable level for the patient rather than placed in a supine position. Short appointments, stress reduction with profound local anesthesia and possibly conscious sedation, and use of supplemental oxygen should be considered.

### **Bleeding disorders;**

Patients with a history of bleeding problems caused by disease or drugs should be managed to minimize the risks of hemorrhage. Identification of these patients through the health history, clinical examination, and clinical laboratory tests is paramount. Health questioning should cover (1) the history of bleeding after previous surgery or trauma, (2) past and current drug history, (3) history of bleeding problems among relatives, and (4) illnesses associated with potential bleeding problems.

Clinical examination can detect jaundice, ecchymosis, spider telangiectasia, hemarthrosis, petechiae, hemorrhagic vesicles, spontaneous gingival bleeding, and gingival hyperplasia. Laboratory tests include methods to measure the hemostatic, coagulation, or lytic phase of the clotting mechanism, depending on clues regarding which phase is involved (Table 39.6). These tests include bleeding time, tourniquet test, complete blood cell count, prothrombin time (PT), partial thromboplastin time (PTT), and coagulation time. Bleeding disorders are classified as coagulation disorders, thrombocytopenic purpuras, or nonthrombocytopenic purpuras.

### **Coagulation Disorders**

The main inherited coagulation disorders include hemophilia A, hemophilia B, and von Willebrand disease.

**Hemophilia A** results in a deficiency of coagulation factor VIII, and the clinical severity of the disorder depends on the level of factor VIII remaining. Patients with severe hemophilia who have less than 1% of normal factor VIII levels can have severe bleeding on the slightest provocation, whereas those with more moderate hemophilia (i.e., 1% to 5% of factor VIII) have less frequent spontaneous hemorrhage but still bleed with minimal trauma.

Patients with mild hemophilia (i.e., 6% to 30% of factor VIII) rarely bleed spontaneously but may still hemorrhage after severe trauma or during surgical procedures. The clinician should consult the patient's physician before dental treatment to determine the risk of bleeding and treatment modifications required.

To prevent surgical hemorrhage, a factor VIII level of at least 30% is needed. Parenteral 1-deamino-8-d-arginine vasopressin (DDAVP; desmopressin) can be used to raise factor VIII levels twofold to threefold in patients with mild or moderate hemophilia.

DDAVP has the significant advantage of avoiding the risk of viral disease transmission from factor VIII infusion and is considered the drug of choice in responsive patients. Most patients with moderate or severe hemophilia require infusion of factor VIII concentrate before surgical procedures. Before 1985, the risk of viral disease transmission from these infusions was high.

Since then, virally safe, highly purified monoclonal antibody or recombinant DNA factor VIII products have come into widespread use.

**Hemophilia B (i.e., Christmas disease)** -results in a deficiency of factor IX.

The severity of the disorder depends on the relative amount of existing factor IX. Surgical therapy requires a factor IX level of 30% to 50%, which is usually achieved by administration of purified prothrombin complex concentrate or factor IX concentrate.

**Von Willebrand disease**- results from a deficiency of von Willebrand factor, which mediates adhesion of platelets to the injured vessel walls and is required for primary hemostasis. Von Willebrand factor also carries the coagulant portion of factor VIII in the plasma.

Laboratory Tests for Bleeding Disorders

Vascular	Platelet	Coagulation	Lysis
1.Tourniquet test N: 10 petechiae Abn: >10 petechiae	1.Platelet count N: 150,000-300,000/mm <sup>3</sup> Abn: Thrombocytopenia occurs at $\leq 100\ 000\text{mm}^3$ , clinical bleeding occurs at $\leq 80\ 000\text{mm}^3$ , spontaneous bleeding occurs at $\leq 20\ 000\text{mm}^3$ .	1. PT measures extrinsic and common pathways: factors I, II, V, VII, and X. N: 11–14 sec (depending on laboratory) measured against control PT reported as international normalized ratio (INR): N: INR = 1.0 Abn: INR >1.5	1. Euglobin clot lysis time N: $\leq 90$ min Abn: $\geq 90$ min
2. Bleeding time N: 1–6 min Abn: >6 min	2. Bleeding time 3. Clot retraction 4. Complete blood cell count	2. PTT measures intrinsic and common pathways: factors III, IX, XI, and low levels of factors I, II, V, X, and XII. N: 25–40 sec (depending on laboratory) measured against control Abn: >1.5 times normal 3. Clotting (coagulation) time N: 30–40 min Abn: >1 hr	
<b>Clinical Disease Associations</b>			
Vascular (capillary) wall	Thrombocytopenia		Increase in fibrinolytic

defect			activity
<b>Rule out:</b>	<b>Rule out:</b>	<b>All three tests:</b>	
Thrombocytopenia Purpuras Telangiectasia Aspirin or NSAID therapy Leukemia Renal dialysis	Vascular wall defect Acute or chronic leukemia Aplastic anemia Liver disease Renal dialysis	Liver disease Warfarin therapy Aspirin or NSAID therapy Malabsorption syndrome or long-term antibiotic therapy (lack of vitamin K metabolism) PT: factor VII deficiency PTT: hemophilia Renal dialysis	

### Inherited Coagulation Disorders:

Type	prolonged	Normal	treatment
Hemophilia A	PTT	PT Bleeding time	DDAVP factor VIII concentrate or cryoprecipitate Fresh frozen plasma Fresh whole blood ε- Aminocaproic acid (Amicar) Tranexamic acid
Hemophilia B	PTT	PT Bleeding time	Purified prothrombin complex concentrates Factor IX concentrates Fresh-frozen plasma
Von Willebrand disease	Bleeding time PTT Variable factor VIII deficiency	PT Platelet count	DDAVP factor VIII concentrate or cryoprecipitate

### Liver diseases:

Liver disease affects all phases of blood clotting because most coagulation factors are synthesized and removed by the liver. Long-term alcohol abusers or chronic hepatitis patients often demonstrate inadequate coagulation.

Coagulation can be impaired by vitamin K deficiency, often caused by malabsorption syndromes, or by prolonged antibiotic administration, which alters the intestinal microflora that produces vitamin K.

Dental treatment planning for patients with liver disease should include the following:

1. Physician consultation
2. Laboratory evaluations: PT, bleeding time, platelet count, and PTT (for patients in later stages of liver disease)

3. Conservative, nonsurgical periodontal therapy whenever possible
4. When surgery is required (may require hospitalization)
  - International normalized ratio (INR; PT) should be less than 2.0; for simple surgical procedures, an INR of less than 2.5 is usually safe.
  - Platelet count should be more than 80,000/mm<sup>3</sup>.

### **Anticoagulant medication:**

Patients usually in the 2.5 to 3.5 range.<sup>39</sup> Traditional recommendations for periodontal treatment are as follows:

1. Consult the patient's physician to determine the nature of the underlying medical problem and the degree of required anticoagulation.
2. The procedure to be done determines the acceptable INR. Infiltration anesthesia, scaling, and root planing can be done safely in patients with an INR of less than 3.0. Block anesthesia, minor periodontal surgery, and simple extractions usually require an INR of less than 2.0 to 2.5. Complex surgery or multiple extractions may require an INR of less than 1.5 to 2.0.
3. The physician must be consulted about any changes (i.e., discontinuing or reducing) in anticoagulant dosage until the desired INR is achieved. The dentist must inform the physician what degree of intraoperative and postoperative bleeding is usually expected with the planned procedure. If the INR is higher than the level at which significant bleeding is likely to accompany a particular procedure, the physician may elect to change anticoagulant therapy. Often the anticoagulant is discontinued for 2 to 3 days before periodontal treatment (i.e., clearance half-life of warfarin is 36 to 42 hours), and the INR is checked on the day of therapy. If the INR is within the acceptable target range, the procedure is done and the anticoagulant resumed immediately after treatment.
4. Careful technique and complete wound closure are paramount. For all procedures, application of pressure can minimize hemorrhage. Use of oxidized cellulose, microfibrillar collagen, topical thrombin, and tranexamic acid should be considered for persistent bleeding.

### **Antiplatelet Medications:**

Aspirin interferes with normal platelet aggregation and can result in prolonged bleeding. Because it binds irreversibly to platelets, the effects of aspirin last at least 4 to 7 days. Aspirin typically is used in small doses of 325 mg or less per day, which usually does not alter bleeding time. Patients taking low doses of aspirin daily usually do not need to discontinue aspirin therapy before periodontal procedures.<sup>90</sup> However, higher doses can increase bleeding time and predispose the patient to postoperative bleeding. For patients taking more than 325 mg of aspirin per day, it may need to be discontinued 7 to 10 days before surgical therapy that could result in significant bleeding; this should be done in consultation with the physician.

### **Leukemia:**

Altered periodontal treatment for patients with leukemia is based on their enhanced susceptibility to infections, bleeding tendency, and effects of chemotherapy.<sup>55</sup> The treatment plan for leukemia patients is as follows:

1. Refer the patient for medical evaluation and treatment. Close cooperation with the physician is required.
2. Before chemotherapy, a complete periodontal treatment plan should be developed with a physician (discussed in the previous discussion).
  - Monitor hematologic laboratory values daily: bleeding time, coagulation time, PT, and platelet count.
  - Administer antibiotic coverage before periodontal treatment because infection is a major concern.
  - If systemic conditions allow, extract all hopeless, nonmaintainable, or potentially infectious teeth at least 10 days before the initiation of chemotherapy
  - Periodontal debridement (i.e., scaling and root planing) should be performed and thorough oral hygiene instructions given if the patient's condition allows. Twice-daily rinsing with 0.12% chlorhexidine gluconate is recommended after oral hygiene procedures. Recognize the potential for bleeding caused by thrombocytopenia. Use pressure and topical hemostatic agents as indicated.
3. During the acute phases of leukemia, patients should receive only emergency periodontal care. Any source of potential infection must be eliminated to prevent systemic dissemination. Antibiotic therapy is frequently the treatment of choice, combined with nonsurgical or surgical debridement as indicated.

4. Oral ulcerations and mucositis are treated palliatively with agents such as viscous lidocaine. Systemic antibiotics may be indicated to prevent secondary infection.

5. Oral candidiasis is common in leukemic patients and can be treated with nystatin suspension (400,000–600,000 U/mL four times daily) or clotrimazole vaginal suppositories (10 mg four or five times daily).

6. For patients with chronic leukemia and those in remission, scaling and root planing can be performed without complication, but periodontal surgery should be avoided if possible. Platelet count and bleeding time should be measured on the day of the procedure. If either is low, postpone the appointment and refer the patient to a physician.

### **Agranulocytosis:**

Patients with agranulocytosis (i.e., cyclic neutropenia and granulocytopenia) have an increased susceptibility to infection.

When possible, periodontal treatment should be done during periods of disease remission. At such times, treatment should be as conservative as possible while reducing potential sources of systemic infection. After physician consultation, severely affected teeth should be extracted. Oral hygiene instruction should include chlorhexidine rinses twice daily. Scaling and root planing should be performed carefully under antibiotic protection.

### **Thrombocytopenic Purpuras –**

Thrombocytopenia is defined as a platelet count of less than 100,000/ mm<sup>3</sup> . Periodontal therapy for patients with thrombocytopenia should be directed toward reducing inflammation by removing local irritants to avoid the need for more aggressive therapy.<sup>55,68</sup> Oral hygiene instructions and frequent maintenance visits are paramount. Physician referral is indicated for a definitive diagnosis and to determine alterations in planned therapy. Scaling and root planing are usually safe unless the platelet count is less than 60,000/mm<sup>3</sup> . No surgical procedure should be performed unless the platelet count is greater than 80,000/mm<sup>3</sup> . Platelet transfusion may be required before surgery. Surgical technique should be as atraumatic as possible, and local hemostatic measures should be applied.

### **Nonthrombocytopenic Purpuras;**

Nonthrombocytopenic purpuras result from vascular wall fragility or thrombasthenia (i.e., impaired platelet aggregation). Vascular wall fragility can result from hypersensitivity reactions, scurvy, infections, chemicals (e.g., phenacetin, aspirin), dysproteinemia, and other causes. Thrombasthenia occurs in uremia, Glanzmann disease, aspirin ingestion, and von Willebrand disease.<sup>68</sup> Both types of nonthrombocytopenic purpura can cause immediate bleeding after gingival injury. Treatment consists primarily of direct pressure applied for at least 15 minutes. This initial pressure should control the bleeding unless coagulation times are abnormal or reinjury occurs. Surgical therapy should be avoided until the qualitative and quantitative platelet problems are resolved.

### **Renal diseases;**

The most common causes of renal failure are glomerulonephritis, pyelonephritis, kidney cystic disease, renovascular disease, drug nephropathy, obstructive uropathy, and hypertension.

The following treatment modifications should be made:

1. Consult the patient's physician.
2. Monitor BP; patients in end-stage renal failure are usually hypertensive.
3. Check laboratory values: PTT, PT, bleeding time, and platelet count; hematocrit; blood urea nitrogen
4. Eliminate areas of oral infection to prevent systemic infection.
  - Good oral hygiene should be established.
  - Periodontal treatment should aim at eliminating inflammation or infection and providing easy maintenance. Questionable teeth should be extracted if medical parameters permit.
  - Frequent recall appointments should be scheduled.
5. Drugs that are nephrotoxic or metabolized by the kidney should not be given (e.g., phenacetin, tetracycline, aminoglycoside antibiotics). Acetaminophen may be used for analgesia and diazepam for sedation. Local anesthetics such as lidocaine are usually safe.

The patient who is receiving dialysis requires modifications in treatment planning. The three modes of dialysis are intermittent peritoneal dialysis (IPD), chronic ambulatory peritoneal dialysis (CAPD), and hemodialysis. Only hemodialysis patients require special precautions. They have a high incidence of viral hepatitis, anemia, and prolonged hemorrhage. The risk of hemorrhage is related to anticoagulation during dialysis, platelet trauma from dialysis, and the uremia that develops with renal failure. Hemodialysis patients have an internal arteriovenous fistula or an external arteriovenous shunt. The shunt is often located in the arm and must be protected from trauma. In addition to guidelines for patients with chronic renal disease, the following recommendations are made for those receiving hemodialysis:

1. Screen for hepatitis B and hepatitis C antigens and antibodies before any treatment.
2. Provide antibiotic prophylaxis to prevent endarteritis of the arteriovenous fistula or shunt. IPD and CAPD patients do not usually require prophylactic antibiotics.
3. Patients receive heparin anticoagulation on the day of hemodialysis. Periodontal treatment should be provided on the day after dialysis, when the effects of heparinization have subsided. Hemodialysis treatments are usually performed three or four times per week. (IPD and CAPD patients are not systemically heparinized; they usually do not have the potential bleeding problems associated with hemodialysis.)
4. The hemodialysis shunt or fistula must be protected when the patient is in the dental chair. If the shunt or fistula is placed in the arm, do not cramp the limb; BP readings should be taken from the other arm. Do not use the limb for the injection of medication. Patients with leg shunts should avoid sitting with the leg dependent for longer than 1 hour. If the appointment lasts longer, allow the patient to walk about for a few minutes, then resume therapy.
5. Refer the patient to the physician if uremic problems develop, such as uremic stomatitis. To prevent systemic dissemination, refer to the physician if oral infections do not resolve promptly.

The renal transplant patient's greatest foe is infection. Transplant recipients take immunosuppressive drugs that greatly reduce resistance to infection.<sup>79</sup> Excessive bleeding can occur during or after periodontal treatment because of drug-induced thrombocytopenia or anticoagulation, or both. A periodontal abscess is a potentially life-threatening situation, and a dental team approach should be used before transplantation to determine which teeth can be easily maintained. Many organ transplantation centers include dental examination in their standard protocols. Teeth with severe bone and attachment loss, furcation invasion, periodontal abscesses, or

extensive surgical requirements should be extracted, leaving an easily maintainable dentition. In addition to the recommendations for patients with chronic renal failure, the following should be considered for the renal transplant recipient:

1. Hepatitis B and C screening
2. Determination of the level of immune system compromise resulting from antirejection drug therapy
3. Prophylactic antibiotics using AHA recommendations or a specific regimen based on physician consultation; not all transplant recipients require antibiotic coverage, and physician consultation is warranted before prescribing.

### **Thyroid and Parathyroid Disorders;**

Periodontal therapy requires minimal alterations for the patient with adequately managed thyroid disease. Patients with thyrotoxicosis and those with inadequate medical management should not receive periodontal therapy until their condition is stabilized. Patients with a history of hyperthyroidism should be carefully evaluated to determine the level of medical management, and they should be treated in a way that limits stress and infection.

Patients with hypothyroidism require careful administration of sedatives and narcotics because of the potential for excessive sedation. Routine periodontal therapy can be provided to patients with parathyroid disease after the disorder has been identified and the proper medical treatment given. However, patients who have not received medical care may have significant renal disease, uremia, and hypertension. If hypercalcemia or hypocalcemia exists, the patient may be more prone to cardiac arrhythmias.

### **Adrenal Insufficiency;**

Acute adrenal insufficiency is associated with significant morbidity and mortality rates as a result of peripheral vascular collapse and cardiac arrest.

The periodontist should be aware of the clinical manifestations and ways of preventing acute adrenal insufficiency in patients with a history of primary adrenal insufficiency (i.e., Addison disease) or secondary adrenal insufficiency (i.e., most often caused by use of exogenous glucocorticosteroids).

In the normal healthy patient, stress activates the HPA axis, stimulating increased endogenous cortisol production by the adrenal glands. Exogenous steroids may suppress the HPA axis and impair the patient's ability to respond to stress with increased endogenous cortisol production, leading to the potential for acute adrenal

crisis. The degree of adrenal suppression depends on the drugs used, dose, duration of administration, time elapsed since steroid therapy was terminated, and route of administration.

Management of the patient in an acute adrenal insufficiency crisis is as follows:

1. Terminate periodontal treatment.
2. Summon medical assistance
3. Give oxygen.
4. Monitor vital signs.
5. Place the patient in a supine position.
6. Administer 100 mg of hydrocortisone sodium succinate (SoluCortef) intravenously over 30 seconds or intramuscularly.

### **Pulmonary Diseases;**

The periodontal treatment of a patient with pulmonary disease may require alteration, depending on the nature and severity of the respiratory restrictive ventilatory disorders caused by muscle weakness, scarring, obesity, or any condition that can interfere with effective lung ventilation.<sup>70,87</sup> Combined restrictive-obstructive lung disease may also develop.

The clinician should be aware of the signs and symptoms of pulmonary disease, such as increased respiratory rate, cyanosis, clubbing of the fingers, chronic cough, chest pain, hemoptysis, dyspnea or orthopnea, and wheezing. Patients with any of these problems should be referred for medical evaluation and treatment. Most patients with chronic lung disease can undergo routine periodontal therapy if they are receiving adequate medical management. Caution should be practiced in relation to any treatment that may depress respiratory function.

***Acute respiratory distress can be caused by slight airway obstruction or depression of respiratory function.*** Because of limited vital lung capacity, patients also have decreased cough effectiveness.<sup>87</sup> They must continually deal with the mental anxiety caused by air hunger and alter their position in attempts to improve their ventilatory efficiency.

The following guidelines should be used during periodontal therapy:

1. Identify and refer patients with signs and symptoms of pulmonary disease to their physician.

2. For patients with known pulmonary disease, consult with their physician regarding medications (e.g., antibiotics, steroids, chemotherapeutic agents) and the degree and severity of pulmonary disease.
3. Avoid elicitation of respiratory depression or distress:
  - Minimize the stress of a periodontal appointment. The patient with emphysema should be treated in the afternoon, several hours after sleep, to allow for airway clearance.
  - Avoid medications that could cause respiratory depression (e.g., narcotics, sedatives, general anesthetics).
  - Avoid bilateral mandibular block anesthesia, which could cause increased airway obstruction.
  - Position the patient to allow maximal ventilatory efficiency, be careful to prevent physical airway obstruction, keep the patient's throat clear, and avoid excess periodontal packing.
4. For a person with a history of asthma, especially if asthma attacks are frequent, make sure the patient's medication (inhaler) is available. The inhaler should be readily accessible on the countertop in the dental treatment room.
5. Patients with active fungal or bacterial respiratory diseases should not be treated unless the periodontal procedure is an emergency.

### **Prosthetic Joint Replacement**

The main treatment consideration for patients with prosthetic joint replacement is the potential need for antibiotic prophylaxis before periodontal therapy. No scientific evidence indicates that prophylactic antibiotics prevent late prosthetic joint infections, which can occur from transient bacteremia induced by dental treatment

In December 2012, the AAOS and ADA released new joint recommendations for the routine use of antibiotics for joint replacement patients.

#### **Recommendation 1**

*The practitioner might consider discontinuing the practice of routinely prescribing prophylactic antibiotics for patients with hip and knee prosthetic implants undergoing dental procedures.*

#### **Recommendation 2**

*The work group was unable to recommend for or against the use of topical oral antimicrobials in patients with prosthetic joint implants or other orthopaedic implants undergoing dental procedures.*

#### **Recommendation 3**

*In the absence of reliable evidence linking poor oral health to prosthetic joint infection, it is the opinion of the work group that patients with prosthetic joint implants or other orthopaedic implants maintain appropriate oral hygiene.*

## **Pregnancy**

- The aim of periodontal therapy for the pregnant patient is to minimize the exaggerated inflammatory response related to pregnancy-associated hormonal alterations. Meticulous plaque control, scaling, root planing, and polishing should be the only nonemergency periodontal procedures performed.
- The second trimester is the safest time to perform treatment. However, long, stressful appointments and periodontal surgical procedures should be delayed until the postpartum period. As the uterus increases in size during the second and third trimesters, obstruction of the vena cava and aorta can occur if the patient is placed in a supine position. The reduction in return cardiac blood supply can cause *supine hypotensive syndrome*, with decreased placental perfusion.<sup>106</sup> Decreasing BP, syncope, and loss of consciousness can occur.
- This can be prevented by placing the patient on her left side or by elevating the right hip 5 to 6 inches during treatment. Appointments should be short, and the patient should be allowed to change positions frequently. A fully reclined position should be avoided if possible.
- Other precautions during pregnancy relate to the potential toxic or teratogenic effects of therapy on the fetus. Ideally, no medications should be prescribed. However, analgesics, antibiotics, local anesthetics, and other drugs may be required during pregnancy, depending on the patient's needs. Before being prescribed, all drugs should be reviewed for potential adverse effects on the fetus.<sup>55,106</sup>
- As for any patients, use of dental radiographs during pregnancy should be kept to a minimum. The small amount of radiation exposure during diagnostic dental radiography poses little or no risk to the fetus as long as the mother is properly shielded.<sup>4,21</sup> The ADA has stated that "normal radiographic guidelines do not need to be altered because of pregnancy."<sup>4</sup> Use of a properly positioned lead apron is an absolute requirement.

## Infectious Diseases

### Hepatitis

Six distinct viruses that cause viral hepatitis have been identified: hepatitis A, B, C, D, E, and G viruses.<sup>20,33,49</sup> A single-stranded deoxyribonucleic acid (DNA) virus known as *transfusion-transmitted virus* has been identified in cases of acute and chronic hepatitis<sup>4</sup>

**Hepatitis A virus (HAV)** and **hepatitis E virus (HEV)** produce self-limited infections with no associated chronic liver disease

**Hepatitis B virus (HBV)** infection can result in chronic liver disease and a chronic carrier state. Chronic HBV infection develops in about 5% to 10% of infected individuals, with much higher rates among infants and children

**Hepatitis D virus (HDV)** is a defective virus that requires the presence of HBV for its survival, replication, and infectivity. The HDV genetic material is packaged in the HBV surface-antigen coating.

**Hepatitis C virus (HCV)** is probably the most serious of all viral hepatitis infections because of its high chronic infection rate. Only 15% of patients infected with HCV recover completely; 85% develop chronic HCV infection, which dramatically increases the risk of cirrhosis, hepatocellular carcinoma, and liver failure.

**Hepatitis G virus (HGV)** is a ribonucleic acid (RNA) virus, and its epidemiology and virology are not fully understood. HGV rarely occurs as a solitary infection, instead usually appearing as a coinfection with hepatitis A, B, or C. HGV is transmitted through the blood and has frequently been associated with transfusions

#### **The following guidelines are offered for treating hepatitis patients:**

1. If the disease, regardless of type, is active, do not provide periodontal therapy unless the situation is an emergency. In an emergency case, follow the protocol for patients testing positive for hepatitis B surface antigen (HBsAg).
2. For patients with a history of hepatitis, consult the physician to determine the type of hepatitis, course and length of the disease, mode of transmission, and any chronic liver disease or viral carrier state.
3. For recovered HAV and HEV patients, perform routine periodontal care.
4. For recovered HBV and HDV patients, consult with the physician and order HBsAg and anti-HBs (i.e., antibody to HBV surface antigen) laboratory tests.

- If HBsAg and anti-HBs test results are negative but HBV is suspected, order another HBs determination.
  - Patients who are HBsAg positive are probably infective (i.e., chronic carriers); the degree of infectivity is measured by an HBsAg determination.
  - Patients who are anti-HBs positive may be treated routinely because they have antibody to HBsAg.
  - Patients who are HBsAg negative may be treated routinely.
5. For HCV patients, consult with the physician to determine the patient's risk for transmissibility and current status of chronic liver disease.
6. If a patient with active hepatitis, positive-HBsAg (i.e., HBV carrier) status, or positive-HCV carrier status requires emergency treatment, use the following precautions:
- Consult the patient's physician regarding status.
  - If bleeding is likely during or after treatment, measure the PT and bleeding time. Hepatitis can alter coagulation; change the treatment accordingly.

All personnel in clinical contact with the patient should use full barrier techniques, including masks, gloves, glasses or eye shields, and disposable gowns.

- Use as many disposable covers as possible, covering light handles, drawer handles, and bracket trays. Headrest covers should also be used.
- All disposable items (e.g., gauze, floss, saliva ejectors, masks, gowns, gloves) should be placed in one lined wastebasket. After treatment, these items and all disposable covers should be bagged, labeled, and disposed of following proper guidelines for biohazardous waste.
- Aseptic technique should be followed at all times. Minimize aerosol production by not using ultrasonic instrumentation, air syringe, or high-speed handpieces; remember that saliva contains a distillate of the virus. Prerinsing with chlorhexidine gluconate for 30 seconds is highly recommended.
- When the procedure is completed, all equipment should be scrubbed and sterilized. If an item cannot be sterilized or disposed of, it should not be used.

## **Menopause**

Oral mucosal thinning is seen during menopause therefore extra soft toothbrush, dentifrices with minimal abrasive and rinses with low alcohol concentrations are recommended.

### **Family history**

Genetic predisposition will be there in case of Aggressive periodontitis and genetic syndromes are associated with aggressive periodontitis. Therefore it is important to know about the patient's family history.

Polymorphism in genes encoding for interleukin 1, TNF  $\alpha$ , Fc $\gamma$ R and vitamin D predispose patients to periodontitis and are called genetic markers.

Aggressive periodontitis has familial aggregation. Therefore younger siblings of the patient with aggressive periodontitis should be examined for the signs of the disease educated about preventive measures and monitored closely.

### **Personal history**

In personal history, a detailed description of patient's personal habits should be recorded. The patient should also be asked about his/her oral hygiene and dietary habits. The patient also should be asked about any kind of adverse habits like smoking, alcohol consumption as they may also affect the treatment plan. Details should be gathered about the oral hygiene measures exercised by the patient by asking questions like ;

How many times do you brush your teeth?

What kind of toothbrush and tooth paste do you use?

What technique of tooth brushing he/she is following?

How frequently do you replace your tooth brush?

Do you use any other oral hygiene measure like flossing, interdental aids or chemical plaque control measures etc?

All these details are the indicative of awareness of the patient about the importance of maintaining good oral hygiene. also it helps to formulate the treatment plan accordingly and make any required changes in patient's habits to aid in better post-treatment outcome.

Morris and Bohanna (1969) classified habits

1. Non-pressure habits
2. Pressure habits
  - sucking habits (Lip, thumb sucking, tongue thrusting)
  - Biting habit – Nail biting, Needle, thread holding
  - Posturing habits- pillow, hand rest
  - Miscellaneous- bruxism, cheek biting

Always ask for a history of smoking and alcohol consumption

### **Challenge of Assessing Smoking Status**

#### **Current Smokers**

Ask about current smoking and past smoking. Many smokers are trying to quit, and therefore simply asking how many cigarettes they are smoking today may not give an accurate assessment of their lifetime exposure (e.g., a patient who is currently smoking 5 cigarettes per day may have been smoking 40 cigarettes per day until yesterday, when he or she decided to cut down). Try to get an indication of the patient's approximate level of smoking (e.g., the average number of cigarettes per day for a certain number of years). It can also be useful to calculate the number of pack-years:

In other words, 1 pack-year is the cumulative exposure that corresponds with the smoking of 1 pack of 20 cigarettes per day for 1 year. For example, a smoker who has smoked 20 cigarettes per day for 15 years has 15 pack-years of smoking.

#### **Former Smokers**

Ask patients about their past smoking. Patients with periodontitis may have a significant smoking history that has had an impact on their periodontal status, even if they no longer smoke. Former smokers should always be congratulated for their achievement in quitting, but it is also very important to document the following:

- How much they used to smoke
- How many years they smoked
- When they quit

### Is the Patient's Response Accurate?

The inaccurate or false reporting of smoking status is common; patients will tell you what they think you want to hear, or they may be embarrassed because they have not managed to cut down yet. Many patients report smoking 20 cigarettes per day, because this is the number of cigarettes in a pack in most countries, so 20 may be a convenient response rather than an accurate response. Cultural factors may also influence responses.<sup>128</sup>

### When Is a Smoker Not a Smoker?

- Smokers have smoked  $\geq 100$  cigarettes in their lifetime and currently smoke.
- Former smokers have smoked  $\geq 100$  cigarettes in their lifetime and do not currently smoke.
- Nonsmokers have not smoked  $\geq 100$  cigarettes in their lifetime and do not currently smoke.

It must be noted that many periodontal research studies have not used these definitions, and this can sometimes make it difficult to interpret the studies, particularly in the context of what constitutes a former smoker. For example, from an exposure point of view, there is a big difference between someone who smoked 5 cigarettes per day for 10 years and who quit 30 years ago as compared with someone who smoked 40 cigarettes per day for 20 years and quit 6 months ago. It is always best in clinical practice to gather full information about each patient's smoking history

#### Effects of Smoking on Gingivitis and Periodontitis

Periodontal Disease	Effects of Smoking
Gingivitis	↓ Gingival inflammation and bleeding on probing
Periodontitis	‡ Prevalence and severity of periodontal destruction
	‡ Pocket depth, attachment loss, and bone loss
	‡ Rate of periodontal destruction
	‡ Prevalence of severe periodontitis
	‡ Tooth loss
	‡ Prevalence with increased number of cigarettes smoked per day
	↓ Prevalence and severity with smoking cessation

**Beyond E-Cigarettes**

The popularity of e-cigarettes took most people by surprise. But what's next?

***“Heat-Not-Burn” Tobacco Products***

These products heat tobacco to ~500°C, producing an inhalable aerosol.<sup>24</sup> Although not a new idea, they have received recent attention. One manufacturer introduced a product into the Japanese market in 2015, which has been popular, with the media reporting sales outstripping demand.

***Water Pipes (Hookah, Shisha)***

Popular in some communities, these are likely to carry significant negative health risks. A good summary is produced by the National Center for Smoking Cessation and Training (NCSCCT).<sup>94</sup>

***Nicotine Gels***

These gels allow nicotine to be absorbed through the skin. Currently they are not very popular.

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## Helping Your Patients to Quit Smoking

Smoking cessation is a public health priority for governments around the world. Excellent online resources are available to provide information about the harmful effects of smoking and to help people to quit, including the following:

- <http://www.cdc.gov/tobacco>
- <http://www.ash.org.uk>
- <http://smokefree.nhs.uk>

Smoking cessation must be an integral part of the management of dental patients who smoke, and it is the responsibility of all dental health professionals to address this issue with their patients. The dental team is well placed to provide this treatment, because they see patients on a regular basis as part of ongoing routine dental management. Furthermore, interventions to help patients quit smoking in dental practices are effective, with quit rates of 15% to 20% as compared with approximately 5% in control groups.<sup>119</sup> The whole dental team should therefore be involved in smoking cessation, but this is not always the case.

Various methods for helping patients to quit smoking in the dental environment have been described, and these are typically referred to as *brief intervention programs*. One such program<sup>12</sup> is known as the 5 A's:

**ASK** Ask the patient about his or her smoking status.

This should be part of the medical history.

**ADVISE** Advise smokers of the associations between oral disease and smoking.

Be informative, honest, and helpful but not judgmental. The patient's response to this information will reveal his or her interest in quitting.

**ASSESS** Assess the patient's interest in and readiness to attempt smoking cessation. Patients may not yet be in an action phase when it comes to quitting smoking, which is why it is always important to make these assessments every time you see the patient.

**ASSIST** Assist the patient with his or her quit attempt.

If you are trained, there are many techniques that can be used (see Box 12.4).

Alternatively, assist the patient with seeking the help that he or she needs.

**ARRANGE** Arrange for a follow-up visit or a referral to professional smoking cessation services.

The most important aspect of this strategy is to keep in regular contact, particularly around the quit date and during the immediate period after the patient quits.

A simplified version of this is the 3 A's. This is a *very brief intervention* and can be particularly useful for the dental team.<sup>95,111</sup> The intervention is designed to be used at every clinical contact, and its very brief nature may help overcome some of the

barriers presented by dental practices (the duration is <30 seconds). The focus is taken away from advising smokers to stop and shifts to offering support. The “advise” step deliberately leaves out the health benefits of stopping smoking or the harms of smoking. This minimizes the duration of the intervention and helps to avoid a defensive reaction or developing anxiety in the patient. The 3 A’s technique is as follows:

**ASK** and record smoking status.

**ADVISE** how to stop.

**ACT** on the patient’s response (prescribe, monitor, or refer).

Clearly, for the patient undergoing a comprehensive course of periodontal therapy, over several visits, there may be more opportunity to focus on the harms of smoking and the personal benefits of quitting.

**Barriers Against and Stimuli for the Provision of Smoking Cessation Advice by the Dental Team in Dental Practice**

**Barriers**

**Professional Characteristics**

Perceived lack of efficacy or lack of confidence in giving the advice

Concerns about disturbing the patient–dentist relationship

Lack of knowledge about how to give the correct advice

Belief that counseling is unnecessary or perception that advising patients is frustrating and has a low success rate

Dental team member may be a smoker himself or herself

**Stimuli**

Self-efficacy

Positive attitude toward giving advice as part of health care provider role

Training

Self-belief

Dental team member needs to quit!

<b>Practice</b>	Lack of time	Task delegation
<b>Organization</b>	No organizational support in the practice to deliver advice	Focus on helping smokers quit
<b>Health Care System</b>	No reimbursement	Health care system changes to encourage healthier lifestyles
	No referral options for further help	Local availability of smoking cessation services

### **Methods of Smoking Cessation**

#### **Willpower Alone**

This is the least effective method of smoking cessation, with only 3% of smokers managing to quit after 12 months.

#### **Self-Help Materials**

The provision of self-help materials can increase quit rates compared to no intervention, although only by a small amount. When included with any other intervention, there was no additional benefit.

#### **Brief Intervention Program in Primary Care**

A brief advice intervention delivered by a physician or dentist can increase the rate of quitting (12 months) by 40% to 90%.<sup>25,132</sup> Assuming an unassisted quit rate of 3%, a brief intervention by a dentist could increase the quit rates to 4.5% to 6%. Although this cessation rate may seem low, if the dental team gave this brief advice to most of their smoking patients, a significant number of smokers in the whole population would be assisted to quit each year.

#### **Nicotine Replacement Therapy**

Nicotine replacement therapy (NRT) can increase the rate of quitting (12 months) by 50% to 70%.<sup>133</sup> For example, in primary care settings in which brief advice is given,

12-month success rates can increase from around 5% to around 8% if NRT is also used. In an intensive setting such as a smoker's clinic, success rates increase from around 10% to up to 16%. NRT is not a magic cure, but it helps with cravings and withdrawal when a person quits smoking. Although NRT products do contain nicotine, they do not contain the toxic products such as tar and carbon monoxide that are found in cigarette smoke. NRT products include the following:

- Patches (available in different doses and worn for 16 to 24 hours per day)
- Lozenges and gum (available in different flavors; should be chewed slowly to allow the nicotine to be absorbed through the mouth)
- Nasal spray (delivers nicotine solution via the nasal passages)
- Inhalator (a plastic mouthpiece with a supply of nicotine cartridges that fit on the end; nicotine is absorbed in the mouth by drawing on the inhalator like a cigarette).

### **Varenicline**

A course of varenicline, at standard dose, can increase the rate of quitting (12 months) by 100% to 150%.<sup>22</sup> Varenicline is a nicotine receptor partial agonist, and it aims to reduce both withdrawal symptoms and the pleasure people usually experience when they smoke.

### **Bupropion**

Bupropion can increase the rate of quitting (12 months) by 50% to 80%.<sup>62</sup> This medication is used as an antidepressant at higher doses, but it is effective for smoking cessation at lower doses. It is usually prescribed to be started 1 to 2 weeks before the quit date. There are serious potential drug interactions and unwanted effects.

### **Other Methods**

Whatever works for the patient is good! In addition to combinations of the methods listed here, techniques for smoking cessation can include intensive counseling, motivational interviewing, cognitive behavioral therapy, hypnosis, and acupuncture. Many smokers are now also using e-cigarettes to help to quit smoking.

Effects of Smoking on the Etiology and Pathogenesis of Periodontal Disease	
Etiologic Factor	Effects of Smoking
Microbiology	Increased complexity of the microbiome and colonization of periodontal pockets by periodontal pathogens
Immune-inflammatory response	Altered neutrophil chemotaxis, phagocytosis, and oxidative burst response  ‡ Tumor necrosis factor- $\alpha$ and prostaglandin E2 in gingival crevicular fluid  ‡ Neutrophil collagenase and elastase in gingival crevicular fluid  ‡ Production of prostaglandin E2 by monocytes in response to lipopolysaccharide
Physiology	↓ Gingival blood vessels with ‡ inflammation ↓ Gingival crevicular fluid flow and bleeding on probing with ‡ inflammation  ↓ Subgingival temperature ‡ Time needed to recover from local anesthesia
Effect on calculus formation: Pindborg found a positive correlation between smoking and calculus deposition. They reported that pipe smokers have more supragingival calculus than cigarette smokers. The reason given for this is that pH of pipe smokers is more and pipe smokers circulate the smoke around the mouth.	

Effects of Smoking on the Response to Periodontal Therapy	
Therapy	Effects of Smoking
Nonsurgical	↓ Clinical response to root surface debridement ↓ Reduction in probing depth ↓ Gain in clinical attachment levels ↓ Negative impact of smoking with ‡ level of plaque control
Surgery and implants	↓ Probing depth reduction and ↓ gain in clinical attachment levels after access flap surgery ‡ Deterioration of furcations after surgery ↓ Gain in clinical attachment levels, ↓ bone fill, ‡ recession, and ‡ membrane exposure after guided tissue regeneration ↓ Root coverage after grafting procedures for localized gingival recession ↓ Probing depth reduction after bone graft procedures ‡ Risk for implant failure and periimplantitis
Maintenance care	‡ Probing depth and attachment loss during maintenance therapy ‡ Disease recurrence in smokers ‡ Need for retreatment in smokers ‡ Tooth loss in smokers after surgical therapy

Chronic alcoholism can cause cirrhosis of the liver which can increase bleeding tendency during periodontal instrumentation. Liver is responsible for the metabolism of various drugs: these would be contraindicated in liver cirrhosis. This is the reason for recording any history of chronic alcoholism.

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## Chapter 4

### ORAL HYGIENE HABITS

- Toothbrush
- Dentifrice
- Frequency of tooth-brushing
- Brushing techniques
- Other oral hygiene aids

#### Oral hygiene habits:

The main etiologic agent of inflammatory periodontal disease (gingivitis and periodontitis) is dental plaque.

Definition of plaque control: Plaque control is the regular removal of dental plaque and the prevention of its accumulation on the teeth and adjacent gingival surfaces.

Plaque control can be achieved by both mechanical and chemical methods. Mechanical plaque control is also called as oral physiotherapy.

Mechanical plaque control includes the use of:

1. Tooth brushes, 2. Interdental aids, 3. Tongue cleaning, 4. Irrigation,
5. Dentifrices and

Chemical plaque control includes the use of: 1. Mouthwash 2. Irrigation with antiplaque agents. 3. Dentifrices with antiplaque agents.

#### Tooth brush

- The parts of the toothbrush are: handle, shank and head.
- ADA specifications number for toothbrushes are:
- Length: 1 to 1.25 inches
- Width: 5/16 to 3/8 inches
- 2 to 4 rows
- 5 to 12 tufts per row
- 80 to 86 bristles per tuft

Tooth brushes are of two types – manual and powered. Powered toothbrushes are specially indicated in patients with decreased manual dexterity and In physically or mentally challenged patients.

Sonic and ultrasonic toothbrushes: they produce high frequency vibrations. They disrupt plaque and stains through cavitation and acoustic micro streaming.

Ionic toothbrushes: they send a small, imperceptible electronic current through the brush head. The electrons reduce the H<sup>+</sup> ions from the organic acid in the plaque which may result in the decomposition of bacterial plaque. (Hoover et al 1992).



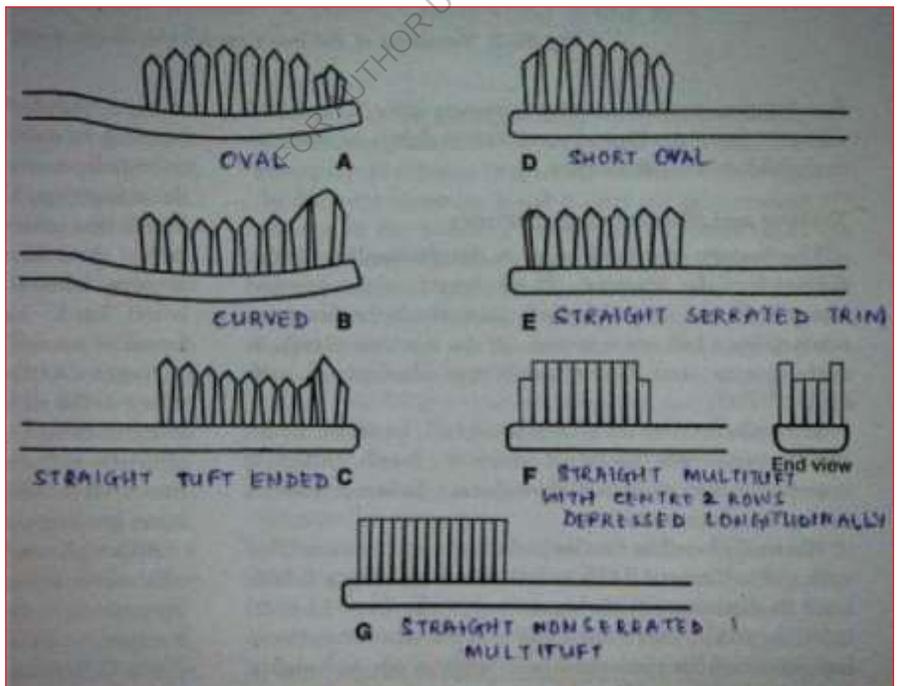
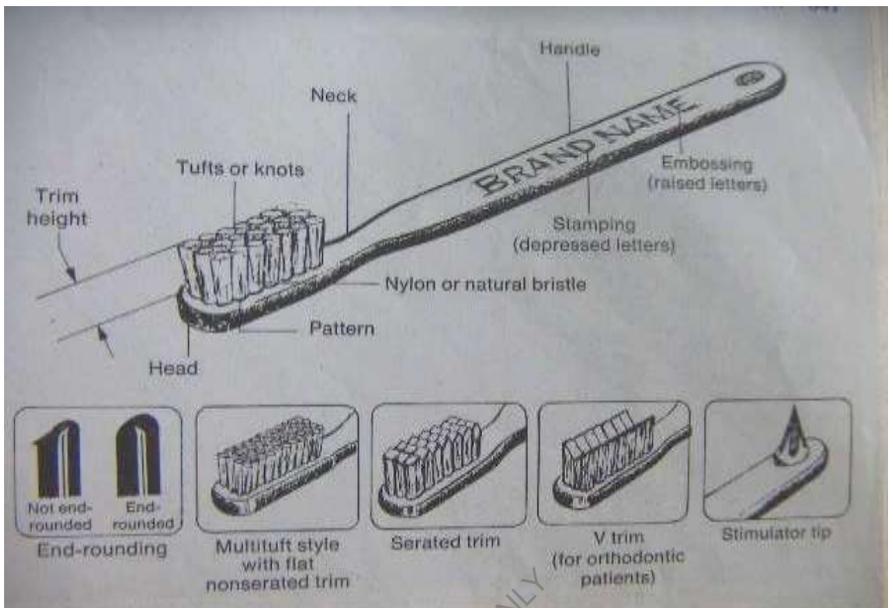
Advise patients to use a soft or medium bristled toothbrush. Bristles have been classified according to their diameter as:

Soft- 0.2 mm (0.007inch)

Medium- 0.3 mm (0.011 inch)

Hard- 0.4mm (0.014 inch)

- Chinese fabricated toothbrushes made with bone or ivory fitted with natural hog bristles. 1600 A.D.
- Natural bristles made from hog's hair are usually very sharp and unkind to soft tissues.
- These are expensive, very hard, sharp, and abrasive to both cervical root surfaces and gingival tissues.
- Present day - Nylon bristles of varying quality, end rounded by a polishing process, affixed to plastic handles of diverse designs.



## TUFT DESIGN

Straight, multi tuft trim with three rows of bristles –most common

Bristle textures	Recommended
"Extra-soft" brush (6 mil)	When the gingival tissue is particularly tender and Prone to bleeding when brushed.
"Soft" brush (7 mil)	Normally for young children
Medium-grade brush (8 mil)	Most preferred –as they are sufficiently stiff to effectively remove plaque on tooth surfaces and in the gingival sulcus.
Hard" brush	When the brushing forces are heavy Suitable for someone with heavily keratinized gingival Tissues that will withstand the stiffness.
Extra hard -12mil	Only in extremely rare instances. Disadv -- may cause gingival damage and cervical abrasion, resulting in gingival recession.

## Special modifications of tooth brush

BRUSH	DESIGN	RECOMMENDED
Orthodontic brushes	2 rows of longer bristles on each side of a middle row of shorter and stiffer bristles	To clean teeth, gingival tissues, the orthodontic brackets, wires and attachments.
Special sulcular cleansing brushes	With a small head and softer bristles	For the patient with periodontal pockets.
Pacemaker 45 (Oral-B Laboratories, Inc.)	Bristles of the brush are automatically placed at 45° angle to the tooth and sulcular surfaces when held normally.	Design is aimed to facilitate the adoption of the bass method of tooth brushing or other methods of intra sulcular brushing
Inter dental and interproximal brushes		For patients with bridges, partial dentures, and fixed orthodontic appliances.
Travelling brushes	2 sections: assembled before use with the brush head fitting into the handle.	

Bristles usually fray in 9 weeks and therefore toothbrushes should be replaced atleast every 3 months. If they fray earlier than 3 months it indicates overzealous brushing and if they longer it means they are probably not used every day.

Dentifrice:

Composition of dentifrice:

- Detergent (1-2%): lowers surface tension penetrates and loosens surface deposits and stains, emulsifies debris and has a foaming action. Substances used: sodium lauryl sulphate USP, sodium n-lauryl sarcosinate and sodium monoglyceride sulfonate.
- Cleaning and polishing agents (25 -60%): to produce a smooth shiny tooth surface and provide a high polish which prevents or delays re-accumulation of stains and deposits. Substances used: calcium carbonate, calcium pyrophosphate, dicalcium pyrophosphate dehydrate and dicalcium phosphate anhydrous.
- Binder or thickener (1-2%) – prevents separation of the solid and liquid ingredients during storage, substances used: alginates and synthetic derivatives of cellulose.
- Humectant (20-40%): retain moisture and prevent hardening on exposure to air. Substances used: glycerine, sorbitol, propylene glycol.
- Preservatives (2-3%): prevents bacterial growth, substances used: alcohols, benzoates, formaldehyde and dechlorinated phenols.
- Sweetening agents: impart a pleasant flavour
- Flavouring agents (1-1.5%): make the dentifrice desirable. Substances used: essential oils, menthol and artificial non-cariogenic sweeteners.
- Colouring agents: make the tooth paste attractive vegetable dyes may be used.
- Water (15-50%): water is the chief ingredient.
- Therapeutic agents (1-2%): they have a specific preventive/ treatment action.
- Substances used: pyrophosphates and fluorides.

Toothpowder contains about 95% of abrasives, whereas toothpaste contains 20-40%. Severe cervical abrasion and gingival recession can be seen in patients using toothpowder. In India, other materials such as ash, charcoal powder, brick powder and tobacco and herbal products like neem turmeric are used to clean teeth. It is not only important to find out which dentifrice the patient is currently using but also necessary to find out what he was using in the past. If the patient

was previously using tooth powder, it could account for recession and abrasion even if he has switched to tooth paste now.

### **Frequency of tooth-brushing**

Patients are asked to brush their teeth two times a day because of:

- Complexity of the technique recommended
- Patients on an average brush for less than 2 minutes each time which is insufficient.
- Only 40% of the plaque gets removed at one time.

### **Brushing techniques:**

- Bass technique
- Roll technique
- Scrub technique
- Circular/fones techniques
- Modified stillman 's
- Charter's technique
- Physiologic technique

Bass technique

- Placement of the toothbrush bristles at a 45° angle to the long axis of the teeth
- Gently pressing the ends of the bristles into the gingival sulcus and interproximal areas while the brush is vibrated in a back-and-forth short stroking motion.
- 2-4 teeth and their interproximal spaces cleansed at one time.
- Occlusal surfaces brushed using short antero-posterior strokes.



Roll technique:

- Bristles placed firmly at a 45° angle on the attached gingivae and the brush head is rolled in a coronal direction using an arcuate motion.
- Motion is repeated systematically for the entire oral cavity.
- Occlusal surfaces are brushed in an antero-posterior scrubbing motion.

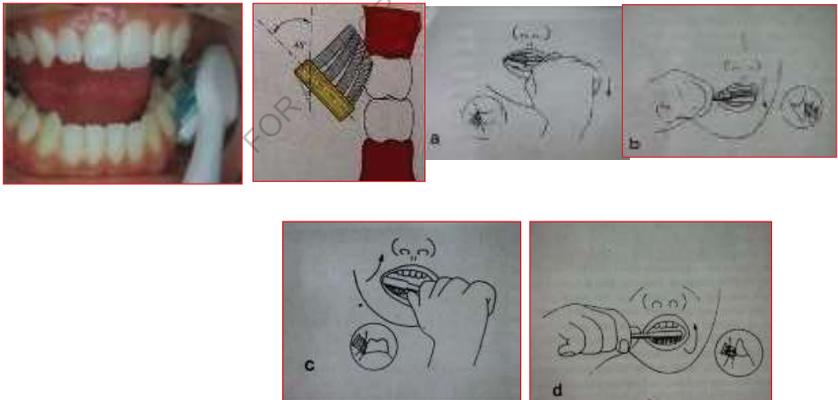
Scrub technique:

- The bristles are applied at 90° to the tooth surface and the brush is moved back and forth as in scrubbing a floor.

Circular/fones technique:

- Bristles at 90°, and the entire brush head is moved in a circular scrubbing motion using light pressure. The spherical pathway is limited to the mucobuccal space.
- No deliberate attempts at intra sulcular cleansing is made. This technique is said to be effective for young children with minimal manual dexterity.

Modified stillman technique:



Mechanical and chemical plaque control

- Placement of the bristles at 45° to the long axis of the teeth on the gingival margin.
- The brush is vibrated mesiodistally as the brush head is rotated toward the coronal surface.

- Technique stresses interproximal cleansing and the massaging effects of the bristles on the gingival tissues.

**Indication:** Cleaning in areas with progressing gingival recession & root exposure to prevent further tissue destruction.

**Charter ' s Technique:**

- Starts with bristles placed at a 45° angle to the teeth, but they are firmly pushed into the interproximal spaces with a slight rotary and vibratory action.
- Main action depends on the massaging effects of the sides of the bristles.
- Occlusal surfaces are brushed using a rotary movement.



**Indications:**

- Individual's having open inter-dental spaces with missing papilla & exposed root surfaces
- For patients who have had periodontal surgery

**Physiologic technique:**

- This method requires a soft brush and the brushing is done by sweeping from coronal portion apically toward the gingival margin and the attached gingivae similar to the pathway of food during mastication.

**Disclosing Agents:**

- A good disclosing agent stains the teeth only very faintly by staining the pellicle a faint pink color but stains the dental plaque deeply and vividly.

- Agents used
  - Basic fuchsin
  - Erythrocin
  - Fast green
  - Other vegetable and food coloring dyes.
  - Mode of application
  - By professional personnel
  - Dropped directly into the mouth and swished in the mouth with a few drops of water, or
  - Can be applied with a cotton swab directly to teeth.
  - Dis-plaque (Oral-B Laboratories, Inc.)
  - Dye that differentiates plaque by staining older plaque in blue tones and more recent thin deposits in red tones. This dye is designed to minimize the staining of the soft tissues and usually fades much faster than erythrocin



TABLETS, CAPSULES, AND WAFERS ARE PROBABLY MORE EASILY MANAGED BY CHILDREN AND PARENTS FOR HOME USE



### **Plak-lite mirror**

- Uses a fluorescent dye in conjunction with a special mirror and avoids the use of a red dye.
- Useful for adult males who object to red staining of the lips, tongue and cheeks.
- Stained plaque should fluoresce as a brilliant yellow-green color.
- Clean tooth surfaces and plaque free gingivae not stained by the fluorescent dye, whereas dental plaque is seen vividly by the fluorescent light source.
- Patient using Plak-Lite mirror in conjunction with a fluorescent dye to disclose plaque to a brilliant yellow green colour.

### **Dental Floss:**

- Made from nylon filaments.
- Usually from multiple filaments, 2 to 3 deniers thick, which are combined into an end.
  - *Denier (D)* is best defined on the basis of the weight of a 500-denier floss. The denier of any yarn is its weight in a 9000 m length; thus 9000 m of 500 D yarn should weigh 500 g.)
- Each dental floss, depending on its thickness. is made with 4 to 18 ends of filaments twisted in a predetermined number of twists per inch' (tips).
- A floss that is designed to basically serve as ties for securing a rubber dam in place should have a high tips and wax coating, whereas for greater splaying action to clean interproximal surfaces of teeth, a lower tip is more desirable.
- Waxed vs Unwaxed floss.
  - wax being left on the interproximal surfaces fromwaxed floss
  - unwaxed floss is usually thinner and splays more on use.
  - Waxed floss is used much more in dental offices and is recommended to those patients who do not manage the thinner unwaxed floss well.
  - Mechanical deplaquing effect of flossing is greater than the use of a fluoride dentifrice.

**Flossing technique:**

- Effective use dental floss is a function of age, manual dexterity and eye-hand coordination.
- Not all children are able to floss effectively.
- Flossing should be done thoroughly at least once a day.
- Flossing can either precede or follow toothbrushing.

**Flossing Technique:**



Use about 18" of floss, leaving an inch or two to work with.



Gently follow the curves of your teeth.



Be sure to clean beneath the gumline, but avoid snapping the floss on the gums.

## Spool flossing method for adults

Steps:

1. Break off a piece of floss from the spool 12 to 18 inches long
2. Wrap floss around middle finger 2 to 3 times wrap remaining floss around left middle finger (or vice versa)
3. For maxillary insertion grasp floss firmly with thumb and index finger of each hand using ½ inch of floss between finger tips.
4. For mandibular insertion direct the floss down with the index fingers.
5. Select area to begin flossing and establish a pattern to progress throughout the mouth.
6. Set a fulcrum on the cheek or in the mouth
7. Use gentle seesaw motion to pass through contact area.
8. Pass floss below gingival margin
9. Wrap tightly in C shape around tooth
10. Move floss up and down on mesial of tooth 3 to 4 strokes then move above papilla (just below contact) wrap in C shape on distal of adjacent tooth moving floss up and down 3 to 4 strokes.
11. Use a seesaw motion to remove floss through contact
12. Advance floss to new area by unwrapping floss from left hand middle finger and wrapping on to right hand middle finger
13. Repeat steps 5 to 11 until all teeth have been completed. Continuing to grasp the floss with the thumb and index fingers.
14. Dispose of floss in waste receptacle.

## Rationale

- An up and down motion inter proximally covers the entire length of the interproximal area rather than a single area accomplished by a shoeshine motion. Moving the floss above the papilla before wrapping the C shape on the opposite surface avoids a floss cut in the papilla.
- A seesaw motion back out of the contact allows for more gentle removal of the floss
- Floss is advanced to a new area after each interproximal space to avoid spreading bacteria from sulcus to sulcus. This is an attempt to contain diseased bacteria to localized sites.
- The entire mouth should be flossed including the distal of the most posterior tooth in each quadrant.

- Floss is meant for one time use.

### **Loop flossing method for children and clients with limited manual dexterity**

Steps:

1. Break off a piece of floss from the spool 8 to 10 inches long
2. Tie the two ends together in a knot.
3. For maxillary insertion grasp floss firmly with thumb and index finger of each hand using ½ inch of floss between finger tips.
4. For mandibular insertion direct the floss down with the index fingers.
5. Select area to begin flossing and establish a pattern to progress throughout the mouth.
6. Set a fulcrum on the cheek or in the mouth
7. Use gentle seesaw motion to pass through contact area.
8. Pass floss below gingival margin
9. Wrap tightly in C shape around tooth
10. move floss up and down on mesial of tooth 3 to 4 strokes then move above papilla (just below contact) wrap in C shape on distal of adjacent tooth moving floss up and down 3 to 4 strokes.
11. Use a seesaw motion to remove floss through contact
12. Advance floss to new area by sliding floss away from the knot
13. Repeat steps 5 to 11 until all teeth have been completed. Continuing to grasp the floss with the thumb and index fingers.
14. Dispose of floss in waste receptacle.

### **Rationale**

Less floss is needed to loop than to wrap around the middle fingers. A midsize piece of floss is still needed however to advance the floss to new areas in the mouth.

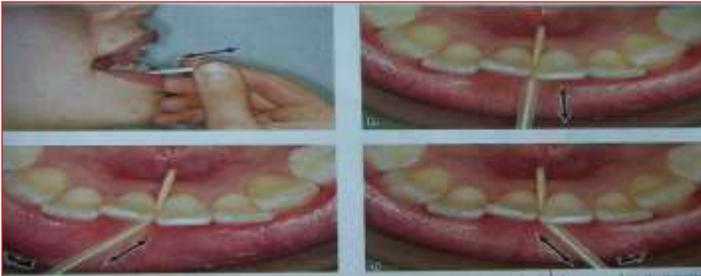
Tying the two ends together puts the floss into a complete circle. With this method the floss does not need to be wrapped around the middle finger of each hand. Which often causes the blood flow to be reduced in the fingers. A loop is also easier to control.

Steps 3 to 10 use the same techniques for both methods of flossing.

- Floss is advanced to a new area after each interproximal space to avoid spreading bacteria from sulcus to sulcus. This is an attempt to contain diseased bacteria to localized sites.

- The entire mouth should be flossed including the distal of the most posterior tooth in each quadrant.
- Floss is meant for one time use.

### Interdental cleansing aids



- TOOTHPICK is used extensively, particularly in Southeast Asian countries and Japan.
- Used essentially to dislodge food particles and foreign materials impacted in the interdental areas but not designed to cleanse interproximal surface
- STIMUDENT, a soft resilient type of wood toothpick, shaped to fit the interdental space used to dislodge food
- Particle and effectively remove plaque interdentally.
- Stimudent or similar products does not damage periodontal tissues and is pleasantly flavored to leave a good taste after use.
- Various flavors and even therapeutic agents (e.g., fluoride) can be incorporated in the wood to enhance patient acceptance and deliver additional protective benefits to these Caries susceptible sites.





### Chemical plaque control:

#### Ideal properties

- Agent should affect only the target tissue.
  - An antimicrobial agent should affect only bacteria known to cause gingivitis or periodontitis, or both.
  - An agent that alters the surface of the tooth should affect only the tooth or root surface and not the oral mucosa.
  - An enzyme or anti-metabolite should affect only the metabolic process of the plaque bacteria for which it is intended.
  - Active agents should remain at the site of the action for a time sufficient to produce the maximum therapeutic effect, but not so long that it will produce adverse effects.
  - Agent should be safe to the oral tissues at the concentration and dosage recommended
- Agent should be safe to ingest at a level expected with normal use that produces the maximum therapeutic effect.
- Agent should have desirable characteristics that enhance compliance with a preventive regimen.

- For example, the agent should have acceptable flavor and mouth feel and should not stain oral surfaces or irritate the tongue or other mucosal area.
- Ideally, the product containing the active agent should be inexpensive.
- Agent should produce an effect on plaque that will result in a statistically and clinically meaningful reduction in gingivitis or periodontitis, or both.
- The clinical benefit of plaque control can best be demonstrated by a significant reduction in gingivitis. Therefore, it will be necessary to demonstrate statistically significant reduction in both plaque and gingivitis by the products.
- Also, plaque reduction per se is not an end benefit for the consumer, rather, gingivitis reduction is.

The most widely tested chemotherapeutic agents used to treat plaque and gingivitis include antiseptics, phenolic compounds, chlorhexidine, antibiotics, and stannous fluoride.

Chemotherapeutic Agents Used in Treating Plaque Calculus and Gingivitis		
Type	Agents	Clinical Use
Bis-biguanides and related compounds	<u>Chlorhexidine</u> , <u>Alexidine</u>	Use approved in Europe. Limited use by prescription only in the United States
Antiseptics (quaternary ammonium compounds)	<u>Cetylpyridinium chloride</u>	Used in Cepacol and Scope mouthwashes
Antibiotics	Penicillin Metronidazole Tetracycline Vancomycin <u>Kanamycin</u>	Short-term adjunctive therapy in severe periodontal disease—not an antiplaque agents per se
Fluorides and inorganic ions	<u>Stannous fluoride</u>	Available as 0.4% stannous fluoride gel—used experimentally to control plaque and periodontal conditions
	Chlorine dioxide Hydrogen peroxide Sodium bicarbonate Sodium chloride Domiphen bromide	Commercially used in Oxyfresh mouthwash* Used in Keyes' technique for adjunctive treatment of periodontal disease None
Enzymes	<u>Dextranase</u>	None
	<u>Glucose—amylglucosidases</u>	Used in Zendum toothpaste*
Organic compounds	Sanguinarine	Used in Vivadent demifrice*
	Menthol/thymol	Used in Listerine mouthwash*
Anticalculus agents	<u>Soluble pyrophosphates</u>	Used in Crest and Colgate demifrices

## Chlorhexidine

- Chlorhexidine digluconate mouth rinses in concentrations of 0.2% to 1 % are highly effective in inhibiting dental plaque.
- Four chlorophenyl rings and 2 biguanide groups connected by a central hexamethylene group.

### Mechanism of action

- Spectrum of activity -- gram-positive and gram-negative bacteria and yeasts as well as Streptococcus mutans
- Can practically eliminate S. mutans from the mouth without reappearance for at least 11 weeks.
- The long-term use of chlorhexidine over a 24-month period showed that Streptococcus sanguis developed slight resistance.
- The antiseptic binds strongly to bacterial cell membranes
- At low concentration this results in increased permeability with leakage of intracellular components including potassium.
- At higher concentration, chlorhexidine causes precipitation of bacterial cytoplasm and cell death.
- Bacteriostatic action – 12 hours

### UNDESIRABLE SIDE EFFECTS OF CHLORHEXIDINE

- A brown diffuse discoloration of the teeth, composite restorations and the tongue,
- Unpleasant bitter taste.
- Dryness of the mouth and burning sensations of the tongue.

### With high concentrations,

- Desquamation of oral epithelial cells may occur, and hyperkeratosis and dysplasia of the mucosa have been reported in animal studies.
- Rarely, allergic responses may also occur.
- May be toxic to submucosal tissue if applied directly on them during surgical procedures.
- Long-term use of chlorhexidine may alter the oral ecology and may result in an increase in calculus.



### **Chlorhexidine staining**

- Degradation of the chlorhexidine molecule to release parachloraniline.
- Catalysis of maillard reaction.
- Protein denaturation with metal sulfide formation.
- Precipitation of anionic dietary chromogens.

### **Clinical uses of chlorhexidine**

- As an adjunct to pral hygiene and professional prophylaxis
- Postoral surgery including periodontal surgery or root planing
- For patients with jaw fixation
- For oral hygiene and gingival health benefits in the mentally and physically handicapped.
- Medically compromised individuals predisposed to oral infections.
- High risk caries
- Recurrent oral ulceration.
- Denture stomatitis

### **CETYLPIRIDINIUM CHLORIDE AND PHENOLIC AND OTHER COMPOUNDS**

- Quaternary ammonium compounds - antiplaque properties.
- Other such compounds include
  - Domiphen bromide,
  - Mixtures of essential oils in alcohol - active ingredients in antiplaque agents,
  - Sanguinaria extract,
  - Mixture of benzophenathridine alkaloids,

- zinc fluoride/hexetidione-containing mouthwash,
- An enzyme dependent mineralizing mouthwash, alexidine,
- Fluoride and Iodines
- Several commercially available mouthwashes containing cetylpyridinium chloride as the main active ingredient are effective antiplaque agents in conc of 0.025% to 0.05%.
- Patient acceptance of its taste and staining properties are generally favorable.
- Ciancio recommended products that contain cetylpyridinium chloride or phenols to patients with extensive fixed prosthesis and/or periodontal defects that cannot be surgically corrected.
- They could be used either as a forced rinse or in a powered oral irrigating device.
- Additionally, a regimen of systemic tetracycline may be prescribed
- for those patients for whom irrigation is also recommended.
- Antibiotics
- Antibiotics like penicillin, tetracycline, hydrochloride, metronidazole. and clindamycin used successfully by clinicians in conjunction with thorough scaling, root planing, and periodontal surgery.
- For e.g. in treatment of juvenile periodontitis, the local application of tetracycline either systemically or locally by hollow cellulose acetate fibers delivers an effective conc of the drug in the gingival fluid.
  - local applications -- short-lived results
  - rebound of micro-organism occurs readily.
- Children receiving tetracycline before age 7 show severe staining of the anterior teeth due to tetracycline incorporation into the dentine and enamel.
- Kanamycin, a nonabsorbable aminoglycoside with a broad spectrum activity has been shown to reduce plaque and gingivitis when used as a topically applied paste in institutionalized mentally retarded subjects

- Long-term use of antibiotics for plaque control is inappropriate because of the high risk and low benefit.
- ONLY selective and carefully prescribed and monitored doses of tetracycline and other antibiotics may have some benefits in the short-term management of patients who fail to respond to conventional therapy

## Fluorides

### Actions:

- Cariostatic properties,
- Reduces dental plaque formation.
- Enhances pellicle deposition on teeth which thickens and is stained by disclosing agent, yellow to light brown.
- Selective inhibition effect on the growth of *S. mutans*, but little or no effect on *Lactobacillus*.
- SnFconc > 125 ppm of fluoride -- bactericidal against *S. mutans* about 10 ppm of fluoride -- alterations in DNA and glucan

production by *S. mutans*.

- Clinically, anti plaque effects of SnF related to
  - frequency of use,
  - concentration of the agent,
  - stability of the Sn<sup>++</sup> and F<sup>-</sup> ions in commercially available preparations.

### Mechanism of action

- retained in the mouth for a prolonged period after application, and antimicrobial inhibition properties related to the quantity of tin uptake by *S. mutans*.

For optimal antibacterial effect, critical factors are,

- pH of the SnF gel
- a pH < 4 produces greater plaque inhibition than the same fluoride conc (e.g., 0.1 % stannous fluoride) at a pH of 5 or 6.
- The plaque uptake of tin in stannous per milligram of plaque is also related to the pH of the agent.

The fluoride concentration, a snfconc of 0.4% is much more effective than a 0.1 % or 0.04% solution or gel.

- Commercially available SnF gel preparations differ in their
- stability, as measured by the availability of the stannous ions and percentage of fluoride ions ranging from 21% to 51% Sn<sup>++</sup> ion and 85% to 93% F<sup>-</sup> respectively.

Enzymes:

Mechanism of action.

- It is intended to enhance the lactoperoxidase system already present in human saliva, and its function is to oxidize the thiocyanate (SCN<sup>-</sup>) in saliva in the presence of hydrogen peroxide to form hypothiocyanate.
- The hypothiocyanate (OSCN<sup>-</sup>) would react with sulfhydryl groups of oral micro-organisms, resulting in their inhibition.

Anti-tartar agents:

- Fluoride dentifrices claim to “control "tartar" or new calculus buildup following professional prophylaxis.

E.g. Crest (Procter and Gamble)

- Zacherl et al tested a dentifrice formulation containing a combination of soluble pyrophosphates,
  - 3.4% tetrasodium pyrophosphate,
  - 1.37% disodium dihydrogen pyrophosphate, and
  - 0.243% sodium fluoride in a silica gel.
- He found that it caused a reduction of newly formed calculus by 32%, and had no untoward side effects on soft tissues.
- In a similar study using a dentifrice containing 3.3% soluble pyrophosphate, a significant 26% reduction in calculus formation was obtained.
- Colgate has used a pyrophosphate formulation that has shown to reduce new calculus formation by 44.2%.
  - Pyrophosphates may prevent calcification by interfering with the conversion of amorphous calcium phosphate to hydroxyapatite.
  - A 2% zinc chloride dentifrice formulation, introduced as an effective ingredient in anti calculus dentifrices such as Prevent (Johnson & Johnson Products, Inc.) showed a 51% reduction in calculus.

## Chapter 5

### CLINICAL EXAMINATION

- Extra oral examination
- Intra oral examination
- Gingival status
- Periodontal status
- Indices
- Mucogingival problems
- Hard tissue examination
- Occlusal examination

#### Extra oral examination

Symmetry of face – Facial asymmetry can be summarized and divided in to 3 main categories'

1. Congenital originating prenatally.
2. Developmental, arising during growth with inconspicuous etiology
3. Acquired, resulting from injury or disease
4. Inflammatory resulting from endodontic or periodontic origin and involving facial spaces.

<b>Congenital</b>	<b>developmental</b>	<b>Acquired</b>	<b>Inflammatory</b>
Cleft lip and palate Hemifacial microsomia Craniosynostosis Tessier Craniofacial cleft Vascular disorders Torticollis Hemi-atrophy or hemi-hypertrophy	Usually, have an unknown cause	TMJ ankylosis Unilateral condylar hyperplasia Facial trauma Childhood radiotherapy Fibrous dysplasia Romberg's disease Other cysts and tumors Bell' s palsy	Due to space abscess Dentoalveolar abscess

## Lymph glands

Lymphnodes should be examined for their number, location, temperature of the overlying skin, surface, margins and consistency. Lymph node enlargement can be:

Inflammatory: caused by infection ( Acute lymphadenitis, chronic lymphadenitis, tuberculosis, syphilis)

Neoplastic: caused due to neoplasms (primary- lymphosarcoma, or secondary- carcinoma, sarcoma, malignant melanoma )

Hematological: caused due to hematological disorders { hodgkin's lymphoma non hodgkin's lymphoma chronic lymphatic leukemia)

Immunological: caused due to immunological disorders ( serum sickness, systemic lupus erythematosus, rheumatoid arthritis etc ).

Features of lymphnodes in infection and malignancy

<b>Features of lymphnodes in infection and malignancy</b>		
Characteristic features	Infection	malignancy
Consistency	Soft	firm
Surface texture	Smooth	nodular
Fixity to underlying tissue	Absent	Present
Tenderness on palpation	Present	absent

Periodontal conditions where lymphnodes might be palpable

- ANUG
- Abscess
- Acute herpetic gingivostomatitis
- Aggressive periodontitis
- Pericoronitis

Lymphnodes Examination

The lymph nodes of the head and neck are peripheral and deep nodes.

The peripheral and deep nodes are arranged in to superficial and deep nodes.

Superficial – submental, submandibular, occipital, anterior cervical and superficial cervical

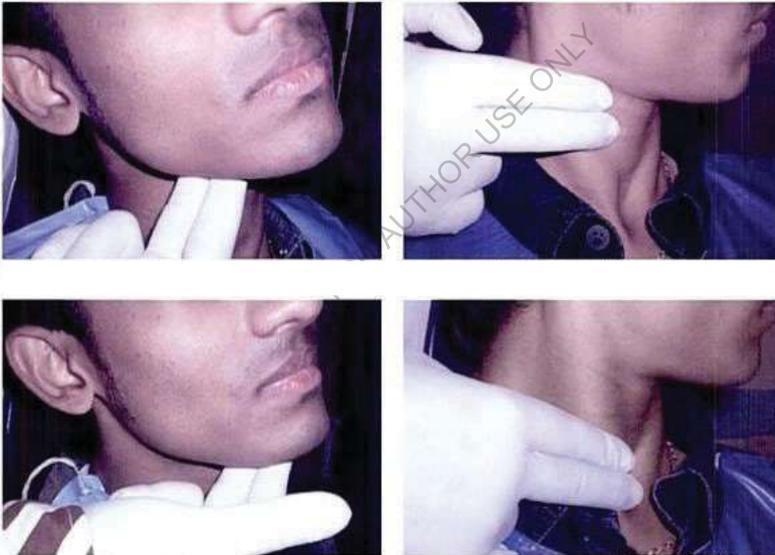
Deep – prelaryngeal, pretracheal, and retrolaryngeal .

Deep cervical – jugulodigastric, jugulo-omohyoid

The lymph nodes draining the periodontal area are the submandibular, submental and pre auricular lymphnodes. The entire lymph from the head and neck drains ultimately in to the deep cervical nodes either directly or through peripheral nodes.

Submandibular lymph nodes are palpated by placing the thumb along the lateral surface of the mandible and using the pads of the index and middle fingers to push the nodes against the bone. The examiner has to stand behind the patient and the patient is asked to tilt his head towards the same side that is being palpated.

This technique is known as bimanual palpation. Examining the submental nodes is similar, however the fingers are placed at the chin instead. The pre-auricular lymph nodes are palpated in front of the tragus of the ear.



TMJ (Temporo mandibular joint)

Classification of TMJ disorders

1 masticatory muscle disorders

- Protective muscle splinting
- Muscle hyperactivity or spasm
- Myositis (muscle inflammation)

## 2. Disc-interference disorders (Internal derangements)

- In- coordination
- Deformation of the articular disc
- Partial anterior disc displacement
- Anterior disc displacement with reduction
- Anterior disc displacement without reduction
- Anterior disk displacement with perforation
- Posterior disk displacement

## 3. problems that result from extrinsic trauma

- Tendonitis
- Myositis
- Traumatic arthritis
- Dislocation
- Fracture
- Internal derangement

## 4 degenerative joint disease

- Arthrosis (no inflammatory phase)
- Osteoarthritis (inflammatory phase)
- Osteochondritis dissecans or avascular necrosis

## 5 Inflammatory joint disorders

- Synovitis and capsulitis
- Retro diskitis
- Inflammatory arthritis – Rheumatoid arthritis  
   Infectious arthritis  
   Metabolic arthritis

## 6 chronic mandibular hypomobility

- Ankylosis
- Fibrosis of articular capsule
- Contracture of elevator muscles ( myotatic or myfibrotic)
- Internal disc derangement (closed lock)

## 7 growth disorders of the joint

- Developmental disorders
- Acquired disorders
- Neoplastic disorders

## 8 Postsurgical problems

### TMJ Examination

The patient should be asked about the site, character, radiation and aggravating or relieving factors associated with pain. TMJ pain is often a dull constant ache that is aggravated by opening the mandible or chewing. There may be a complaint of limited jaw opening and frequent clicking, popping or grinding noise within the joint associated with mandibular movement or mastication. Other less frequent symptoms include tinnitus, changes in hearing, facial numbness and headache.

### Lateral and posterior palpation of the joint

The examiner palpates the lateral pole of the condyle with the index finger or 2 fingers placed near the tragus of the ear. The patient is asked to slowly open and then close the mouth. The test is positive if pain is present. In posterior palpation the examiner palpates the posterior portion of condyle with the little finger in the patient's ear. The patient is asked to slowly open and then close the mouth. The test is positive if pain is present. Popping and clicking of the joint can also be felt in many cases if it is present.

### Auscultation of the joint

In this stethoscope is placed on the lateral aspect of the joint and any sounds during joint movement is recorded. Auscultation with a stethoscope is considered positive if the clicking sound is observed at least 4 times during 5 repetitions of mouth opening.

### Deviation during movement

The examiner stands in front of the patient and the patient is asked to slowly open the mouth widely without causing any pain. Normally in an adult, the maximum mouth opening ranges from 35-50mm. During opening if the

mandible deviates to one side, it indicates disequilibrium between right and left TMJ.

Lateral and protrusive /retrusive movement of the joint.

In lateral movement, the patient is asked to slowly move the mandible to the right and then to the left side to the maximum without causing any pain. The movement should be similar on both sides. The normal lateral movement of the mandible is usually 8-10mm. reduced or abnormal movement on one side indicates a TMJ problem

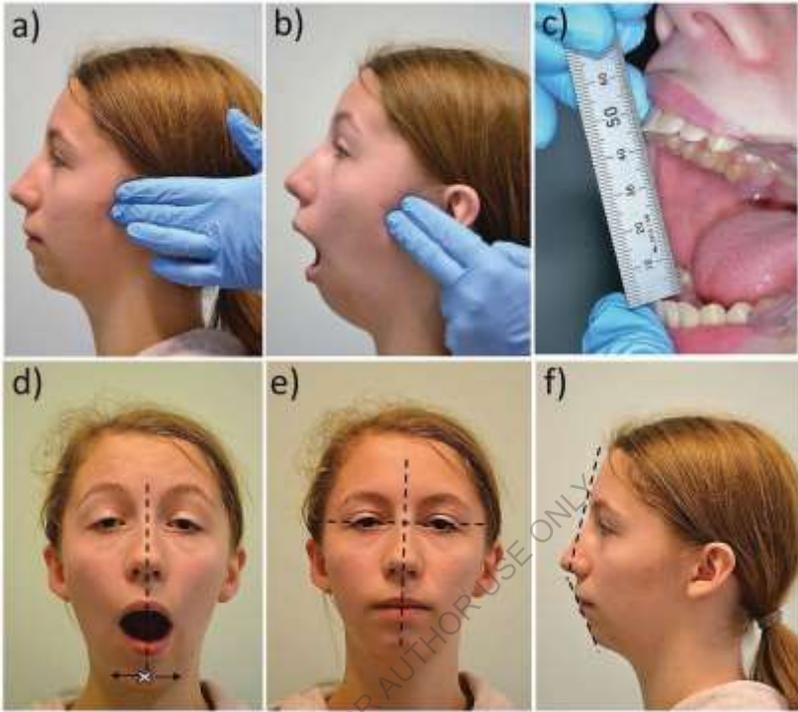
.in protrusive /retrusive movements- if the problem is intracapsular, mandible will move to the side of involved joint during protrusion and be restricted during contralateral movement. (ie. Normal movement to the ipsi lateral side). If the problem is extracapsular, there will be no deflection during the protrusive movement and and no restriction in lateral movements.



TMJ EXAMINATION



Palpation of the TMJ.  
A. Lateral aspect of the joint with the mouth closed.  
B. Lateral aspect of the joint during opening and closing.  
C. With the patient's mouth fully open, the clinician moves a finger behind the condyle to palpate the posterior aspect of the joint.



## Treatment of TMJ Disorders

Step 1 – patient education and self care

Step 2- behaviour modification- identify specific parafunction or postural problem

- Cognitive-behavioural self-regulation exercises
- Myotherapy /physical therapy referral

Step 3- Pharmacotherapy – analgesic appropriate for pain level

- Muscle relaxant
- Tricyclic antidepressant
- Anxiolytic

Step 4- Trigger-point management- injection with local anaesthetic

Physical therapy: vapo coolant spray or ice and stretching.

Step 5 – orthopaedic appliance therapy: muscle relaxation splint.

### **Lip seal**

Lip seal is a natural seal made between upper and lower lip at rest. The lips may be described as,

Competent: here a lip seal is produced with minimal muscular effort when the mandible is in rest position.

Incompetent: in this case due to morphologically short upper or lower lip a lip seal cannot be made in a relaxed state. Lips can only be brought together by the contraction of circumoral muscles.

Incompetent lips are usually associated with mouth breathing. In these patients gingiva appear erythematous and shiny, especially in the maxillary anterior region. This change has been attributed to surface dehydration.

Potentially incompetent: in this case lips fail to make a lipseal in a relaxed muscular state due to protruding upper central incisors.

### **Intra oral examination:**

Oral mucosa is divided into 3 parts

Masticatory mucosa- gingiva and hard palate

Specialized mucosa – dorsum of the tongue

Lining mucosa – labial mucosa, buccal mucosa and lining of the floor of the mouth

If any of the lesions are seen on mucosal areas they should be described according to their location, size, color, consistency and presence or absence of tenderness.

Buccal mucosa: physiological alterations that may be seen include cheek bite (linea alba buccalis), ectopic sebaceous glands (Fordyce's granules) and leukedema. Fordyce's granules appear as yellow colored granules on the buccal surface.

Lichen planus, leucoplakia, oral submucous fibrosis, candidiasis, hemangioma, aphthous ulcers are most commonly observed lesions on the buccal mucosa.

Labial mucosa: on the labial mucosa vesicles and ulcers may be present due to herpes labialis. Scaling and root planing should be done once the lesions subside. Self-protective measures should be followed during examination of these patients as the condition is contagious. When it spreads to the clinician's finger the lesion is called herpetic whitlow.

Floor of the mouth: mucous retention cysts (ranula) might be observed in floor of the mouth.

Tongue: the tongue has an irregular surface which offers ideal niches for sheltering bacteria and retaining desquamated cells and food remnants.

- Tongue coating is particularly seen in case of hairy tongue or fissured tongue (lingua plicata). This tongue coating is responsible for halitosis.
- Tongue thrusting habit causes pathologic tooth migration and anterior open bite which may further lead to mouth breathing. To check for tongue thrusting the lip should be reflected and the patient should be asked to swallow. The normal position of tongue on swallowing is at anterior palate. People with tongue thrusting habit push the tongue towards the mandibular anteriors.
- Other lesions on the tongue include geographic tongue or migratory glossitis and median rhomboid glossitis. The tongue should be checked for ankyloglossia and micro or macroglossia.

### **Palate:**

Palatine tori may be used as autografts if the patient has angular bone loss and requires osseous regenerative procedures. If tori come in the way of oral hygiene procedures or denture construction they should be removed.

Smokers may exhibit smoker's palate.

Presence of cleft palate may complicate ultrasonic scaling as the water might flow into the nasal cavity.

### **Halitosis:**

Synonyms- bad or foul breath

Breath malodor

Oral malodour

Foetor ex-ore

Stomatodysodia

Foetor oris

Oral malodour is defined as the subjective perception after smelling someone's breath.

Types: Miyazaki et al in 1999 classified halitosis as genuine halitosis, pseudo halitosis and halite phobia. Genuine halitosis is further classified in to physiologic and pathologic halitosis.

**Aetiology:**

Physiological halitosis- morning breath odour, tobacco smoking & certain foods and medications.

Pathological halitosis:

**Intra-oral or extra -oral origin**

90% of patients- oral cavity

Bacteria, volatile sulphur compounds

**Intra oral origin**

Poor oral hygiene, dental caries, periodontal disease in particular NUG, NUP, periodontitis, dry socket, other oral infections, tongue coating and oral carcinoma.

Tongue coatings include desquamated epithelial cells food debris, bacteria and salivary proteins and provide an ideal environment for the generation of VSCs and other compounds that contribute to malodour.

**Extra-oral origin:**

10-20%

Gastro-intestinal diseases

Infections or malignancy in respiratory tract

Chronic sinusitis and tonsillitis

Systemic pathological conditions that cause halitosis:

Systemic condition	Characteristic odour
--------------------	----------------------

Diabetes mellitus	Acetone, sweet fruity
Renal failure	Urine or ammonia
Liver failure	Fresh cadaver
Tuberculosis/lung abscess	Foul, putrefactive
Internal hemorrhage/blood disorders	Decomposed blood

**Volatile sulphur compounds:** hydrogen sulphide (H<sub>2</sub>S rotten egg smell), dimethyl sulphide CH<sub>3</sub><sub>2</sub>S rotten cabbage smell and methyl mercaptan CH<sub>3</sub>SH)

**Non sulphur containing substances** – putrescine, cadaverine, skatole, indole.

Short chain FA- butyric, Propionic, Valeric, Isovaleric acid.

Others- acetone, acetaldehyde, ethanol diacyl.

**Common causes of halitosis:**

Food impaction

Acute necrotising ulcerative gingivitis

Acute gingivitis

Aggressive periodontitis

Pericoronitis

Dry socket

Xerostomia

Oral ulceration

Oral malignancy

**Respiratory disease:**

-sinusitis

Tonsillitis

Malignancy

Bronchiectasis

**Volatile food stuffs:**

-Garlic

-Onions

-Spiced foods

Mico-organisms associated with halitosis include *T. forsythia*, *T. denticola*, *P. gingivalis*, *P. intermedia*, *P. nigrescence*, *A. a comitans*, *C. rectus*, *F. nucleatum*, *P. micros*, and *Eubacterium* species. These produce volatile sulphur compounds.

### **Methods to check malodor: clinical and laboratory examination**

**Self examination-** involve the patient in monitoring the results of therapy by self examination. it is done by making the patient smell a metallic spoon after scraping the back of the tongue, toothpick inserted in an interdental area, saliva spit into a small cup or wrist which has been licked and allowed to dry.

**Organoleptic rating:** a trained judge sniffs the expired air, this gives him an estimate of the breath odor. He also checks for oral cavity odor (subject opens mouth and refrains from breathing), tongue odor (smelling the tongue scrapping) and nasal breath odor (subject expires through the nose, keeping the mouth closed). This method is considered the gold standard. The value gives are the

- 0- No odor present
- 1- Barely noticeable
- 2- Slight but clearly noticeable odor
- 3- Moderate odor
- 4- Strong offensive odor
- 5- Extremely foul odor.

**Portable volatile sulfide monitor (halimeter):** analyses concentration of hydrogen sulfide and methyl mercaptan but does not differentiate between two.

**Gas chromatography:** it can differentiate between the 3 key sulfides.

**Dark field microscopy:** used to visualize spirochetes which produce volatile sulfide compounds.

Ninhydrin method of detecting amine compounds: Amine levels are higher in the saliva of subjects suffering from halitosis and lower in healthy controls. Iwanicka et al (2005)

Diamond probe: used for detection of halitosis

**Electronic nose:**an electronic, artificial nose uses to clinically assess oral malodor strength and oral health status.

Halitox system: Quick and simple

Detects VSCs and poly amines

TOPAS: it detects both VSC and polyamines in the sample

The absorbent point given with the kit is inserted into the pocket.

Left in place for 1 minute

Submerge the absorbent point tip in the toxin reagent

Wait for 5 minutes and see for yellow colour in the specimen on the scale of 0-5 which is directly proportional to the level of toxins in the sample.

BANA test: used to determine the proteolytic activity of certain oral anaerobes that contribute to oral malodor.

**Treatment:**

**Treatment needs for halitosis have been categorized into 5 classes in order to provide guidelines for clinicians in treating halitosis patients**

- Treatment of physiologic halitosis (TN 1)
- Oral pathologic halitosis (TN 1 & TN 2)
- Pseudo-halitosis (TN 1 and TN 4) should be the responsibility of a dentist
- However treatment of extra-oral pathologic halitosis (TN3) or halitophobia (TN5) should be undertaken by a physician or medical specialist such as a psychiatrist or psychologist.

Treatment needs for halitosis

Category	Description
TN 1	Explanation of halitosis and instructions for oral hygiene(support and reinforcement)
TN 2	Oral prophylaxis, professional cleaning and treatment for oral diseases especially periodontal diseases.
TN 3	Referral to a physician or medical specialist
TN 4	Explanation of examination data, further professional instructions, education and reassurance
TN 5	Refferal to a clinical psychologist, or psychiatrist or other psychological specialist.

Mechanical reduction: tongue cleaning, tooth brushing, using interdental aids.

Chemical reduction: chlorhexidine, listerine, triclosan, cetylperidinium chloride, chlorine dioxide, fluoride/stannous fluoride

Chemical neutralization: oxidizing agents like hydrogen peroxide and bivalent metal ions such as zinc.

Conversion of volatile sulfide compounds- metal salt solutions, toothpastes, chewing gums

Masking: Rinses, mouth sprays, Lozenges containing volatiles, chewing gum

Herbal treatment: give raw carrots as a midday treat to help scour teeth of bacteria-laden plaque, a common cause of bad breath.

Cardamom tea contains cineole, a potent antiseptic that kills bad-breath bacteria and sweetens breath

Thymol, one of the constituents of thyme, is contained in antiseptic mouthwashes

Neem leaf powder can be used as an effective tooth powder to fight plaque and gingivitis when mixed with astringent herb powders and/or baking soda.

A few drops of tea tree oil, lemon or peppermint essential oils can be added to warm water for an effective mouth rinse to freshen breath.

## **Gingival status**

The gingiva is the part of the oral mucosa that covers the alveolar processes of the jaws and surrounds the necks of the teeth. It is divided into marginal, attached and interdental areas.

All gingival changes must be described as being localized or generalized and also in relation to the part of gingiva being affected as papillary, marginal or diffuse.

Colour of the gingiva

The normal colour of the gingiva is coral pink

Factors which determine gingival colour are

- Thickness of epithelium
- Degree of keratinization
- Vascular supply

- The presence of pigment containing cell

The changes in the colour of the gingiva in inflammation are:

Reddish pink: this is due to increased blood vessels and reduced keratinization.

Bluish red: Blue colour of tissues is always associated with reduced oxygen supply, similarly gingiva turns bluish red because of venous stasis and anoxemia.

The gingiva appear red in either acute gingivitis (ANUG and herpetic gingivostomatitis) or in acute exacerbation of chronic gingivitis. Bluish red colour is associated with chronic gingivitis.

The localization of these changes in colour helps in diagnosis:

ANUG- marginal involvement

Herpetic gingivostomatitis- diffuse

Chemical irritation- patch like

HIV- localized erythema along the marginal gingiva known as linear gingival erythema.

Pigmentation: pigmentation is a discoloration of oral mucosa or gingiva with the wide variety of lesions and conditions.

It is associated with exogenous and endogenous etiologic factors.

Mostly cause by 5 pigments

1. Melanin
2. Melanoid
3. Oxy-Hb
4. Reduced Hb
5. Carotene

Others- bilirubin & iron

Endogenous causes: Melanin is increased in the following systemic condition:

Addison's disease (adrenal dysfunction)

PeutzJegher's syndrome (intestinal polyposis)

Albright's syndrome (fibrous dysplasia)

Von recklinghausen's disease (neurofibromatosis)

Exogenous causes are:

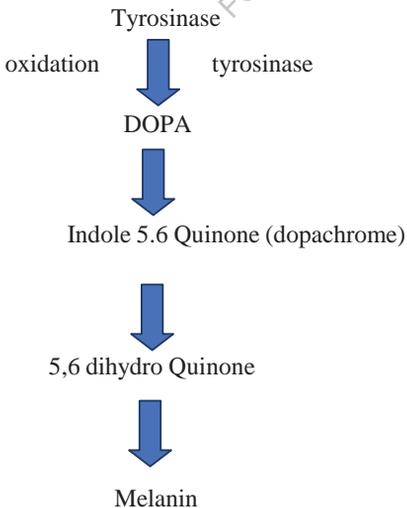
- Metallic pigmentation due to bismuth, arsenic, lead and silver: it appears as a grey to black line following the marginal gingiva. Pigmentation occurs when inflammation leads to increased vascular permeability and there is precipitation of metallic sulfides into the connective tissue. Therefore the treatment consists of scaling.



- Tobacco
- Coloring agents in food and lozenges
- Amalgam tattoo or implantation of amalgam in to the gingiva

Melanin pigmentation correlates with the cutaneous pigmentation. It appears 3 hours after birth.

Melanin is produced in melanocytes in organelles contains tyrosinase which hydroxylates tyrosine to dihydroxyphenylalanine (dopa) which is further converted to melanin.



Dummett, 1946 described the distribution of melanin in black individuals as:

Palate-61%

Gingiva-60%

Mucous membrane-22%

Tongue-15%

Systemic and local causes of pigmentation

1. Amalgam tattoo
2. Pigmented nevi
3. Oral melanotic macula
4. Melanoma
5. Physiologic pigmentation
6. Smokers melanosis
7. Antimalarial drugs
8. Minocycline use:
9. Hemochromatosis
10. HIV infections

Depigmentation: The removal of gingival pigmentation can be achieved by a procedure called depigmentation.

Procedures for depigmentation

Technique	Advantages	disadvantages
Surgical/scalpel technique: the gingival epithelium is scraped away from the underlying connective tissue.	Simple & in expensive	Intraoperative bleeding is greater than in some other techniques
Use of rotary burs: diamond finishing burs are used in a	Simple and in expensive	Intraoperative bleeding is greater than in some other techniques

sweeping motion.		
Electrosurgery: A loop electrode is used and the tip is kept moving. The heat produced volatilizes the cells.	Good hemostasis	Unpleasant odorinjurious use lead to tissue damage. Delayed healing. cant be used in patients with poorly shielded pacemakers. Expensive equipment is necessary.
Laser. The most commonly used lasers for soft tissue procedures are CO <sub>2</sub> , Nd:YAG and diode.	Decreased bleeding and pain Dry surgical field and better visualization Faster healing response Minimal mechanical trauma	Expensive equipment is necessary Require specialized training No single wavelength will optimally treat all dental disease Harmful to eyes and skin
Gingival grafting: free gingival grafts taken from the palate or maxillary tuberosity can be placed over the concerned area.	Less incidence of repigmentation	Technique sensitive Two surgical sites. Colour will not match adjacent tissue.

Cryosurgery and chemicals have been used for depigmentation but depth of penetration cannot be controlled so they are not preferred over the above procedures.

Repigmentation is the reappearance of melanin pigment after a period of clinical depigmentation of the oral mucosa resulting from chemical, thermal, surgical, pharmacologic, or idiopathic factors.

#### **Size of the gingiva:**

The size of the gingiva is determined by the sum total of

- Cells
- Intracellular substances

- Vascular supply

Increase in the size of the gingiva is called gingival enlargement and is classified based on its etiology as :

**Classification of Gingival Enlargement:**

1. Inflammatory enlargement

- Acute
- Chronic

2. Drug influenced gingival enlargements

- Antiepileptic agents: Phenytoin
- calcium channel blockers: Nifedipine
- Immunosuppressants: Cyclosporine

Associated with systemic conditions/Associated with systemic disease:

Systemic condition: the reaction to plaque is increased leading to gingival enlargement, pregnancy, puberty, plasma cell gingivitis, pyogenic granuloma, scurvy.

Systemic disease: enlargement is due to the disease itself, irrespective of the plaque, for examples like leukemia, Wegener,s granulomatosis or sarcoidosis.

3. Neoplastic:

- benign- fibroma, papilloma, giant cell granuloma
- Malignant- carcinoma, malignant melanoma

4. False enlargement:

- due to underlying bone lesion: Paget,s disease, fibrous dysplasia, osteoma, osteosarcoma
- due to underlying dental tissue: prominence of enamel during tooth eruption

**INDICES**

Bokenkamp and Bohnhorst 1994

Grade 0- no signs of gingival enlargement

Grade 1- involves only interdental papilla

Grade 2- involves IDP and marginal gingiva

Grade 3- involves all 3 quarters more of crown

According to Angelopoulos and Goaz 1972

Grade	Hyperplasia	Size	Tooth coverage
Grade 0	No	Normal	No
Grade 1	Minimal	≤2 mm	Cervical 3 <sup>rd</sup> or less
Grade 2	Moderate	2-4 mm	Middle 3 <sup>rd</sup>
Grade 3	Severe	≥4mm	More than 2/3 <sup>rd</sup>

#### Management:

Inflammatory gingival enlargement usually subsides after scaling if it is edematous in nature if fibrotic it is excised by surgical gingivectomy.

For drug induced gingival enlargement the offending drug should be substituted by another drug by the physician. Phenytoin is substituted by carbamazepine or valproic acid, nifedipine with diltiazem or verapamil and cyclosporine with tacrolimus. Next, scaling should be performed as inflammatory mediators can promote drug induced enlargement by activating fibroblasts.

It takes 6 months to 1 year for the enlargement to subside after drug substitution. If the enlargement hasn't subsided either gingivectomy or flap surgery is indicated. gingivectomy is carried out if there is adequate attached gingiva, no requirement for osseous surgery and less than 6 teeth are involved. Flap surgery is indicated if the attached gingiva is inadequate, there is a need for osseous surgery or more than 6 teeth are involved.

In case of pregnancy, thorough scaling and root planning has to be performed

-surgical excision is done for tumor like enlargement

-spontaneous reduction after the termination of pregnancy

-2<sup>nd</sup> trimester is safest

Leukemic gingival enlargement is seen in acute and subacute leukemia. A hematologist should be consulted prior to periodontal therapy and bleeding time, clotting time and platelet count must be estimated. prophylactic antibiotics should be administered from the evening before to 48 hours after treatment. Scaling and root planning is carried out in stages and oral hygiene instructions are given including the use of chlorhexidine.

During acute phases of leukemia patients should receive only emergency periodontal care

-if there is persistent gingival bleeding

-cleanse the area with 3 %hydrogen peroxide

-carefully explore the area and remove all etiologic factors

-recleans with 3%hydrogen peroxide place the cotton pellet soaked in thrombin against bleeding points.

-cover with a gauze

-if oozing persists after removal of gauze replace cotton and then place a periodontal dressing over a area for 24 hours.

Gingival abscess:

- cause of abscess should be removed
- drainage can be established
- if lesion persists it can be curetted under LA or incised
- if persistent and severe – systemic antibiotics may be prescribed
- any residual pockets –subgingival curettage or gingivectomy

### **Consistency of the gingiva**

Normal consistency of the gingiva is firm and resilient due to:

- Collagenous nature of the lamina propria and
- Contiguity with the mucoperiosteum of the alveolar bone
- Gingival fibres contribute to the firmness of gingival margin

In gingivitis, the consistency may be soft and oedematous due to oedema, inflammatory cell infiltration and degeneration of connective tissue elements.

Since gingivitis is a chronic inflammatory condition the outer wall may show repair in the form of increased fibrosis and keratinization. In these cases, the gingiva appears pale pink and firm in consistency though the inner lining of the sulcus is still atrophic or ulcerated. Here presence of bleeding on probing helps us arrive at the diagnosis of gingivitis irrespective of the outer changes in colour or consistency.

Fibrous consistency of gingiva is seen in drug induced and idiopathic gingival enlargement.

### **Contour of the Gingiva**

Scalloping refers to the rise and fall of the gingival margin corresponding with the shape of the tooth. Knife edge refers to the sharp margins and interdental papilla. The contour of the gingiva is scalloped with knife edge margins.

Gingival contour depends upon the following factors

- Shape of the teeth
- Alignment of the teeth in the arch
- Proximal contact
- Dimension of gingival embrasure

Contour is accentuated in labially placed teeth and the gingiva is thickened in lingually placed teeth. Besides these physiologic variations in contour, in areas of diastema the interdental papilla is missing and the gingiva is firmly adherent to the underlying bone. In gingivitis, the knife edge appearance will not be there due to the inflammation margins become rounded with blunting of interdental papilla.

Other inflammatory changes in contour of gingiva

Stillman's cleft: Apostrophe shaped indentations extending from and into the gingival margin for varying distances. The clefts are divided into simple clefts with cleavage in a single direction and compound clefts in which cleavage occurs in more than one direction. These lesions are more common in the mandibular anteriors.

McCall's festoon: A thickened band of gingiva or life saver shaped enlargement of the marginal gingiva that occurs frequently in the canine and premolar areas on the facial surface.

These lesions were earlier attributed to traumatic occlusion but are now known to be due to inflammation.



### Surface texture of the gingiva:

The attached gingiva and central portion of the interdental papilla show an orange peel appearance called stippling. This is best visualized by drying the gingiva. Stippling appears by 5 years of age and reduces after middle age.

Minute pin-point depressions on the surface of attached gingiva and central portion of interdental papilla constitute stippling.

It is more prominent on the facial than the lingual and more in the anterior region than the posterior region.

Cause of stippling: alternate rounded protuberances and depressions in the gingival surface due to the projection of the connective tissue papilla into the epithelium.

The papillary layer of connective tissue projects into the elevations. The elevated and depressed areas are covered by stratified squamous epithelium.

Function of stippling: functional adaptation of the gingiva.

Stippling is absent in inflammation due to the degeneration of connective tissue and increased vascularity in inflammation.

Stippling is increased in drug induced gingival enlargement.

Other changes in surface texture include peeling off in desquamative gingivitis, leathery texture in hyperkeratosis and nodular texture in drug induced gingival enlargement.



### Position of the Gingiva:

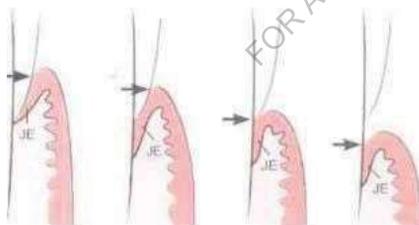
The position of the gingiva refers to the level at the margin is attached to the tooth.

When the tooth erupts into the oral cavity, the margin and sulcus are at the tip of the crown as eruption progresses, they are seen closer to the root.

Active eruption: movement of the teeth in direction of occlusal plane

Passive eruption: exposure of teeth by apical migration of the gingiva

Stages of passive eruption: Gottlieb and Orban



Stage 1: base of gingival sulcus and JE are on enamel

Stage 2: base of gingival sulcus is on enamel and part of JE is on the root

Stage 3: base of the gingival sulcus is at the CEJ line

Stage 4: base of the gingival sulcus and the JE are on root.

Normal position of the gingiva is 1mm coronal to the CEJ

When the gingival margin is below the CEJ, it is called recession. It is defined as the exposure of root surface due to apical migration of the gingival margin.

Recession may be considered hidden or visible based on the actual and apparent position of the gingiva.

Actual position: level of epithelium attachment on the tooth.

Apparent position: level of crest of gingival margin

Severity of recession is determined by the actual position.

The part of the root exposed to the oral cavity is called visible recession, the part covered by the gingival wall is called hidden recession. Total recession is the sum total of both visible and hidden recession.

Classification of recession:

### **P D MILLER (1985)**

Class I: marginal tissue recession not extending to the mucogingival junction. No loss of interdental bone or soft tissue.

Class II: marginal tissue recession extends to or beyond the mucogingival junction. No loss of interdental bone or soft tissue.

Class III: marginal tissue recession extends to or beyond the mucogingival junction. Loss of interdental bone or soft tissue is apical to the CEJ. But coronal to the apical extent of marginal tissue recession.

Class IV: marginal tissue recession extends beyond the mucogingival junction. Loss of interdental bone extends to a level apical to the extent of the marginal tissue recession.



Atkin and Sullivan classification

I shallow-narrow

II shallow-wide

III Deep-narrow

IV Deep-wide

The prognosis is good in class I and class II recession as the interdental bone and soft tissue are intact.

Class I and II recession in relation to the anterior teeth are treated with either pedicle grafts or free grafts. Posterior areas are usually not treated as they do not adversely affect aesthetics.

Root coverage procedures are

Pedicle grafts:

Coronally positioned flap including tornow's technique

- Lateral pedicle flap
- Double papilla flap

Free grafts:

- Free gingival graft
- Subepithelial connective tissue graft

Causes of gingival recession:

- Faulty toothbrush technique
- Use of hard bristled toothbrush
- Abnormal frenal attachment
- Gingival inflammation
- Labially placed teeth
- Congenital defects such as thin bone margins and dehiscence
- Pressure from denture clasps
- Pressure from orthodontic bands
- Following periodontal surgery
- Overhanging restorations

**Importance of gingival biotype:**

Earlier greater importance was given to the width of the attached gingiva in the aetiology of gingival recession. However the thickness of the gingiva is of greater importance in the development of recession, in 1989, seibert and Lindhe, gave two types of periodontal biotypes thin scalloped and thick flat biotype. Inflammation causes pocket formation in the thick biotype and gingival recession in the thin biotype (kao et al 2008).

### **Bleeding on probing:**

Bleeding on probing is an objective sign indicating periodontal disease. Other signs such as changes in color or consistency are subjective and might be interpreted differently by different examiners.

The presence of bleeding on probing and exudation indicates that the disease is active. Absence of bleeding on probing is a good prognostic indicator as it correlates with periodontal stability.

### **Method to check for bleeding on probing:**

Walking the probe along the long axis of the tooth. it might take 30 to 60 seconds for the bleeding to become apparent.

Reduced bleeding on probing is seen in smokers

Increased bleeding on probing is seen in:

Local - chronic: chronic gingivitis and periodontitis

- Acute: ANUG, injuries either mechanical, chemical, or thermal

Systemic:

Bleeding disorders: Haemophilia, Christmas disease, thrombocytopenia, leukaemia hypoprothrombinaemia, scurvy

Hormonal: pregnancy, puberty, patients on oral contraceptives, diabetes mellitus

Medications: Salicylates (aspirin) and anticoagulants (heparin, warfarin)

Bleeding on probing in gingivitis is because of the increase in blood vessels and atrophy of the epithelium which brings the vessels closer to the surface.

Spontaneous bleeding is seen in scurvy, leukaemia and acute necrotizing ulcerative gingivostomatitis.

Microorganisms associated with gingival bleeding : P. gingivalis, T. forsythia, T. denticola (red complex organisms). Bleeding can be assessed using the

following indices: sulcus bleeding index, papillary bleeding index, gingival bleeding index, modified sulcular bleeding index, Eastman interdental bleeding index.

**Exudation:**

Exudation indicates suppurative inflammation of the lateral wall.

Certain changes are observed in the sulcular epithelium due to chronic inflammation.

Neutrophils enter the epithelium from the connective tissue and release hydrolytic enzymes which kills bacteria and degrade the adjacent epithelial cells as well.

On applying digital pressure on the lateral aspect of the gingival margin the pus consisting of dead and live neutrophils, dead and live bacteria and desquamated epithelial cells are expressed as exudate.

Therefore, this exudate does not correlate with the pocket depth but is merely a lateral wall change which indicates that the disease is active.

**Signs and Symptoms of Periodontal Abscess**

**Acute Abscess**

- Mild to severe discomfort
- Localized red, ovoid swelling
- Periodontal pocket
- Mobility
- Tooth elevation in socket
- Tenderness to percussion or biting
- Exudation
- Elevated temperature
- A Regional lymphadenopathy

**Chronic Abscess**

- No pain or dull pain
- Localized inflammatory lesion
- Slight tooth elevation
- Intermittent exudation
- Fistulous tract often associated with a deep pocket Usually without systemic involvement May indicate the need for systemic antibiotics.

Data from Dahlen G: Microbiology and treatment of dental abscesses and periodontalendodontic lesions. *Periodontol* 2000 28:206, 2002; Meng HX: Periodontal abscess. *Ann Periodontol* 4:79, 1999; and Sanz M, Herrera D, van Winkelhoff AJ: The periodontal abscess. In Lindhe

## **Differential Diagnosis of Periodontal and Pulpal Abscess**

### **Periodontal Abscess**

- Associated with a pre-existing periodontal pocket.
- Radiographs show periodontal angular bone loss and furcation radiolucency.
- Tests show vital pulp. Swelling usually includes gingival tissue, with an occasional fistula.
- Pain is usually dull and localized.
- Sensitivity to percussion may or may not be present.

### **Pulpal Abscess;**

- The offending tooth may have large restoration.
- The tooth may have no periodontal pocket or, if present, it probes as a narrow defect.
- Tests show nonvital pulp.
- Swelling is often localized to the apex, with a fistulous tract.
- Pain is often severe and difficult to localize.
- Sensitivity to percussion is noted.

Modified from Corbet EF: Diagnosis of acute periodontal lesions. Periodontol 2000 34:204, 2004.

## **Gingival Abscess**

The gingival abscess is a localized acute inflammatory lesion that may arise from a variety of sources, including microbial plaque infection, trauma, and foreign body impaction. Clinical features include a red, smooth, sometimes painful, often fluctuant swelling.

abscess may occur in the absence of periodontal disease.

Periodontal abscesses are classified according to location as follows:

1. Abscess in the supporting periodontal tissues along the lateral aspect of the root. With this condition, a sinus generally occurs in the bone that extends laterally from the abscess to the external surface.
2. Abscess in the soft-tissue wall of a deep periodontal pocket.

The localized acute abscess becomes a chronic abscess when its purulent content drains through a fistula into the outer gingival surface or into the periodontal pocket and the infection that is causing the abscess is not resolved.

The bacterial invasion of tissues has been reported in abscesses; the invading organisms were identified as gram-negative cocci, diplococci, fusiforms, and spirochetes. Invasive fungi were also found and were interpreted as being “opportunistic invaders.”<sup>22</sup> Microorganisms that colonize the periodontal abscess have been reported to be primarily gram-negative anaerobic rods.

Microscopically, an abscess is a localized accumulation of viable and nonviable PMNs within the periodontal pocket wall. The PMNs liberate enzymes that digest the cells and other tissue structures, thereby forming the liquid product known as pus, which constitutes the center of the abscess. An acute inflammatory reaction surrounds the purulent area, and the overlying epithelium exhibits intracellular and extracellular edema and the invasion of leukocytes

#### Treatment Options for Periodontal Abscess

1. Drainage through pocket retraction or incision
2. Scaling and root planning
3. Periodontal surgery
4. Systemic antibiotics
5. Tooth removal Modified from Sanz M, Herrera D, van Winkelhoff AJ:

[The periodontal abscess.](#) In Lindhe J, editor: [Clinical periodontology](#), Copenhagen, 2000, Munksgaard.

#### Indications for Antibiotic Therapy in Patients With Acute Abscess

1. Cellulitis (nonlocalized, spreading infection)
2. Deep, inaccessible pocket
3. Fever
4. Regional lymphadenopathy
5. Immunocompromised status Gentle digital pressure may be sufficient to express purulent discharge.

#### Antibiotic Options for Periodontal Infections Antibiotic of Choice

Amoxicillin, 500 mg • 1.0-g loading dose, then 500 mg three times a day for 3 days

- Re evaluation after 3 days to determine need for continued or adjusted antibiotic therapy

## Penicillin Allergy

Clindamycin • 600-mg loading dose, then 300 mg four times a day for 3 days  
Azithromycin (or Clarithromycin) • 1.0-g loading dose, then 500 mg four times a day for 3 days

Data from American Academy of Periodontology: Position paper: systemic antibiotics in periodontics. J Periodontol 67:1553, 2004

**Specific Treatment Approaches** Treatment of the periodontal abscess includes two phases: resolving the acute lesion, then managing the resulting chronic condition.

**Acute Abscess** The acute abscess is treated to alleviate symptoms, control the spread of infection, and establish drainage.

Before treatment, the patient's medical history, dental history, and systemic condition are reviewed and evaluated to assist in the diagnosis and determine the need for systemic antibiotics.

**Drainage Through the Periodontal Pocket** The peripheral area around the abscess is anesthetized with sufficient topical and local anaesthetic agents to ensure comfort.

The pocket wall is gently retracted with a periodontal probe or curette in an attempt to initiate drainage through the pocket entrance. Gentle digital pressure and irrigation may be used to express the exudate and drain the pocket.

If the lesion is minimal and access is uncomplicated, debridement in the form of scaling and root planing may be undertaken at this appointment. If the lesion is large and drainage cannot be established, root debridement by scaling and root planing or surgical access should be delayed until the major clinical signs have abated. In these patients, use of adjunctive systemic antibiotics with a short-term high-dose regimen is recommended.

Antibiotic therapy alone without subsequent drainage and subgingival scaling is contraindicated.

**Drainage Through an External Incision** To drain the abscess, the lesion is dried and isolated with gauze sponges.

A topical anesthetic agent is applied, followed by a local anesthetic agent injected peripheral to the lesion. A vertical incision through the most fluctuant center of the abscess is made with a no. 15 surgical blade. The tissue lateral to the incision can be separated with a curette or periosteal elevator. The fluctuant matter is expressed, and the wound edges are approximated under light digital

pressure with a moist gauze pad. In abscesses manifesting with severe swelling and inflammation, aggressive mechanical instrumentation should be delayed in favor of antibiotic therapy to avoid damage to healthy contiguous periodontal tissues.

Once bleeding and suppuration have ceased, the patient may be dismissed. For patients who do not need systemic antibiotics, posttreatment instructions include frequent rinsing with warm salt water (1 tbsp/8-oz glass) and periodic application of chlorhexidine gluconate 0.12% oral rinse either by rinsing or applied locally with a cottontipped applicator.

Reduced physical exertion and increased fluid intake are often recommended for patients showing systemic involvement. Analgesics may be prescribed for comfort. By the following day, the signs and symptoms have usually subsided. If the problem continues and the patient is still uncomfortable, the previously recommended regimen is repeated for an additional 24 hours.

This often results in satisfactory healing, and the lesion can be treated as a chronic abscess. Chronic Abscess As with a periodontal pocket, the chronic abscess is usually treated with scaling and root planing and, if indicated, surgical therapy.

Surgical treatment is suggested when deep vertical pocket or furcation defects are encountered that are beyond the therapeutic capabilities of nonsurgical instrumentation. Access to subgingival calculus must be achieved in areas of deep pockets. The patient should be advised of the possible postoperative sequelae usually associated with periodontal nonsurgical and surgical procedures. As with the acute abscess, antibiotic therapy may be indicated.



*Gingival Abscess:* Treatment of the gingival abscess is aimed at reversal of the acute phase and, when applicable, immediate removal of the cause. To ensure comfort, topical or local anaesthesia by infiltration is administered.

When possible, scaling and root planing are completed to establish drainage and remove microbial deposits. In more acute situations, the fluctuant area is incised with a no. 15 scalpel blade, and exudate may be expressed by gentle digital pressure.

Any foreign material (e.g., dental floss, impression material) is removed. The area is irrigated with warm water and covered with moist gauze under light pressure. Once bleeding has stopped, the patient is dismissed with instructions to rinse with warm salt water every 2 hours for the remainder of the day. After 24 hours, the area is reassessed, and if resolution is sufficient, scaling not previously completed is undertaken. If the residual lesion is large or poorly accessible, surgical access may be required.

*Pericoronal Abscess:* As with other abscesses of the periodontium, treatment of the pericoronal abscess is aimed at management of the acute phase, followed by resolution of the chronic condition. The acute pericoronal abscess is properly anesthetized for comfort, and drainage is established by gently lifting the soft tissue operculum with a curette.

If the underlying debris is easily accessible, it may be removed, followed by gentle irrigation with sterile saline. If the patient has regional swelling, lymphadenopathy, or systemic signs, systemic antibiotics may be prescribed. The patient is dismissed with instructions to rinse with warm salt water every 2 hours, and the area is reassessed after 24 hours. If discomfort was one of the original complaints, appropriate analgesics should be used. Once the acute phase has been controlled, the partially erupted tooth may be definitively treated with either surgical excision of the overlying tissue or removal of the offending tooth.

EXAMINATION OF THE GINGIVAL CLINICAL MARKERS			
	APPEARANCE IN HEALTH	CHANGES IN DISEASE CLINICAL APPEARANCE	CAUSES FOR CHANGES
Color	Uniformly pale pink or coral pink	Acute: bright red	Inflammation Capillary dilation Increased blood flow
	Variations in pigmentation related to complexion, race	Chronic: bluish pink, bluish red	Vessels engorged Blood flow sluggish Venous return impaired Anoxemia Increased fibrosis
		Attached gingiva: color change may extend to the mucogingival line	Deepening of pocket, mucogingival involvement
Size	Not enlarged Fits snugly around the tooth	Enlarged	Edematous: inflammatory fluid cellular exudate vascular engorgement hemorrhage Fibrotic: new collagen fibers
Shape (contour)	Marginal gingiva: knife-edged, flat, follows a curved line about the tooth Papillae: (1) normal contact: papilla is pointed and pyramidal; fills the interproximal area (2) space (diastema) between teeth; gingiva is flat or saddle shaped	Marginal gingiva: rounded rolled Papillae: bulbous flattened blunted cratered	Inflammatory changes: edematous or fibrotic  Bulbous with gingival enlargement (see edematous and fibrotic, above)  Cratered in necrotizing ulcerative gingivitis
	Consistency	Firm Attached gingiva firmly bound down	Soft, spongy: dents readily when pressed with probe Associated with red color, smooth shiny surface, loss of stippling, bleeding on probing  Firm, hard: resists probe pressure Associated with pink color, stippling, bleeding only in depth of pocket
Surface texture	Free gingiva: smooth	Acute condition: smooth, shiny gingiva	Inflammatory changes in connective tissue; edema cellular infiltration
	Attached gingiva: stippled	Chronic: hard, firm, with stippling, sometimes heavier than normal	Fibrosis

EXAMINATION OF THE GINGIVAL CLINICAL MARKERS (Continued)			
	APPEARANCE IN HEALTH	CHANGES IN DISEASE CLINICAL APPEARANCE	CAUSES FOR CHANGES
Position of Gingival Margin	Fully erupted tooth; margin is 1-2 mm above cemento-enamel junction, at or slightly below the enamel contour	Enlarged gingiva; margin is higher on the tooth, above normal, pocket deepened Recession: margin is more apical; root surface is exposed	Edematous or fibrotic  Junctional epithelium has migrated along the root; gingival margin follows
Position of Junctional Epithelium	During eruption along the enamel surface (Figure 12-7) Fully erupted tooth; the junctional epithelium is at the cemento-enamel junction	Position determined by use of probe, is on the root surface	Apical migration of the epithelium along the root
Mucogingival Junctions	Make clear demarcation between the pink, stippled, attached gingiva and the darker alveolar mucosa with smooth shiny surface	No attached gingiva: (1) Color changes may extend full height of the gingiva; mucogingival line obliterated (2) Probing reveals that the bottom of the pocket extends into the alveolar mucosa (3) Frenal pull may displace the gingival margin from the tooth	Apical migration of the junctional epithelium Attached gingiva decreases with pocket deepening Inflammation extends into alveolar mucosa
Bleeding	No spontaneous bleeding or upon probing	Spontaneous bleeding Bleeding on probing; bleeding near margin in acute condition; bleeding deep in pocket in chronic condition	Degeneration of the vascular epithelium with the formation of pocket epithelium Blood vessels engorged Tissue edematous
Exudate	No exudate expressed on pressure	White fluid, pus, visible on digital pressure Amount not related to pocket depth	Inflammation in the connective tissue Excessive accumulation of white blood cells with serum and tissue make up the exudate (pus)

### **Periodontal Examination:**

Periodontitis is defined as an inflammatory disease of the supporting tissues of the teeth caused by specific microorganisms or groups of specific microorganisms resulting in progressive destruction of the periodontal ligament and alveolar bone with pocket formation, recession or both.

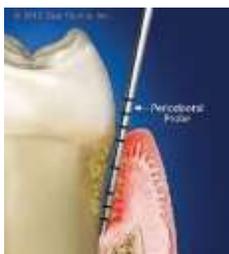
### **Periodontal pocket:**

it's a pathologically deepened gingival sulcus.

Method to check for pocket:

Technique to check for pockets is called "walking the probe". Probing should be done using a standard force of 25 grams (Armitage et al 1977) or 0.75 N which is equivalent to the capillary pressure. Probing force cannot be kept

constant with conventional manual probes, but require pressure sensitive probes like vine Valley and Toronto probes. A practical test for establishing force before probing in the patient is to gently insert the probe point under the finger nail without causing pain or discomfort.



4 point and 6 point probing: when the pocket is measured at the mesiofacial, midfacial, distofacial and palatal areas it is called 4 point probing.

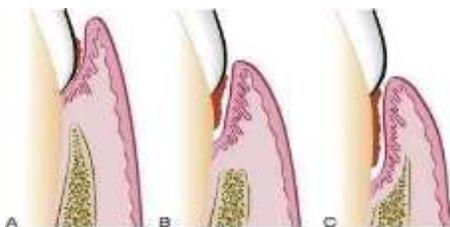
When the measurement is made at the mesiofacial, midfacial, distofacial, mesiopalatal, midpalatal and distopalatal areas it is called 6 point probing.

Classification of periodontal pocket

1. **Gingival Pocket (Pseudopocket)** – formed by gingival enlargement without destruction of the underlying tissues. The sulcus is deepened because of the increased bulk of the gingiva.
2. **Periodontal Pockets** – it occurs with destruction of supporting periodontal tissues.

**Two types of periodontal pockets exist :**

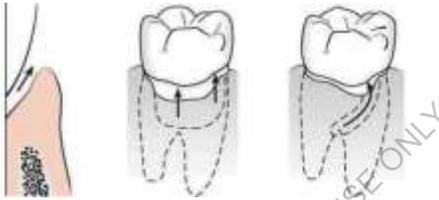
- I. **Suprabony (Supracrestal or Supraalveolar)** - In this, bottom of the pocket is coronal to the underlying alveolar bone.
- II. **Intrabony (Infrabony, Subcrestal or intraalveolar)** - In this, bottom of the pocket is apical to the level of the adjacent alveolar bone and the lateral pocket wall lies between the tooth surface & alveolar bone.



A. Gingival Pocket B. Suprabony C. Infrabony Pocket

[A] According to involved tooth surface

1. Simple
2. Compound
3. Complex or Spiral – originating on one surface and twisting around the tooth to involve one or more additional surfaces ( most commonly found in furcation area)



B. Depending upon the nature of the soft tissue wall of the pocket:

- (1) Edematous Pocket.
- (2) Fibrotic Pocket.

C. Depending upon disease activity:

- (1) Active Pocket.
- (2) Inactive Pocket

Differences between suprabony and infrabony pockets

Suprabony	Infrabony
Base of the pocket is coronal to the crest of the alveolar bone	Base of the pocket is apical to the crest of the alveolar bone
Horizontal bone loss	Angular bone loss
Interproximally transeptal fibers are arranged horizontally	Interproximally, trans-septal fibers are arranged obliquely
Facially and lingually periodontal ligament fibers follow a horizontal course	Facially and lingually periodontal ligament fibers follow an angular course

Clinical features

**SIGNS :**

- 1) Bluish red, thickened marginal gingiva.
- 2) A Bluish red vertical zone from the gingival margin to alveolar mucosa.
- 3) Gingival bleeding and suppuration.
- 4) Tooth mobility.
- 5) Diastema formation.
- 6) A rolled edge separating the gingiva Margin from the tooth surface.
- 7) A break in the facio-lingual continuity of interdental gingiva.
- 8) Shiny, puffy gingiva leads to exposed root surface.

**SYMPTOMS**

- 1) Localized pain or “pain deep in the bone”
- 2) Usually painless but may give rise to localized / radiating pain or sensation of pressure after eating which gradually reduces.
- 3) A foul taste in localized areas.
- 4) Sensitivity to hot & cold.
- 5) Toothache in the absence of caries is also sometimes present.
- 6) A tendency to suck material inter proximally.
- 7) Feeling of itching in the gums.
- 8) Urge to dig a pointed instrument in the gums.
- 9) Feeling of loose teeth.

Correlation of clinical and histopathological changes in periodontal pockets:

Bluish red discolouration: circulatory stagnation

Flaccidity of tissues: destruction of gingival fibers and surrounding tissues

Smooth, shiny surface: atrophy of epithelium and edema

Bleeding on probing: increase in vascularity, thinning of epithelium and proximity of engorged vessels to inner surface.

Exudation: suppurative inflammation of the lateral wall.

Level of attachment versus pocket depth:

Pocket depth is measured from the gingival margin to the base of the pocket whereas level of attachment is from the CEJ to the base of the pocket. It is more reliable to assess level of attachment as it is from a fixed point. The gingival margin might move coronally due to inflammation and then apically once the inflammation subsides.

Clinical significance:

The transformation of a gingival sulcus into a periodontal pocket creates an area where plaque removal becomes impossible and a feedback mechanism is established. The rationale for pocket reduction is based on the need to eliminate areas of plaque accumulation.

Theories of pathogenesis of pocket formation

James and Counsel 1927 – two stage pocket formation

Becks 1929 – pocket formation initiates in a defect in sulcus wall

Skillen 1930 – pathologic destruction of epithelial attachment due to infection or trauma

Wilkinson 1935 – proliferation of epithelium of lateral wall is the initial change in formation of the periodontal pocket.

Box 1941 – periodontal pocket is initiated by invasion of bacteria at base of the sulcus or absorption of bacterial toxins through epithelial lining of sulcus.

Orban & Weinmann 1942 – subgingival bacterial growth: secondary to pocket

Gottlieb 1926, 1946 – the initial change in pocket formation occurs in the cementum

Fish 1948 – destruction of gingival fibers: pre-requisite for initiation of pocket formation

Aisenberg & Aisenberg 1948 – simulation of the epithelial attachment by inflammation: Pre-requisite for initiation of the periodontal pocket

Waerhaug 1976 – bacteria spreading subgingivally – pocket formation

Schroeder and Attstrom 1980 – microbial invasion of subgingival dentogingival junction- pathological pocket

Takata & Donath:

Early & established lesion- degenerative changes in most coronal part of JE



Deep crevice formation Advanced lesions -

Deep pocket epithelium



calculus  
Toxic bacterial products & mechanical irritation of



Thin and ulcerated



Periodontal pocket

Pathogenesis:

Initial lesion: inflammation of gingiva

Not a predictor of future attachment and bone loss

Cellular and inflammatory exudate: degeneration of CT and fibers

Matrix metalloproteinases

Phagocytosis

Apical cells of JE: finger like projections

Coronal portion: detaches from the root

60% of PMNs : loss of tissue cohesiveness

Sulcus shifts apically

Plaque → gingival inflammation → more plaque formation → pocket formation →

Histopathology:

**Changes in the soft tissue wall:**

- The connective tissue is edematous & densely infiltrated with plasma cells (approx. 80%), lymphocytes & a scattering of PMNs.
- Blood vessels are increased in number, dilated and engorged
- particularly in the subepithelial connective tissue layer.

- Connective tissue exhibit varying degrees of degeneration.
- The connective tissue shows proliferation of endothelial cells with newly formed capillaries, fibroblasts and collagen fibres.
- The Junction Epithelium at the base of the pocket is usually much shorter than that of a normal sulcus and usually coronal length of junctional epithelium is reduced to only 50-100  $\mu$ m.

#### **Changes along the lateral wall :**

- Most severe degenerative changes occur along lateral wall.
- The epithelium presents striking proliferative & degenerative changes .
- Epithelial buds or interlacing cords of epithelial cells project from lateral wall into adjacent inflamed connective tissue & may extend farther apically to Junctional Epithelium.
- These epithelium projection and remainder of lateral epithelium are densely infiltrated by Leukocytes and edema from the inflamed connective tissue.
- These cells can undergo vacuolar degeneration and rupture to form vesicles.
- Progressive degeneration & necrosis of epithelium lead to Ulceration of lateral wall, Exposure of inflamed connective tissue and suppuration.
- The severity of degenerative changes are not necessarily related to pocket depth.
- Ulceration may occur in shallow pockets and deep pockets with intact lateral
- epithelium is rarely observed.
- The Epithelium at the gingival crest of a periodontal pocket is generally intact & thickened, with prominent rete pegs.

#### **Bacterial Invasion:**

- Occurs along the lateral & apical areas of the pocket in cases of chronic periodontitis.
- Filaments, Rods & coccoid organisms with predominant gram- negative cell walls have been found in intercellular spaces of epithelium.
- **Hillmann et al** reported presence of *Porphyromonas gingivalis* and
- *Prevotella intermedia* in the gingiva of aggressive Periodontitis cases
- *Actinobacillus actinomycetumcomitans*(AA) has also been found in the tissues.

- Bacteria may invade intercellular space under exfoliating epithelial cells but also found between deeper epithelial cells and accumulating on the basement lamina.
- Some bacterial traverse the basement lamina and invade the subepithelial connective tissue.

### **The micro topography of the gingival wall of the pocket**

SEM reveals several areas in the soft tissue wall of the pocket where different types of activity take place.

These areas are irregularly oval or elongated and adjacent to one another and measure about 50-200 micrometer.

This suggests that the pocket wall is the constantly changing as a result of interaction between host and bacteria. Following areas have been noted:-

- Area of relative quiescence:** Shows relatively flat surface with minor depressions & mounds and occasional shedding of cells.
- Area of bacterial accumulation:** which appear as depression on the epithelial surface with abundant debris and bacterial clumps penetrating into the enlarged intercellular spaces. These Bacteria are mainly Rod, cocci, filamentous & a few spirochetes.
- Areas of emergence of leukocyte:** leucocyte appear in the pocket wall through holes located in the intercellular spaces.
- Areas of Leukocyte-bacteria interaction:**
  - Numerous leukocytes are present & covered with bacteria in an apparent process of phagocytosis.
  - Bacterial plaque associated with the epithelium is seen either as an organised matrix covered by a fibrin like material in contact with the surface of cells or as bacteria penetrating into the intercellular spaces.
- Areas of intense epithelial desquamation:** consist of semi- attached & folded epithelial squames, sometimes partially covered with bacteria.
- Areas of ulcerations** with exposed connective tissue.
- Areas of haemorrhage** with numerous erythrocytes.

### **The transition from one area to another could result from:**

Bacterial accumulation in previously quiescent areas

↓

Triggering the emergence of leukocytes

↓

Leukocyte-bacteria interaction

↓

Lead to intense Epithelial desquamation

↓

Finally to ulceration & haemorrhage

### **PERIODONTAL POCKET AS A HEALING LESIONS**

- Periodontal pocket are chronic inflammatory lesion and thus constantly undergoing repair.
- Complete healing does not occur because of persistence of the bacterial attack which continues to stimulate an inflammatory response, causing degeneration of the new tissues formed in continuous effort at repair.
- There are destructive and constructive tissue changes and their balance determines the clinical features as color, consistency & surface texture of the pocket wall.
- If Inflammatory fluid & cellular exudate predominate, the pocket wall is bluish-red, soft, spongy and friable, with a smooth, shiny surface, at the clinical level and this is referred to as an edematous pocket wall.
- If there is predominance of newly formed connective tissue cells & fibers, the pocket wall is more firms and pink, and known as fibrotic pocket wall.
- Edematous and fibrotic pockets represent opposite extremes of the same Pathologic process, not different disease entities.
- Fibrotic pocket walls may be misleading because they do not necessarily reflect what is taking place throughout the pocket wall.
- The most severe degenerative changes in periodontal tissues occur adjacent to the tooth surface & subgingival plaque.
- In some cases inflammation and ulceration on inside of the pocket are walled off by fibrous tissue on the outer aspects. Externally the pocket appears pink and fibrotic, despite the inflammatory changes occurring internally.

## **POCKET CONTENT:**

Periodontal pocket contains –

- Debris (consisting of microorganism & their products mainly enzymes, endotoxins and other metabolic product)
- Gingival fluid
- Food remnants
- Salivary mucin
- Desquamated epithelial cells &
- Leukocytes

Plaque covered calculus projects from tooth surface.

- If purulent exudate present:consists of–
- Living, degenerated and necrotic leukocytes,
- Living and dead bacteria Serum
- A scant amount of fibrin.

## **ROOT SURFACE WALL:**

The root surface wall of periodontal pocket often undergoes changes that are significant because they may perpetuate the periodontal infection, causing pain, and complicate periodontal treatment.

As the pocket deepens, collagen fibers embedded in the cementum are destroyed

↓

Cementum become exposed to the oral environment

↓

Remnants of Sharpey's fibers in the cementum undergo degeneration

↓

Creating a favorable environment for bacterial penetration

↓

Penetration and growth of bacteria leads to fragmentation and breakdown of the cementum surface

↓

Result in area of necrotic cementum, separated from the tooth by mass of

Bacteria

## **Decalcification And Remineralisation Of Cementum**

### **Areas of increased mineralization:**

- Probably a result of an exchange, on exposure to the oral cavity, of minerals and organic components at the cementum- saliva interface.
- The mineral content of exposed cementum increases.
- The minerals that are increased in diseased root surfaces include Ca, Mg, P & F.
- Micro hardness, however, remains unchanged.
- The development of highly mineralized superficial layer may increase the
- tooth resistance to decay.

### **Areas of demineralization/Root caries:**

- Exposure to oral fluid and bacterial plaque results in proteolysis of the embedded remnants of the Sharpy's fibres.
- The cementum may be softened & may undergo fragmentation and cavitations.
- Unlike Enamel caries, root surface caries tend to progress around rather than into the tooth.

### **Root caries lesion:**

Active

- well defined yellowish/ Light brown areas
- frequently covered by plaque have softened or leathery consistency on probing

Inactive

- well defined dark lesion with a smooth surface
- harder consistency on probing

Caries of the cementum require special attention when the pocket is treated.

The necrotic cementum must be removed by scaling and root planing until firm tooth surface is reached even if this extended in dentin

### **Areas of cellular resorption of cementum and dentin**

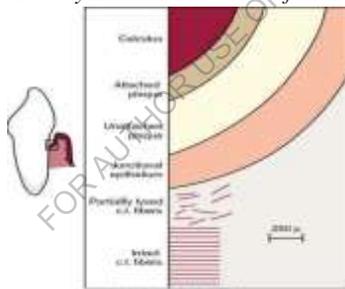
- They are common in roots unexposed by periodontal diseases.

- They are of no significance because they are symptom free and as long as the root is covered by the periodontal ligament, they are likely to undergo repair.

### Surface Morphology Of Tooth Wall Of Periodontal Pocket:

The following zones can be found in the bottom of a periodontal pocket:

1. *Cementum covered by calculus*
2. *Attached Plaque* – covers calculus and extends apically from it to a variable degree (100-500  $\mu$ m)
3. *The zone of unattached plaque* Surround attached plaque & extends apically to it.
4. *The zone of attachment of Junctional Epithelium to the tooth* – this zone reduced to 100  $\mu$ m (in periodontal pocket) from 500  $\mu$ m found in normal sulcus.
5. *a zone of semi-destroyed connective tissue fibres* – apical to the JE



### PERIODONTAL DISEASE ACTIVITY:

According to the concept of periodontal disease activity, periodontal pockets go through –

1. PERIODS OF QUIESCENCE OR INACTIVITY
  - Characterized by a reduced inflammatory response & little or no loss of bone and connective tissue attachment.

- A build up of unattached plaque with its gram-negative, motile and anaerobic bacteria.

## 2. PERIODS OF EXACERBATION OR ACTIVITY

- Bone and connective tissue attachment are lost and the pocket deepens.
- This period may last for days, weeks, months & eventually followed by a period of remission or quiescence in which G+ve bacteria proliferate and a more stable condition is established.
- Clinical features: shows bleeding spontaneous or on probing and greater amount of gingival exudates.
- Histological Features : Pocket Epithelium appears thin and ulcerated, Infiltrate composed of plasma cells & PMN leukocytes.

### **SITE SPECIFICITY:**

Periodontal destruction does not occur in all parts of the mouth at the same time but rather on a few teeth at a time or even only some aspects of some teeth at any given time. This is referred to as the site specificity of the periodontal disease.

### **Management:**

New attachment techniques:

Reunite the gingiva to the tooth at a position coronal to the bottom of the pre-existing pocket: it is associated with regeneration of bone periodontal ligament and cementum. It is achieved through guided tissue regeneration.

Removal of the pocket wall: most common method pocket wall can be removed by:

Retraction or shrinkage:

Scaling and root planing resolve inflammation, gingiva shrinks reducing the pocket depth. 4-5 mm pockets usually subside after scaling, root planing (non surgical periodontal therapy). Flap surgery is usually indicated in pockets greater than 5mm.

Surgical removal by gingivectomy or undisplaced flap

Apical displacement by apically displaced flap

Removal of the tooth side of pocket: tooth extraction or hemisection/root resection.

**Mobility:**

A tooth is defined as being mobile when the clinician is able to visibly displace the clinical crown away from the central axis using a force under 100 gm (Miller 1950).

Method to check for mobility:

Mobility of the tooth is checked by holding the tooth firmly between handles of two instruments or between a finger and an instrument handle, making an effort to move it in all directions. Examples for devices used to measure mobility are periodon-tometer and periotest.

Stages:

Initial/intra-socket stage: tooth moves by 50-100  $\mu\text{m}$  within the confines of the periodontal ligament space in response to forces of 100g.

Secondary stage: elastic deformation of the alveolar bone occurs when the forces are 500 g. movement depends up on the tooth.

Incisor: 100-200  $\mu\text{m}$

Canine: 50-90  $\mu\text{m}$

Premolar: 8-10  $\mu\text{m}$

Molar: 40-80  $\mu\text{m}$

**Causes:**

Physiologic mobility is the increased mobility in the morning as the teeth are not occluded in sleep.

The other causes of mobility are:

Bone loss

Trauma from occlusion

Periapical infection

Following periodontal surgery

In pregnancy or use of oral contraceptives

Cysts and tumors of the jaws

Mobility is usually more in women probably due to hormonal variations.

### **Classification (WD Miller)**

**Grade I:** tooth moves from 0.2 mm to 1 mm in the buccolingual direction

**Grade II:** tooth moves more than 1 mm in the buccolingual direction but does not move in the apicocoronal direction.

**Grade III:** tooth moves in both the buccolingual and apicocoronal direction.

Micro organisms associated with mobility are P.micrus and C. rectus.

### **Management:**

The underlying cause of mobility should be treated such as

Trauma from occlusion should be corrected by minor occlusal correction (coronoplasty)

Periapical infection should be managed by root canal treatment

Cysts and tumors should be enucleated or excised

Periodontal bone loss should be corrected by scaling, root planning, with or without flap and osseous surgery.

After initial therapy if mobility persists then grade II mobile teeth should be splinted and grade III mobile teeth extracted.

### **Furcation Involvement:**

Furcation involvement is the invasion of bifurcation and trifurcation of teeth by periodontal disease.

Method to check for furcation involvement: A curved probe called Naber's probe is used which has the markings of 3,6,9,12 mm.

Based on horizontal measurement of bone loss Glickman's classification 1953 classified as:

**Grade I:** there is incipient involvement of inter-radicular bone which is felt as a catch with the probe.

**Grade II:** there is partial loss of bone here the probe penetrates partially but does not pass through –and – through. There may be involvement from both sides but these are not connected, since some amount of bone is still remaining. This is called cul de sac which means dead end.

**Grade III:** the bone loss is through-and-through. Radiolucency is seen on radiographs and soft tissue resistance will be there when the probe is inserted.

Grade IV: along with through-and-through bone loss there is gingival recession leading to the furcation area becoming clinically visible.

Based on vertical involvement of bone loss, Tarnow and Fletcher in 1984 have classified furcation involvement as :

Subclass A: bone loss is 1-3mm

Subclass B: bone loss is 4-6mm

Subclass C: bone loss is 7mm or more

Goldman 1958 classified as:

Grade I: incipient

Grade II: cul-de-sac

Grade III: through & through

Hamp 1975 classified as: degree I:  $\leq 3$ mm

Degree II:  $\geq 3$ mm not total width

Degree III: through & through

Ramford & Ash 1979:

Class I: beginning involvement tissue destruction  $\leq 2$ mm

Class II: cul-de-sac  $\geq 2$ mm but not through & through

Class III: through & through

Incidence and distribution: Lorato (1981)

- Average no. of furcation involvement increased with age.
- Furcation involvement most common in 1<sup>st</sup> permanent molars
- In maxillary molars, buccal aspects more often invaded
- Maxillary premolars - lower incidence of furcation

Etiopathogenesis:

Plaque associated inflammation: extension of inflammatory periodontal disease in furcation area leads to inter-radicular bone resorption - reduction of bone height and formation of furcation defect.

Trauma from occlusion: suspected etiologic/contributing factor in isolated furcation defects - crater like or angular deformities in bone - bone destruction is localized to one of the roots - controversial.

Waerhaug (1980): inflammation + edema = extrude tooth



Traumatized and sensitive

- Contributing anatomical factors:
- Cervical enamel projections
- Root length
- Root form
- Interradicular dimension
- Anatomy of furcation

Cervical enamel projections: these are flat ectopic extensions of enamel that extend beyond the normal contours of the cemento-enamel junction.

Development: during root formation, the Hertwig's epithelial root sheath disintegrates to allow the dental follicle cells to come in contact with the root dentin and lay down cementum. In areas where the root sheath has failed to disintegrate the dental follicular cells are unable to come in contact with the dentin. The root sheath cells which are basically the reduced enamel epithelium lay down enamel.

The Sharpey's fibers of the periodontal ligament insert to cementum on one side and to bone on the other. Therefore, in areas of cervical enamel projections there is no attachment of the periodontal ligament fibers, thereby allowing easy spread of periodontal disease into the furcation area.

Classification of CEPs by Masters and Hoskins 1964:

Grade I. CEP extends towards the furcation entrance

Grade II: CEP approaches the furcation entrance

Grade III: CEP extends in to the furcation.

***Enamel pearls:***

These are large round deposits of enamel that can be located anywhere on the root. They are plaque retentive areas which when present near the furcation area can predispose the tooth to furcation involvement.

In, maxillary 2<sup>nd</sup> molar, found near the CEJ extending into molar bifurcations.

Prevent connective tissue attachment



### ***Accessory pulpal canals:***

May extend the pulpal inflammation to the furcation.

### ***Contributing anatomical factors:***

- Root trunk length- teeth with shorter trunk are more prone for development of furcation defects compared to once with longer root trunk length.
- Root length – determines the amount of attachment or support that a tooth will have. Teeth with long root trunks and short roots would have lost significant amount of support by the time furcation is affected.
- Root form – flutings on the root surface coupled with developmental grooves and concavities
- Interradicular dimension- degree of separation
- Anatomy of furcation

### **Diagnosis:**

Probing: Nabers probe is used

- Buccal and lingual furcation can be easily probed
- Proximal furcations are difficult for probing particularly when broad contacts are present in adjacent teeth.
- In maxillary molars mesial furcation is located more palatally than to the buccal tooth surface. It therefore should be probed from the palatal aspect.
- Furcation probing in maxillary premolar is very difficult due to the presence of anatomic variations such as longitudinal furrows, investigations opening at varying distances from the CEJ.

Radiographs:

- It should include intraoral periapical and vertical bitewing radiographs.

- Interdental bone as well as that within the root complex should be examined.
- Inconsistency in clinical and radiographic findings may occur.

**Management:**

The ultimate goal in the management of furcation involvement is the same as the general aim of periodontal therapy, that is to regenerate tissues where possible or else to make the area self cleansable by the patient.

Grade I: scaling and root planing

Grade II: scaling and root planing is done followed by flap surgery with regenerative techniques.

The results following flap surgery are dependent upon the type of cells which come in contact with the tooth surface during healing. This is known as Melcher's concept.

Origin of cells	Type of junction between tooth and gingiva
Gingival epithelium	Long junctional epithelium
Gingival connective tissue	Fibers oriented parallel to tooth rather than perpendicular to the root
Alveolar bone	Root resorption and ankylosis
Periodontal ligament	Periodontal ligament fiber attachment inserting perpendicularly into bone and cementum

It is desirable to have the cells from the periodontal ligament populate the area. However, the gingival epithelial cells migrate faster than the cells from the periodontal ligament. Barrier membranes prevent the gingival epithelial cells from migrating downwards and allow cells from the periodontal ligament to repopulate the area. This is called guided tissue regeneration.

Therefore, grade II furcation involvement is managed using GTR membrane with or without bone grafts.

**Obliteration of the furcation:** Baer et al (1983) proposed the elimination of anatomic niches by filling advanced furcation defects with biocompatible material.

**Increasing access to the furcation:**

Gingivectomy/ apically positioned flap- increase access for plaque control and allows resolution of periodontal inflammation.

Odontoplasty:

It is the reshaping of the tooth coronal to the furcation to improve access for plaque control.

It increases entrance to the furca and reduces its horizontal depth.

Mainly advised for grade I and II furcation defects.

Caution should be exercised with regard to – hypersensitivity, pulpal irritation leading to permanent damage, pulp exposure, increase of root caries.

-Osteoplasty and ostectomy:

-Reshaping surfaces of bone without removing tooth supporting bone

-Reshaping and removal of tooth supporting bone.

Improved plaque control through osteoplasty is reported to be accomplished by:

- Creating bony ramps into the furcation area allowing the gingival to tuck into tooth concavities.
- Removing tip of the bony defect to decrease horizontal depth of the involvement.
- In advanced cases of grade II and grade III furcations ostectomy may be extended into create a tunnel to expose the entire furcation area.
- Tunnel preparation: can be done for grade III furcation defects which permits plaque removal

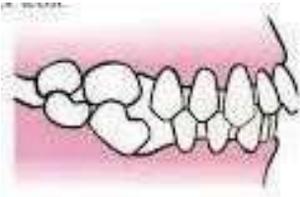
Grade III furcation: scaling and root planing is done followed by either root resection or hemi -section.

Hemisection is the splitting of a two rooted tooth into two separate portions. This is called bicuspidization as the molar is converted into two bicuspids. Root resection or amputation involves the sectioning and the removal of a root of a multi-rooted tooth. These techniques make the inter-radicular areas amenable to plaque control by the patient.

Grade IV furcation: extraction is advised.

***Pathologic migration:***

Pathologic tooth migration refers to tooth displacement that results when the balance among the factors that maintain physiologic tooth position is disturbed by periodontal disease.



In the occlusal or incisal direction is termed extrusion

Drifting:

Drifting of teeth into the space created by unreplaced missing teeth often occurs.

Drifting differs from pathologic migration in that it does not result from destruction of the periodontal tissues.

However, it usually creates conditions that lead to periodontal disease and thus the initial tooth movement is aggravated by loss of periodontal support.

Drifting generally occurs in a mesial direction combined with tilting or extrusion beyond the occlusal plane. The premolars frequently drifts distally.

Although drifting is a common sequela when missing teeth are not replaced it does not always occur.

Two major factors play a role in maintaining the normal position of the teeth.

- The health and normal height of the periodontium
- The forces exerted on the teeth

Factors influencing tooth position:

1. Destruction of periodontal supporting tissues: plays a significant role in the etiology of PTM.
  - Primate studies indicate that a specific part of the periodontium , the transeptal fibers, may play an especially important role in PTM.
  - They form a chain from tooth to tooth and are thought to help maintain contacts between teeth throughout the arch.
  - It has been suggested that if the continuity of this chain is broken or weakened by periodontal disease, the balance of forces is upset and displacement of the teeth can occur. (Moss et al 1982).
2. **Occlusal factors – Posterior bite collapse(PBC):**
  - Most common cause of PTM

- Unfavourable occlusal changes that occur most frequently after first molar teeth are lost and not replaced.
- Results in flaring of anterior teeth.

**-Failure to replace first molars:**

The second and third molars tilt, resulting in a decrease in vertical dimension.

The premolars move distally and the mandibular incisors tilt or drift lingually. While drifting distally the mandibular premolars lose their intercuspal relationship with the maxillary teeth and may tilt distally.

Anterior overbite is increased. The mandibular incisors strike the maxillary incisors near the gingiva or traumatize the gingiva.

The maxillary incisors are pushed labially and laterally

The anterior teeth extrude because the incisal apposition has largely disappeared.

Diastema are created by the separation of the anterior teeth.

**Arch integrity:**

Loss of arch integrity  $\Rightarrow$  etiologic factor for PTM

Occlusal forces are distributed to teeth in the arch through interproximal contacts. If these contacts are destroyed, tooth migration can occur. (Slots 1975).

Besides tooth loss other factors that can destroy interproximal contacts include dental caries, faulty restorations and severe attrition.

Occlusal interferences:

Disruptions such as supra erupted teeth have been described as one of the etiologic factors for PTM.

Protrusive pattern of mastication: Yaffe et al in 1992 studies a group of 27 patients with a protrusive pattern of function. These patients had anterior attrition and 16 had flaring of the incisors. The investigators suggest that this protrusive pattern of mastication should be considered an etiologic factor for anterior PTM.

Bruxism:

Bruxism forces are known to damage the dental attachment apparatus. Also, it is known that bruxism can result in abnormal occlusal forces that are frequent and of long duration.

Bruxism in some patients can act as an unfavourable orthodontic forces to cause PTM. Bruxism as an etiologic factor for PTM does not seem to be evidence based, however parafunctional occlusal habits have been listed as a contributing factor for PTM. (shifman 1998).

Soft tissue pressure of the tongue, cheek and lips:

Soft tissue forces of the tongue, cheeks, lips can move teeth especially after loss of periodontal support.

Periodontal and periapical inflammation:

As early as 1933 Hirschfeld described pathologic drifting of teeth resulting from pressure of inflammatory tissue in periodontal pockets.

Sutton in 1985 proposed a theory that hydrodynamic and hydrostatic forces within the blood vessels and inflamed tissues in the periodontal pocket may account for abnormal tooth migration.

Extrusive forces:

It is known that eruption forces are small in the range of 2 to 10 grams and are present throughout life.

As an erupting tooth emerges from the gingiva and moves toward occlusal contact, movement is rapid (in order of 0.3 to 0.5mm per week).

In addition, the velocity of eruption is much slower

From an animal study it appears that the major eruptive force is localized within the periodontal membrane. Eruption forces are thought to be generated either from contraction of collagen as it matures or traction from contractile fibroblasts.

Since extrusion of incisors is a very common form of PTM. Eruptive forces may play a very important role as a contributing factor in PTM.

Habits:

Oral habits of patients may affect tooth position and have been associated with pathologic tooth migration.

Habits that have been associated with PTM include lip and tongue habits, finger nail biting, thumb sucking, pipe smoking and playing wind instruments.

In considering oral habits as a contributing etiologic factor in PTM. It is important to remember that duration of force in tooth movement than force

magnitude. The greater the duration of the habit, the greater potential to move teeth.

#### Treatment:

Treatment of severe PTM often involves orthodontic therapy that is preceded by non surgical and surgical periodontal therapy and prosthodontic treatment,(Duncan1997).

When PTM is in initial stages and localized, the treatment may be greatly simplified for the patient.

Correction of pathologic tooth migration:

Extraction and replacement of migrated teeth when migration is very severe

Spontaneous correction of the early stages of PTM

Limited or adjunctive orthodontic therapy

Conventional orthodontic treatment

Many case reports describing reactive positioning or spontaneous correction of pathologic migration following periodontal treatment.

These reports indicate migrated teeth sometimes move back to their normal position following non surgical periodontal treatment alone or in some instances when combined with surgical methods.

Spontaneous correction of PTM include patients with severe gingival overgrowth.

When enlarged tissue is removed surgically in some cases migrated tooth move back into a more normal position.

When PTM is in the early stages, periodontal therapy alone is sometimes effective in producing spontaneous correction of the migration. This correction has been reported after non-surgical and surgical treatment.

Light intrusive orthodontic forces are effective in treating extrusion and flaring if inflammation is controlled during all phases of treatment.

Most patients with PTM have moderate to severe periodontitis. Several studies describe successful orthodontic treatment in these patients if inflammation is controlled.

Preventing PTM:

Control of periodontal disease - most effective method to prevent

Treatment of occlusal factors and habits

Early detection

**INDICES:** “These are numerical values describing the relative status of the population on a graduated scale with definite upper and lower limits, which are designed to permit and facilitate comparisons with other populations and are classified by the same criteria and methods.”

### MEASURES FOR GINGIVITIS

- Clinical signs of gingival inflammation i.e. gingivitis is easy to detect
- But how much gingivitis is present is measured by using INDICES.

Quantify the amount and severity of disease

- Indices – clinical practice- helps to assess efficacy of therapeutic agents or devices.

- epidemiological studies – helps to compare the prevalence of gingivitis

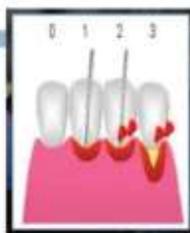
- The indices which has been proposed are:

- Gingival Index (GI)
- Modified gingival index (MGI)
- Gingival bleeding indices

### GINGIVAL INDEX

- Given by Loe and Silness, 1963.
- Only gingival tissues are assessed with the GI - four surfaces of the tooth are examined – Facial, mesial, distal and lingual.

SCORE	CRITERIA
0	Absence of inflammation/normal gingiva.
1	Mild inflammation, slight change in color, slight edema, no bleeding on probing.
2	Moderate inflammation, moderate glazing, redness, edema and hypertrophy, bleeding on probing.
3	Severe inflammation, marked redness and hypertrophy, ulceration, tendency to spontaneous bleeding.



#### □ Calculation and interpretation

- ◆ GI score for a tooth = Scores from 4 areas/4
- ◆ GI score individual = Sum of indices of teeth/no. of teeth examined
- ◆ GI score for group = Sum of all member/Total no of individuals

### CALCULATION FOR GINGIVAL INDEX

Gingival scores	Condition
0.1 – 1.0	Mild gingivitis
1.1 – 2.0	Moderate gingivitis
2.1 – 3.0	Severe gingivitis

### MODIFIED GINGIVAL INDEX

Given by Lobene, Weatherford, Ross, Lamm and Menaker in 1986.

Changes made were:

Elimination of gingival probing

Redefining of the scoring system for mild and moderate inflammation.

Scores	Criteria for MGI
0	Absence of inflammation
1	Mild inflammation: slight change in colour and texture of the portion of marginal or papillary unit.
2	Mild inflammation: colour and texture change of the entire marginal and papillary unit
3	Moderate inflammation: as above with hypertrophy of M and P gingival unit
4	Severe inflammation: as above with spontaneous bleeding, congestion or ulceration

### GINGIVAL BLEEDING INDEX

Developed by Carter H.G. and Barnes G.P. in 1974.

Record the presence or absence of gingival inflammation - by bleeding from interproximal gingival sulci.

The unwaxed floss is alternately passed inter-proximally into the gingival sulcus on both side of the interdental papillae.

30 secs is allowed to reinspect the segment for bleeding. Here,

Presence and absence of bleeding from each unit is recorded.



Gingival bleeding index is based on recordings from all four tooth surfaces of all teeth.

Recorded as

Bleeding present +

Bleeding absent -

A minus recording is equivalent to gingival index scores 0 & 1

A plus recording is equivalent to gingival index scores 2 & 3.

Gingival bleeding index is calculated as a percentage of affected sites.

## **CPITN**

Developed by Jukka Ainamo, David Barnes, George Beagrie, Terry Cutress, Jean Martin and Jennifer Sardo-Infirri in 1982.

Developed to survey and evaluate the treatment needs rather than determining past and present periodontal status.

The CPITN probe was identified as

: CPITN - E – epidemiological probe – 3.5 – 5.5 mm markings

: CPITN - C – clinical probe – 8.5 – 11.5 mm markings

Used to: determine pocket dept

: detect subgingival calculus

CODE	CRITERIA
CODE 0	No signs of disease
CODE 1	Bleeding observed during probing
CODE 2	Presence of supra or subgingival calculus
CODE 3	Pocket of 4 – 5mm GM is on the black marking of the probe
CODE 4	Pocket of 6mm or more. Black band is not visible

CODE	TREATMENT NEEDS
TN 0	No treatment needed
TN 1	Recording of CODE 1 A need to improve oral hygiene
TN 2a	Recording of CODE 2 Need for scaling and improvement in oral hygiene
TN 2b	Recording of CODE 3( 4-5mm) Need for SRP with improvement in oral hygiene
TN 3	Recording of CODE 4(6mm or more) Complex t/t – SRP and surgical procedure

## COMMUNITY PERIODONTAL INDEX (CPI)

Modification of the CPITN

The TN is not recorded but, after recording the CPI score – loss of attachment is calculated.

CODE	CRITERIA
CODE 0	CEJ not visible and CPI score 0-3
CODE 1	CEJ within the black band (LOA 4-5mm)
CODE 2	CEJ between the upper limit of the black band and 8.5 mm ring (LOA 6-8mm)
CODE 3	CEJ between 8.5 – 11.5 mm (LOA 9-11mm)
CODE 4	CEJ beyond 11.5 mm (LOA 12mm or more)
CODE X	Excluded sextant (less than two teeth present)
CODE 9	Not detected (CEJ not visible)

## RUSSEL PERIODONTAL INDEX

	CRITERIA	RADIOGRAPHIC FINDINGS
0	Negative. Neither overt inflammation in the investing tissues nor loss of function due to destruction of supporting bone.	Radiographic appearance is essentially normal.
1	Mild gingivitis. An overt area of inflammation in the free gingiva does not circumscribe the tooth	
2	Gingivitis. Inflammation completely circumscribe the tooth, but there is no apparent break in the epithelial attachment	
4	Used only when radiographs are available.	There is early notch like resorption of alveolar crest.
6	Gingivitis with pocket formation. The epithelial attachment is broken and there is a pocket. There is no interference with normal masticatory function; the tooth is firm in its socket and has not drifted.	There is horizontal bone loss involving the entire alveolar crest, up to half of the length of the tooth root.
8	Advanced destruction with loss of masticatory function. The tooth may be loose, may have drifted, may sound dull on percussion with metallic instrument, or may be depressible in its socket.	There is advanced bone loss involving more than half of the tooth root, or a definite intrabony pocket with widening of periodontal ligament. There may be root resorption or rarefaction at the apex.

$$\text{P.I score per person} = \frac{\text{sum of individual scores}}{\text{no. of teeth present}}$$

Clinical condition	Individual scores
Clinically normal supportive tissue	0.0-0.2
Simple gingivitis	0.3-0.9
Beginning of destructive periodontal disease	1.0-1.9
Established destructive periodontal disease	2.0-4.9
Terminal disease	5.0-8.0

**Mucogingival problems:**

mucogingival problems include:

1. Inadequate width of attached gingiva
2. abnormal frenal attachment
3. shallow vestibule

Recession and pocket are considered mucogingival problems only when they extend beyond the mucogingival junction.

Width of attached gingiva:

Definition- the distance between the mucogingival junction and the projection on the external surface of the bottom of the gingival sulcus or the periodontal pocket.

The mucogingival junction can be located in the following ways:

Anatomically: the gingiva is pink and the alveolar mucosa is reddish pink. (Orban 1948).

Functionally: the gingiva is firmly attached whereas the mucosa shows passive movement (Flaming 1970)

Histologically: Schiller's iodine stains glycogen in the lining mucosa (Fasske et al 1958)

Applying local anesthetic : ballooning is seen in the alveolar mucosa.

Blanch test: the handle of the instrument when run over the tissue causes blanching of the gingiva.

Normal values for width of attached gingiva:

Maxillary incisors region	3.5 to 4.5mm
Mandibular incisors region	3.3 to 3.9 mm
Maxillary premolar	1.9mm
Mandibular premolar	1.8mm

Functions of attached gingiva:

- Prevents apical spread of inflammation
- Deflects food away from gingival margin
- Braces gingiva firmly against teeth
- Acts as buffer between 2 movable mucosa
- Bear the compressive and shear forces during mastication
- Prevents transmission of frenal pull

Adequate attached gingiva?

VARIOUS AUTHORS	ADEQUATE ATTACHED GINGIVA
Corn, 1962	≥3 mm (keratinized gingiva)
Bowers, 1963	≤ 1mm
Friedman 1962, De trety&Bernimoulin 1980	Gingiva that is compatible to gingival health & that prevents retraction of gingival margin during movement of alveolar mucosa
Lang & Loe 1972	2mm

### TISSUE BARRIER CONCEPT:

Outlined by Goldman & Cohen 1979

Postulated that –A dense collagenous band of CT retards or obstructs the spread of inflammation better than does the loose fiber arrangement of the alveolar mucosa.

They recommended increasing the zone of attached gingiva to achieve an adequate tissue barrier. (thick tissue).

Widening of attached gingiva accomplishes following 4 objects:

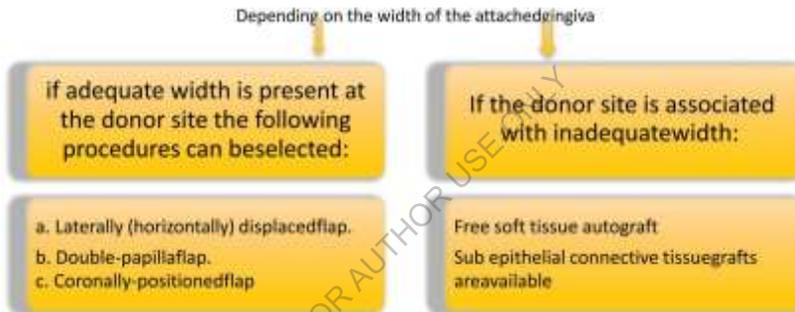
1. enhances plaque removal around gingival margin
2. improve aesthetics
3. reduces inflammation around restored teeth

4.gingival margin binds better around teeth & implants with attached gingiva

## **SURGICAL TECHNIQUES TO INCREASE THE WIDTH OF ATTACHED GINGIVA**

- Gingival augmentation apical to recession
- Gingival augmentation coronal to the recession

Gingival augmentation apical to recession – free connective tissue autograft, free gingival autograft, ( classic technique, variant technique – accordion technique, strio technique, combination epithelial connective tissue strip technique),apically repositioned flap



- **Pedicle soft tissue graft procedures :**
- Rotational flaps
- Laterally positioned flap
- Double papilla flap
- Advanced flaps
- Coronally positioned flap
- Semilunar flap

## Free soft tissue grafts

### Non-submerged graft

- One stage (free gingival graft)
- Two stage (free gingival graft + coronally positioned flap)

### Submerged grafts

- Connective tissue graft + laterally positioned flap
- Connective tissue graft + double papilla flap
- Connective tissue graft + coronally positioned flap
- subepithelial connective tissue graft
- Envelope techniques

### Additive treatments

- Root surface modification agents
- Enamel matrix proteins
- Guided tissue regeneration
  - Non-resorbable membrane barriers
  - Resorbable membrane barriers

Laterally Positioned flap

### Advantages

- a. **One surgical site**
- b. **Good vascularity of the pedicle flap.**
- c. Ability to **cover isolated, denuded roots** that have adequate donor tissue laterally.

### Disadvantages

- a. Limited by the amount of **adjacent keratinized attached gingiva**.
- b. Possibility of **recession at the donor site**.
- c. **Dehiscence or fenestration** at the donor site.
- d. Limited to **one or two teeth with gingival recession**.

### Indications:

- a. For covering the isolated denuded root.
- b. When there is sufficient **width of interdental papilla** in the adjacent teeth,

and **Sufficient vestibular depth**.

### Contraindications:

- a. Presence of **deep interproximal pockets**.
- b. **Excessive root prominence**.
- c. Deep or extensive root abrasion or erosion.

Procedure for laterally Positioned flap

• Step 1: Preparation of the recipient site



**Step 2:** Prepare the flap of the donor site.

**Step 3:** Transfer the flap.

**Step 4:** Protect the flap and donor site.

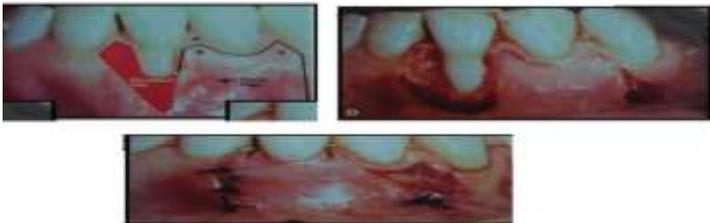


VARIANTS



**Sub-marginal pedicle flap**

**Oblique rotated pedicle flap**



**Oblique rotated pedicle flap**



Double papilla flap

**Indications:**

1. When the **interproximal papillae adjacent to the mucogingival problem are sufficiently wide.**
2. When the **attached gingiva on an approximating tooth is insufficient to allow for a Lateral Pedicle Flap.**

**Advantages:**

1. The risk of **loss of alveolar bone is minimized because the interdental bone is more resistant to loss than is radicular bone.**
2. The papillae usually supply a greater width of attached gingiva than from the radicular surface of a tooth.



Coronally positioned flap

**Indications:**

- Esthetic coverage of exposed roots.
- For tooth sensitivity owing to gingival recession.

**Advantages:**

- Treatment of **multiple areas of root exposure**.
- No need for involvement of adjacent teeth.
- High degree of success.
- Even if the **procedure does not work, it** does not increase the existing problem.

**First technique:**

**Step 1:** With 2 vertical incisions.

**Step 2:** Root preparation



**Step 3:** Return the flap and suture it coronal to the pretreatment position.

**Step 4:** Cover the area with a periodontal dressing.



**Second Technique (Semilunar flap)**

**Indication:**

- Small localized area

**Advantages:**

- **No vestibular shortening**, as occurs with the coronally positioned flap.
- No esthetic compromise of interproximal papillae.

**No need for sutures**

**Disadvantages:**

- **Inability to treat large areas of gingival recession.**
- The **need for a free gingival graft** if there is an underlying dehiscence or fenestration.

**Step 1: Semilunar incision is made and ending about 2 to 3 mm short of the tip of the papillae.**



- **Step 2: Perform a split-thickness dissection coronally from the incision, and connect it to an intrasulcular incision.**



- **Step 3:** The tissue will **collapse coronally, covering the denuded root**, then held in its new position for a few minutes with a moist gauze. **Many cases do not require either sutures or periodontal dressing.**



**Double Lateral sliding bridge flap**

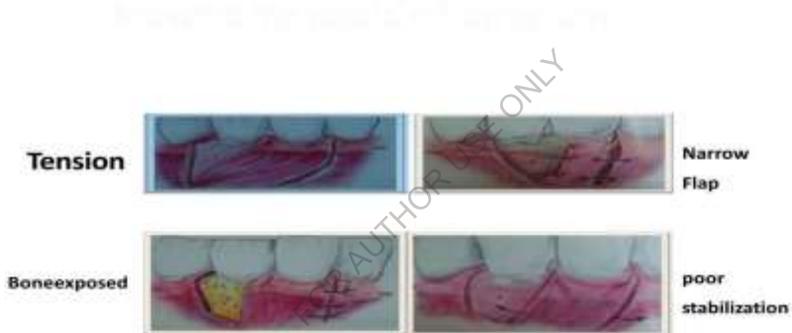
**Multiple gingival recession with or without adequate attached gingiva**

**Coronally  
advanced  
flap**

**Vestibular  
plastic surgery**



Reasons for pedicle flap failure



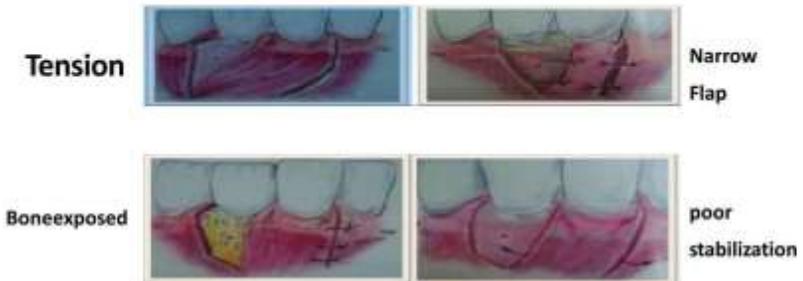
### Free Gingival Autograft

that consist of epithelium and a **thin layer of underlying CT** completely detached from one site and transferred to a remote site.

#### Advantages

- **Increase keratinized tissue around teeth**, implants or crowns and under removable prostheses.

Increase **vestibular depth**



### Free Gingival Autograft

that consist of epithelium and a **thin layer of underlying CT** completely detached from one site and transferred to a remote site.

#### Advantages

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Increase **vestibular depth**

#### Surgi calTechnique

**Step 1: Prepare the recipient site.**

**Step 2: Root preparation:**

**Root planing of exposed root to remove cementum and affected dentin.**

**Etch root surface with tetracycline (pH 2.0).**



**Step 3: Obtain the graft from the donor site:**  
The ideal thickness of a graft is 1.0 - 1.5 mm.



**Step 4: Graft transferred to recipient site.**  
**Step 5: Protect the donor site.**



Sub-epithelial Connective Tissue Graft

**Indications:**

- Where esthetics is of prime concern
- For covering **multiple denuded roots**

- In the **absence of sufficient width of attached gingiva** in the adjacent areas.

#### **Advantages:**

- High degree of cosmetic enhancement
- Incurs **no additional cost for autogenous donor tissue**
- Minimal palatal trauma
- Increased graft vascularity.

#### **Disadvantages:**

- High degree of technical skills required.
- **Complicated suturing**

#### **I. Preparation of recipient site:**

- The initial **horizontal right angle incision** is made into the adjacent **interdental papillae** at, or slightly coronal to the cemento-enamel junction of the tooth with an exposed root surface. → preserve the papillary blood supply → A partial thickness flap is raised without vertical incisions → SRP → Root Conditioning with citric acid pH 1.0 or tetracycline HCl in a concentration of 250 mg mixed in 5 ml of sterile water → approximate mesio-distal width necessary for the graft is measured with a periodontal probe.



## II. Excision of the donortissue

- 1st incision → horizontal incision 2-3mm apical to gingivalmargin  
2nd incision → parallel to the long axis of the teeth, 1 to 2 mm apical to the first incision raise a full thickness periosteal connective tissuegraft



## III. Grafting to the recipientsite:

- With interrupted sutures



## Pouch and Tunnel technique

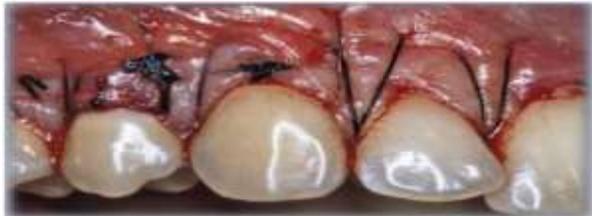
Create "pouch" using full thickness incision and maintain papilla for bilaminar bloodsupply.



- Extend incision to adjacent teeth and undermine flap beyond MGJ, which allows the coronal positioning of the flap.



- Insertion of CTG and suture.



### *FRENAL ATTACHMENT:*

Frenum is a thin fold of mucous membrane with enclosed muscle fibers that attach the lips to the alveolar mucosa and underlying periosteum. ( Carranza 10<sup>th</sup> edition)

### **TYPES OF FRENAL ATTACHMENT**

Depending upon the extent of attachment of fibres, frena have been classified by Placek et al. 1974 as:

**MUCOSAL-** The frenal fibres are attached up to the mucogingival junction.

**GINGIVAL-** The fibres are inserted within the attached gingiva.

**PAPILLARY-** The fibres extend into the interdental papilla.

**PAPILLA PENETRATING-** The frenal fibres cross the alveolar process and extend up to palatine papilla.

### **VARIATIONS**

**Other variations of normal frenal attachment Include:**

- **Simple frenum with a nodule**
- **Simple frenum with appendix**
- **Simple frenum with nichum**
- **Bifid labial frenum**
- **Persistent tectolabial frenum**
- **Double frenum**
- **Wider frenum**



Mucosal frenal attachment



Gingival frenal attachment



Papillary frenal attachment



Papilla penetrating frenal attachment



*Frenum with a nodule*



*frenum with a appendix*



*Wider frenal attachment*

*simple frenum with nichum*

**Tests for frenal attachment:**

1. **Tension Test.**
2. **Blanch Test.**

*Miller et al(1985) recommended that the frenum should be characterised as pathogenic when it is unusually wide or there is no apparent zone of attached gingiva along the midline or the interdental papilla shift when the frenum is extended.*



**Ankyloglossia**

#### SYNDROMES ASSOCIATED WITH ABNORMAL FRENUM

- *Ehlers-Danlos syndrome*
- Infantile hypertrophic pyloric stenosis
- Holoprosencephaly
- *Ellis-van Creveld syndrome*
- Oro-facial-digital syndrome

#### COMPLICATIONS OF ABNORMAL FRENUM

- **Loss of papilla.**
- **Recession.**
- **Persistence of midline diastema.**
- **Difficulty in brushing.**
- **Malalignment of teeth .**
- **Compromised denture fit or retention.**

#### TREATMENT

- Techniques for removal of aberrant frenum are :
- Frenotomy

□ Frenectomy

**Frenectomy**: Refers to the complete removal of frenum, including its attachment to the underlying bone.

It is required in the correction of abnormal diastema between maxillary central incisors (Friedman 1957).

**Frenotomy**: Is the incision of the frenum.

It is usually done to relocate the frenal attachment so as to create a zone of attached gingiva between the gingival margin and the frenum.

**FRENECTOMY**

**INDICATIONS**

1. **Gingival or papillary frenal attachment**: Where frenal fibres radiate into marginal gingiva producing gingival retraction and localized gingival recession.
2. **High frenal attachment**: Where oral hygiene is hindered by shallow vestibule caused by high frenal attachment.
3. **Ankyloglossia**: When lingual frenum interferes with speech.

**TECHNIQUES OF FRENECTOMY**

- Conventional (classical) frenectomy
- Miller's technique
- V-Y plasty
- Z plasty
- Frenectomy by using electrocautery
- Laser frenectomy

**CLASSICAL FRENECTOMY**

The classical technique was introduced by Archer et al 1961 and Kruger et al 1964.

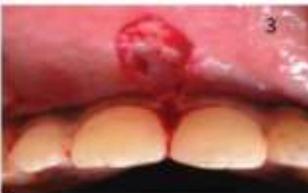
- This approach was advocated in midline diastema cases with an aberrant frenum to ensure the removal of muscle fibres which were supposedly connecting the orbicularis oris with the palatine papilla.



hemostat Bp blade no.15



Suture pliers



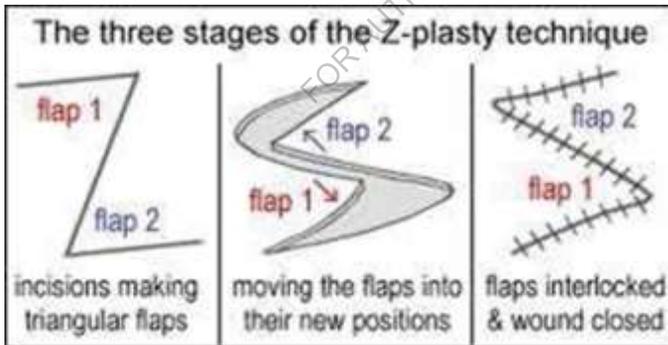
MILLER'S TECHNIQUE

- This technique was advocated by **Miller PD et al in 1985**.
- This was proposed for post-orthodontic diastema cases.
- The ideal time for performing this surgery is after the orthodontic movement is complete and about 6 weeks before the appliances are removed.
- This allows healing and tissue maturation.



#### Z- PLASTY TECHNIQUE

- This technique is indicated when:
  - There is hypertrophy of the frenum with a low insertion, associated with distema.
  - There is a short vestibule.



V-Y PLASTY TECHNIQUE

- This technique can be used for lengthening the localized area, like a broad frena.
- This technique is mostly employed in a case of a papilla type of frenal attachment.



### ELECTROSURGERY

- This technique is recommended for patients with bleeding disorders and non-compliant patients.





### LASER FRENECTOMY

The benefits of a laser frenectomy are greater as compared to traditional techniques .

These include :

- Reduced bleeding during surgery.
- Reduced operating time and rapid postoperative hemostasis, thus eliminating the need for sutures.





PAPILLA PENETRATING FRENAL  
ATTACHMENT



DIODE LASER APPLIED



IMMEDIATE POST OPERATIVE VIEW

#### POST OPERATIVE INSTRUCTIONS

- NOT to eat anything until the anesthesia wears off, as there are chances of biting the lips, cheek or tongue.
- **Avoid extremely hot foods** for the rest of the day and do NOT rinse out your mouth, as these will often prolong the bleeding. **If bleeding continues, apply light pressure to the area with a moistened gauze for 20-30 minutes.**
- Follow a soft food diet, taking care to avoid the surgical area when chewing. Chew on the opposite side and do NOT bite into food. Be sure to maintain adequate nutrition and drink plenty of fluids. **Do NOT use a drinking straw, as the suction may dislodge the blood clot.**
- **Avoid alcohol and smoking until after your post-operative appointment.**
- Maintain normal oral hygiene measures in the areas of mouth not affected by the surgery. In areas where there is dressing, lightly brush only the biting surfaces of the teeth. **Vigorous rinsing should be avoided!**
- **Do NOT pull down the lip or cheek.**

### ***VESTIBULAR DEPTH.***

The problems associated with a shallow vestibule:

- Difficulty in maintaining oral hygiene.
- Most root coverage procedures require adequate vestibular depth.
- Shallow vestibule might come in the way of denture construction.
- Gingival recession displaces the gingival margin apically thus reducing the vestibular depth
- With minimal vestibular depth proper hygiene procedures are jeopardized.
- The sulcular brushing technique requires the placement of the toothbrush at the gingival margin which may not be possible with reduced vestibular depth.
- Minimal attached gingiva with adequate vestibular depth may not require surgical correction if proper atraumatic hygiene is practiced with a soft brush.
- Minimal amount of keratinized attached gingiva with no vestibular depth benefit from mucogingival correction.
- Adequate vestibular depth is also necessary for placement of removable prosthesis

The vestibular depth measured from the gingiva to mucobuccal fold varied from 2.5mm to 11.5 mm and measured from the crest of the lip to mucobuccal fold varied from 10 to 29mm.

The minimum depth of the vestibule determined was 2.5mm and this was associated with a zone of attached gingiva 1mm wide.

Tension test:

The upper lip is moved outwards and downwards and lower lip is moved outwards and upwards. If the gingival margin shows movement or blanches the tension test is considered positive.

### ***Hard tissue examination:***

Number of teeth present and unreplaced missing teeth:

Drifting of teeth into spaces created by lost teeth can lead to periodontal disease. Failure to replace mandibular first molars can lead to the following sequelae.

Second and third molar tilt and reduce the vertical dimension.

Premolars move distally and mandibular incisors tilt lingually increasing the anterior overbite and traumatizing the palatal gingiva adjacent to the maxillary incisors.

Maxillary incisors tilt labially and laterally resulting in diastema formation.

The improper proximal contact leads to food impaction, gingival inflammation, pocket formation, bone loss and mobility.

### ***Dental caries:***

Teeth with extensive caries cause accumulation of plaque and hence it is essential to excavate caries and temporarily restore them in the initial visit so that the patient is able to maintain adequate plaque control.

Pulpal inflammation can spread to the periodontal ligament space through the apical foramen or lateral/accessory foramina and vice versa. These lesions are called endo-perio lesions and may complicate treatment.

Classification:

Primary endodontic lesions

Primary periodontal lesions

Combined lesions

- primary endodontic with secondary periodontal lesions
- primary periodontal with secondary endodontic lesions
- True combined lesions

Clinical significance :

Endodontic therapy should always be carried out first because pulpal symptoms are more severe and if the root canal is left patent it can re-infect the periodontium. Once it is sealed, periodontal surgical procedures are initiated. thus the sequence of therapy would be:

Emergency access if necessary  $\Rightarrow$  scaling and root planing  $\Rightarrow$   
root canal therapy  $\Rightarrow$  flap surgery with or without regenerative techniques.

If the bone loss is due to endodontic reasons the bone regenerates in the periapical area once the lesion subsides hence prognosis is better. If the bone loss is more due to periodontal disease, complicated regenerative approaches may be necessary and the prognosis is not as good. However on comparing periodontal regeneration over vital and non-vital teeth no difference has been found.

Filled teeth:

Overhanging margins can cause plaque retention favours growth of gram negative anaerobic species cause gingival inflammation, recession or pocket formation and bone loss. Subgingival and rough margins are detrimental to periodontal health.

The best way to detect overhangs is through bitewing radiographs.

Overhanging restorations can be corrected using diamond burs, abrasive strips or EVA system. The EVA system consists of a triangular wedge of aluminium, diamond coated on one side and smooth on the other. The diamond coated side is placed towards the overhang and it trims it without traumatizing adjacent tissues.

Prosthetically replaced teeth:

With the exception of self cured acrylic resin all other restorative materials are compatible with periodontal tissues. In fixed partial dentures, a smooth polished interface with the gingiva is desired. Apart from this, in case of subgingival margins care should be taken to ensure that the biologic width is not infringed upon.

The biologic width is defined as the physiologic dimension of the junctional epithelium and the connective tissue attachment. Gargiulo in 1961 has said that the biologic width has a value of 2mm ( $\square, T\Psi$ ). The value given for width of junctional epithelium is 0.97 mm and for connective tissue is 1.07 mm.

Therefore, the sum of these, the biologic width is 2.04mm. however, Vacek et al 1994 have given a range of biologic widths from 0.75 to 4.3 mm. according to them the value varies between individuals and need to be calculated separately for each patient.

Infringement of biologic width results in:

- Gingival inflammation (Gargiulo et al 1961)
- Pocket formation
- Alveolar bone loss (Lindhe 1982)

### Extrusion

Extruded teeth usually have improper contact areas which can lead to food impaction. They might also apply excessive forces or oblique forces on teeth in the opposing arch leading to trauma from occlusion. Thus , it is important to note which teeth are supra-erupted and to check for any associated problems.



Extruded 11

FOR AUTHOR USE ONLY

Plunger cusps and food impaction:

Plunger cusp: cusps that tend to wedge food forcibly into interproximal embrasures are known as plunger cusps.



Food impaction: food impaction is forceful wedging of food into the periodontium by occlusal forces.

Types: vertical and lateral food impaction

Causes:

- Causes of food impaction were given by Hirschfeld in 1930
- Uneven occlusal wear
- Opening of contact point due to loss of proximal support or from extrusion
- Congenital morphologic abnormalities
- Improperly constructed restorations.
- The main causes of food impaction are improper contacts or open contacts or plunger cusp usually seen due to the failure to replace missing teeth.

Lateral food impaction:

Lateral pressure from the lips, cheeks and tongue that forces food interproximally. It is usually seen in an open embrasure associated with papillary recession.

Sequelae of food impaction:

- Feeling of pressure and urge to dig the material from between the teeth.
- Vague pain, which radiates deep in the bone
- Gingival inflammation with bleeding and a foul taste in the involved area.
- Gingival recession
- Periodontal abscess formation
- Varying degree of inflammatory involvement of the periodontal ligament with an associated elevation of the tooth in its socket. Prematurity in functional contact and sensitivity to percussion.

- Destruction of the alveolar bone.
- Caries of the root.

Hypersensitivity:

Definition: dentin hypersensitivity is characterized by short sharp pain arising from exposed dentin in response to stimuli – typically thermal, evaporative, tactile, osmotic, chemical- which cannot be ascribed to any other dental defect or pathology.

Methods to check for hypersensitivity:

The methods to check for hypersensitivity are, thermal (application of cold air through 2 way syringe), tactile (by running the explorer over the tooth surface) and osmotic (use of sugar solution to establish an osmotic gradient causing movement of fluid outwards)cold stimulus leads to greater sensitivity as it makes the dentinal fluid move inwards.

Incidence of hypersensitivity is more in women and in adults between 20 and 40 years of age. This is probably because older adults have a greater amount of secondary and tertiary dentin.

Causes:

Causes are abrasion, attrition, erosion, ablation, abfraction, recession, caries and pocket.

Phases:

Lesion localization

It is the exposure of dentin due to abrasion or erosion

Lesion initiation – it is the opening of the dentinal tubules.

Various theories have been given on hypersensitivity:

Odontoblastic transduction theory

Exposure of odontoblastic process → excitation due to stimuli → release of neurotransmitters → impulse transmission to nerve endings.

Neural theory:

Directly affect the nerve endings

Hydrodynamic theory (Brannstrom and co-workers)

Temperature, physical and osmotic changes  $\Rightarrow$  disturbance of fluid within dentinal tubules  $\Rightarrow$  stimulation of baroreceptor  $\Rightarrow$  neural discharge

Hydrodynamic theory is the accepted theory. The other theories are not accepted as neither the odontoblastic processes nor the nerve endings are present in the outer surface of dentin.

Treatment: scaling should be done as bacteria in plaque produce acids which increase hypersensitivity.

Nerve desensitization: 5% Potassium nitrate reduces dentinal sensory nerve activity due to depolarizing activity of potassium ions.

Plugging dentinal tubules: calcium hydroxide binds loose protein radicals by calcium ions and increases mineralization.

Sodium fluoride increases resistance of dentine to acid decalcification by formation of fluorapatite.

Stannous fluoride induces a high mineral content which forms a calcific barrier and blocks tubular openings.

Fluoride iontophoresis: influencing ionic motion by an electric current used in conjunction with sodium fluoride.

Dentine sealers: resins and adhesives are used to seal the dentine surface.

Lasers: Nd:Yag and carbon dioxide lasers ablate the dentinal tubules.

Restorative materials: composites and GIC are indicated cases with severe loss of cervical tooth structure or when the tooth does not respond to a less invasive protocol.

Soft tissue grafting procedures: Pedicle grafts of free grafts may be used in cases where gingival recession is present and poses an aesthetic problem.

## Wasting diseases

Definition: wasting is a gradual loss of tooth substance characterized by the formation of smooth, polished surfaces without regard for the possible mechanism of loss.

Erosion: saucer shaped defects on the cervical part of the tooth due to chemical agents. It is seen in chemical factory workers working in an acidic environment. 9e.g. leather tanning factories, ) people who consume acidic drinks frequently

(e.g. aerated drinks, citric juices), patients with gastric regurgitation and people with chronic vomiting. (e.g. bulimia).

**Abrasion:** wedge shaped defects due to mechanical wear. This is usually due to mechanical wear. This is due to improper brushing technique, tooth powder, hard bristled brush, and aggressive brushing.

**Attrition:** it is the occlusal wear resulting from functional contacts with opposing teeth. Attrition is severe in people with bruxism.

**Facets** are shiny, smooth, curvilinear surfaces highly reflective to light formed due to fracture of enamel rods. Facets whose surface is perpendicular to the long axis of the tooth is called horizontal facet otherwise it is called an angular facet.

**Ablation:** the wear on the tooth surface resulting from the frictional forces from the soft tissues like the cheeks and tongue is known as ablation.

**Abfraction:** flexural forces on the tooth cause mechanical microfractures in the cervical area called abfraction.

**Developmental anomalies of the tooth;**

Cervical enamel projections, enamel pearls and deep developmental grooves can affect the prognosis of the teeth. Palatogingival groove is more common in the maxillary lateral incisor and extends upto a significant distance on the root surface. It facilitates the spread of inflammation to deeper areas and acts as a plaque anomalies to look for include supernumerary teeth such as mesiodens, gemination, fusion, talon's cusp and mulberry molars.

**Tooth malposition:** crowding of teeth makes it difficult for the patient to keep the area free of plaque and calculus. Teeth which are prominent in the arch may be accompanied by thin bone and gingival recession. Mesially tipped and supra-erupted teeth are usually associated with angular bone loss.

**Occlusal examination:**

**Trauma from occlusion:**

**Definition:** when occlusal forces exceed the adaptive capacity of the tissues, tissue injury results. The resultant injury is termed trauma from occlusion.

**Classification**

**Based on onset:**

Acute	Chronic
Abrupt occlusal impact,	Develops gradually due to changes in occlusion due

eg. Biting on a hard object	to tooth wear, drifting, extrusion and parafunctional habits like bruxism and clenching
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Based on etiology:

Primary	secondary
Caused by increased forces on healthy periodontium. E.g. high filling or extruded teeth	Caused due to reduced ability of periodontium to withstand occlusal forces. e.g. Periodontitis

Stages:

In each stage, the bone is affected in the following ways:

In the injury stage, bone is resorbed on the pressure side and deposited on the tension side.

In the repair stage, bone is deposited on the trabecular and the cortical (central and peripheral buttressing)



Peripheral buttressing

In the adaptive stage, there is funnel shaped defect in the bone due to crestal bone loss. Crestal loss is due to widened periodontal ligament in the area. The widened periodontal ligament withstands the forces better.

Symptoms of TFO:

1. Periodontal pain:

In severe form of TFO, there is localized sharp pain or soreness to the tooth

In chronic long standing TFO, there is little or no pain

The symptoms if present are those of vague regional discomfort

2. Pulpal pain:

Sensitivity of teeth especially to cold is commonly found

3. Food impaction:

The plunger cusp effect of occlusal interference may produce a functional opening of contact between the teeth leading to food impaction.

4. TMJ Pain:

This is always accompanied by an occlusal disharmony

Clinical signs of TFO:

1. Increased tooth mobility:

This is hall

mark of trauma from occlusion

2. Migration of teeth:

Loss of interproximal contact and migration of teeth may be seen in TFO.

3. Atypical pattern of occlusal wear:

Tooth wear which appears to be greater than one might expect in a patient of that age, and which cannot be attributed to any special diet or deficiency in tooth mineralization.

4. Changes in percussion sound:

On percussion, the tooth affected by TFO, gives a dull sound whereas a normal tooth gives a sharp sound. This difference could be due to altered width and consistency of periodontal membrane and partial resorption of lamina dura.

5. Hypertonicity of masticatory muscles:

Bruxism and hypertonicity makes the periodontium susceptible to trauma.

Methods to check for trauma from occlusion:

Clinical methods: Fremitus test/functional mobility

Test to detect TFO



Fremitus is a measurement of the vibratory pattern of the teeth when the teeth are placed in contacting positions and movements.

To measure fremitus, a dampened index finger is placed along the buccal and labial surface of maxillary teeth. The patient is asked to tap the teeth together in the maximum inter cuspal position and then grind systematically in the lateral, protrusive, lateral-protrusive contacting movements and positions.

The teeth are displaced by the patient in these jaw positions are then identified.

Mandibular teeth are assessed in edge to edge occlusion.

The following classification system is used

- class I fremitus- mild vibration or movement detected
- class ii – easily palpable vibration but no visible movement
- class iii – movement visible with naked eyes

Fremitus differs from mobility in that fremitus is tooth displacement created by patient's own occlusal force.

Fremitus is a guide to the ability of the patient to displace and traumatize the teeth.

In the posterior teeth TFO can be detected with help of occlusion registration strips/ articulating paper.

High pressure points can be detected by pattern of impression made by registration strip/articulating paper.

Radiographic features of TFO:

Radiographically detected changes are seen in lamina dura, periodontal ligament spaces, morphology of alveolar crest and density of surrounding bone.

These changes include:

Increased width of periodontal space often with thickening of lamina dura along the lateral aspect of root, in the apical region and in the bifurcation areas.

A vertical rather than horizontal destruction of interdental septum.

Widening of periodontal ligament space at the crest giving a funnel-shaped appearance and angular defects during adaptive remodelling stage.

Root resorption is seen.

Treatment planning for TFO:

The decision to treat the patients occlusion either by adjusting the occlusal surfaces or by the use of occlusal appliance will be influenced by the patients symptoms such as:

- Tooth sensitivity
- Pain on chewing
- Mobility
- Presence of wear facets
- Extent of periodontal destruction
- Patients ability to adequately function.

If the patient is asymptomatic and does not have significant periodontal disease, treatment of occlusion may not be indicated even if significant occlusal discrepancies are present.

If the patient has occlusal discrepancies in addition to periodontal disease, occlusal treatment can be considered.

The decision to perform occlusal therapy should be made after reevaluation of the patient's response to non-surgical treatment such as oral hygiene instructions and root planning.

Mobility and fremitus will often be greatly reduced by these procedures and the need for occlusal treatment may be diminished.

An exception to this treatment timing would be when the patient has difficulty in chewing or tooth pain when chewing that appears directly related to occlusal trauma.

If a decision is made to begin occlusal treatment prior to controlling inflammation, it will probably be necessary to perform further occlusal treatment following control of inflammation. The patient should be informed of this prior to beginning treatment.

Occlusal treatment consists of two basic approaches:

- The use of bite appliance (bite guard)

- Adjusting the occlusion by altering the occlusal relationships between the teeth.

A bite appliance fits over the patients teeth and creates an artificial occlusal surface for the opposing dentition to contact.

A bite appliance is usually made from hard acrylic which has the advantage of cushioning contact forces between the teeth. Heat or cold cured hard acrylic is recommended over a soft acrylic material.

The use of maxillary bite appliance is preferred for most periodontal patients because it will stabilize potentially loose maxillary anterior teeth and prevent flaring.

If a mandibular bite appliance is used against maxillary teeth with compromised teeth, flaring of the maxillary teeth is possible.

Selective grinding/coronoplasty

It is a procedure by which the occlusal surfaces of teeth are precisely altered to improve the over all contact pattern. Tooth structure is selectively removed until the reshaped teeth contact in such a manner as to fulfil the treatment goals.

Treatment of increased tooth mobility:

Situation I

Increased mobility of a tooth with increased width of periodontal ligament but normal height of the alveolar bone.

Situation II

Increased mobility of tooth with increased width of periodontal ligament and reduced height of alveolar bone.

If the excessive forces are reduced or eliminated by occlusal adjustment, bone apposition to the "pretrauma" level will occur the periodontal ligament will regain its normal width and the tooth will become stabilized.

Situation I & II: occlusal adjustment is an effective therapy against tooth mobility when such mobility is caused by an increased width of periodontal ligament.

Situation III

Increased mobility of a tooth with reduced height of the alveolar bone and normal width of the periodontal ligament.

The increased tooth mobility which is the result of a reduction in height of the alveolar bone without a concomitant increase in width of the periodontal membrane cannot be reduced or eliminated by occlusal adjustment.

In teeth with normal width of the periodontal ligament, no further bone apposition on the walls of the alveoli can occur.

If such an increased tooth mobility does not interfere with the patient's chewing function or comfort no treatment is required.

If the patient experiences the tooth mobility as disturbing, however, the mobility can only be reduced in this situation by splinting. i.e by joining the mobile teeth together with other teeth in the jaw into a fixed unit.- a splint.

#### Situation IV

Progressive mobility of a tooth as a result of gradually increasing width of the reduced periodontal ligament.

It will only be possible to maintain such teeth by means of a splint. In such cases a fixed splint has two objectives.

-to stabilize hypermobile teeth

- to replace missing teeth

#### Overjet and Overbite:

Increased anterior overbite or edge to edge bite might be associated with trauma from occlusion. In patients with complete deep bite the mandibular incisors impinge upon the maxillary palatal gingiva traumatizing it and also causing food impaction.

In patients having open bite, there might be associated mouth breathing habits which can cause dryness and gingivitis in the anterior labial region.

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## Chapter 6

### **RADIOGRAPHIC EXAMINATION:**

- Periodontal abscess
- Furcation involvement
- Interdental craters
- Chronic periodontitis
- Localized aggressive periodontitis
- Trauma from occlusion

Periodontal abscess: there is discrete area of radiolucency in the lateral aspect of the root. Acute abscess and abscess in soft tissue are not radiographically visible. Apart from this, the extent of bone destruction and morphology of bone determine whether the abscess is visible on the radiograph.

Furcation involvement: there is decreased radio-density in the furcation region.

Interdental craters: they are seen as irregular areas of reduced radio-opacity on the alveolar crest not sharply demarcated from the rest of the bone but blending gradually with it.

#### **Chronic periodontitis:**

Break in the continuity of lamina dura- lamina dura is the radiographic appearance of the bundle bone which appears radio opaque due to its increased density. Widening of vessel channels and a reduction in calcified tissue at the septal margin causes discontinuity of the lamina dura.

Horizontal bone loss: in case of horizontal bone loss, the interdental septum is parallel to the line joining the cemento enamel junction of the two adjacent teeth: but, the height of the interdental septum is progressively reduced. The height of the interdental septum is progressively reduced by the extension of inflammation and the resorption of bone.

Widening of the periodontal ligament space: resorption of the bone at the lateral aspects of the interdental septum is associated with widening of periodontal ligament space.

**Localized aggressive periodontitis:**

Arc shaped bone loss extending from the distal surface of the second premolar to the mesial surface of the second molar. Mirror image pattern (bilateral) of bone loss is usually seen.

**Trauma from occlusion:**

The main radiographic features seen are widened periodontal ligament space and angular bone loss. In addition to these findings, thickened lamina dura, condensation of the alveolar bone and root resorption may be seen.

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## **Chapter 7:**

### **LABORATORY INVESTIGATIONS:**

#### Systemic disorders

Diabetes mellitus, bleeding dyscrasias, liver disorders and hypertension necessitate certain laboratory investigations.

These are discussed in the section of history taking.

#### Microbiological examination and antibiotic susceptibility test:

In cases of refractory to treatment or aggressive periodontitis there may be tissue invasive bacteria. It may be necessary to isolate the causative microorganisms and find the suitable antibiotic against them.

#### Biopsy:

Patients with gingival enlargement or desquamative gingivitis may require a biopsy for a definitive diagnosis. Diagnosis of desquamative gingivitis might further require direct or indirect immunofluorescence.

## Chapter 8

### DIAGNOSIS:

#### Gingivitis:

A diagnosis of gingivitis is given when the gingiva shows signs of inflammation such as change in colour, consistency, surface texture and presence of bleeding on probing .

At times , there may be no changes in color, consistency, surface texture -but bleeding on probing is present. This is because gingivitis is a chronic condition with active and resting phases. When repair is taking place the outer wall may show fibrosis but the inner lining is ulcerated or atrophic. The diagnosis will still be gingivitis as long as gingiva bleeds on probing.

#### Periodontitis:

A diagnosis of periodontitis Is given when the aforementioned clinical signs of gingivitis are present and in addition there are periodontal pockets and/or gingival recession.

A diagnosis of aggressive periodontitis is given when the following features are seen:

- The amount of local factors does not correlate with the amount of destruction.
- The patient is otherwise healthy,systemically.
- Familial aggregation – usually others in family like siblings also have aggressive disease.
- Rapid attachment loss and bone destruction
- Progression of attachment loss and bone loss may be self arresting.

#### Localized versus generalized aggressive periodontitis:

Localized : when upto 2 permanent teeth other than first molars and incisors are involved.

Generalized: when 3 or more than 3 permanent teeth other than first molars and incisors are involved.

Features of chronic periodontitis, aggressive periodontitis, and periodontitis as a manifestation of systemic disease

Chronic periodontitis	Aggressive periodontitis	Periodontitis as a manifestation of systemic disease
Amount of local factors correspond to the degree of destruction	Amount of local factors do not correspond to the degree of destruction	Amount of local factors do not correspond to the degree of destruction
May be associated with systemic diseases like diabetes or HIV infection.	Not associated with systemic disease	Hematologic or genetic disorders are present

Differences between chronic and aggressive periodontitis:

features	Chronic	Aggressive
Local factors	correspond to the degree of destruction	Do not correspond to the degree of destruction
Rate of progression	Slow to moderate	Rapid
Age of onset	>35 years	<35 years
Systemic disease	Modified by systemic disease such as diabetes mellitus	Seen in a clinically healthy patient
Teeth affected	Areas with increased plaque accumulation . e.g. teeth with developmental grooves or improper restorations	More destruction is seen in incisor and first molar regions especially in localized aggressive periodontitis
Radiographic changes	Horizontal bone loss	Angular bone loss characteristic arc shaped bone loss is seen from distal of second premolar to mesial of second molar in a mirror image pattern in localized aggressive periodontitis.

## CLASSIFICATION OF PERIODONTAL DISEASES & CONDITIONS {1999}

### 1. Gingival diseases (G)

2. Chronic periodontitis (CP)
3. Aggressive periodontitis (AP)
4. Periodontitis as a manifestation of systemic diseases (PS)
5. Necrotizing periodontal diseases (NP)
6. Periodontal abscesses
7. Periodontitis with endodontic lesion
8. Developed and acquired deformations and conditions.

## **1. GINGIVAL DISEASES:**

### GINGIVITIS EXCLUSIVELY CAUSED BY PLAQUE :

- With no local modifying factors
- With local modifying factors .

### GINGIVAL DISEASES MODIFIED BY SYSTEMIC FACTORS:

- Associated with hormonal influences :
  - 1) Puberty associated Gingivitis.
  - 2) Menstrual cycle associated Gingivitis.
  - 3) Pregnancy associated:
    - a) gingivitis
    - b) Pyogenic granuloma
  - 4) Diabetes mellitus associated gingivitis
- Associated with blood disease
  - 1) Gingivitis associated with leukemia
  - 2) Other diseases

### GINGIVAL DISEASES MODIFIED BY MEDICATIONS

1. Drug influenced Gingival diseases.
2. Drug induced gingival enlargements.
3. Drug induced gingivitis:
  - a) associated with oral contraceptives.
  - b) Other medications.

### GINGIVAL DISEASES MODIFIED BY MALNUTRITION

- a. Gingivitis due to lack of vitamin C
- b. Others

### NON-PLAQUE INDUCED GINGIVAL DISEASES:

#### *GINGIVAL DISEASES OF SPECIFIC BACTERIAL AETIOLOGY*

- A. Lesions associated with Neisseria gonorrhoeae
- B. Lesions associated with Treponema pallidum
- C. Lesions associated with Streptococci
- D. Others

#### *GINGIVAL DISEASES OF VIRAL AETIOLOGY*

Infection with the herpes virus

- 1)Primary herpetic gingivostomatitis
- 2)Recurring oral herpes
- 3)Varicella zoster infection
- 4)Others

### *GINGIVAL DISEASES OF FUNGAL AETIOLOGY*

Infection with candida:

- a. Generalised gingival candidiasis
- b. Linear gingival erythema
- c. Histoplasmosis
- d. Others

### *GINGIVAL DISEASES OF GENETIC AETIOLOGY*

- A. Inherited fibromatosis of the gingiva
- B. Others

### GINGIVAL MANIFESTATIONS OF SYSTEMIC CONDITIONS

#### A. MUCOCUTANEOUS LESIONS

- 1) lichen planus
- 2) pemphigoid
- 3) pemphigus vulgaris
- 4) erythema multiformis
- 5) lupus erythematosus
- 6) caused by medications
- 7) others

#### B. ALLERGIC REACTIONS

- 1) Material in restorative dentistry
  - a) Mercury
  - b) nickel
  - c) acrylic
  - d) others

2) Reaction to:

- Toothpaste
- Mouthwashes
- Additives in chewing gum
- Foods and additives
- Others

C. TRAUMATIC LESIONS (FACTITIOUS, IATROGENIC, ACCIDENTS)

- a) CHEMICAL
- b) PHYSICAL
- c) THERMAL

D. REACTION TO FOREIGN BODIES

E. NOT OTHERWISE SPECIFIED

### **PERIODONTAL DISEASES**

Chronic Periodontitis:

- Localized
- Generalized

Aggressive Periodontitis:

- Localized
- Generalized

### **PERIODONTITIS AS A MANIFESTATION OF SYSTEMIC DISEASES:**

A. Associated with hematological disorders:

- i. Acquired neutropenia
- ii. Leukemias
- iii. Other

- B. Associated with genetic disorders:
1. Familial and cyclic neutropenia
  2. Down syndrome
  3. Leukocyte adhesion deficiency syndromes
  4. Papillon-Lefèvre syndrome
  5. Chediak-Higashi syndrome
  6. Histiocytosis syndromes
  7. Glycogen storage disease
  8. Infantile genetic agranulocytosis
  9. Cohen syndrome
  10. Ehlers-Danlos syndrome (Types IV and VIII)
  11. Hypophosphatasia

### **NECROTIZING PERIODONTAL DISEASES**

- A. Necrotizing ulcerative gingivitis (NUG)
- B. Necrotizing ulcerative periodontitis (NUP)

### **ABSCESSSES OF THE PERIODONTIUM**

- A. Gingival abscess
- B. Periodontal abscess
- C. Pericoronal abscess

### **PERIODONTITIS ASSOCIATED WITH ENDODONTIC LESIONS:**

- A. Combined periodontic-endodontic lesions

### **DEVELOPMENTAL OR ACQUIRED DEFORMITIES AND CONDITIONS:**

- Localized tooth-related factors that modify or predispose to plaque-induced gingival diseases/periodontitis
1. Tooth anatomic factors

2. Dental restorations/appliances
3. Root fractures and cemental tears
  - Mucogingival deformities and conditions around teeth
  - Gingival/soft tissue recession
    - facial or lingual surfaces
    - interproximal (papillary)
  - Lack of keratinized gingiva
  - Decreased vestibular depth
  - Aberrant frenum/muscle position
  - Gingival excess
    - a.pseudopocket
    - b.inconsistent gingival margin
    - c.excessive gingival display
    - d.gingival enlargement
  - Mucogingival deformities and conditions on edentulous ridges:
    - Vertical and/or horizontal ridge deficiency
    - Lack of gingiva/keratinized tissue
    - Gingival/soft tissue enlargement
    - Aberrant frenum/muscle position
    - Decreased vestibular depth
    - Abnormal color
  - Occlusal trauma:
    - Primary occlusal trauma
    - Secondary occlusal trauma

## PERIODONTAL HEALTH, GINGIVAL DISEASES/CONDITIONS

### 1. Periodontal health and gingival health

Lang & Bartold 2018 [link](#)

- a. Clinical gingival health on an intact periodontium
- b. Clinical gingival health on a reduced periodontium
  - i. Stable periodontitis patient
  - ii. Non-periodontitis patient

### 2. Gingivitis – dental biofilm-induced

Murakami et al. 2018 [link](#)

- a. Associated with dental biofilm alone
- b. Mediated by systemic or local risk factors
- c. Drug-influenced gingival enlargement

### 3. Gingival diseases – non-dental biofilm induced

Holmstrup et al. 2018 [link](#)

- a. Genetic/developmental disorders
- b. Specific infections
- c. Inflammatory and immune conditions
- d. Reactive processes
- e. Neoplasms
- f. Endocrine, nutritional & metabolic diseases
- g. Traumatic lesions
- h. Gingival pigmentation

## FORMS OF PERIODONTITIS

### 1. Necrotizing Periodontal Diseases

Herrera et al. 2018 [link](#)

- a. Necrotizing Gingivitis
- b. Necrotizing Periodontitis
- c. Necrotizing Stomatitis

### 2. Periodontitis as Manifestation of Systemic Diseases

Jepsen, Caton et al. 2018 Consensus Rept [link](#) Albandar et al. 2018 [link](#)

*Classification of these conditions should be based on the primary systemic disease according to the International Statistical Classification of Diseases and Related Health Problems (ICD) codes*

### 3. Periodontitis

Fine et al. 2018 [link](#)

Needleman et al. 2018 [link](#)

Billings et al. 2018 [link](#)

#### a. Stages: Based on Severity<sup>1</sup> and Complexity of Management<sup>2</sup>

Stage I: Initial Periodontitis

Stage II: Moderate Periodontitis

Stage III: Severe Periodontitis with potential for additional tooth loss

Stage IV: Severe Periodontitis with potential for loss of the dentition

#### b. Extent and distribution<sup>3</sup>: localized; generalized; molar-incisor distribution

#### c. Grades: Evidence or risk of rapid progression<sup>4</sup>, anticipated treatment response<sup>5</sup>

- i. Grade A: Slow rate of progression
- ii. Grade B: Moderate rate of progression
- iii. Grade C: Rapid rate of progression

Periodontitis stage		Stage I	Stage II	Stage III	Stage IV
Severity	<b>Interdental CAL at site of greatest loss</b>	1 to 2 mm	3 to 4 mm	≥5 mm	≥5 mm
	<b>Radiographic bone loss</b>	Coronal third (<15%)	Coronal third (15% to 33%)	Extending to mid-third of root and beyond	Extending to mid-third of root and beyond
	<b>Tooth loss</b>	No tooth loss due to periodontitis		Tooth loss due to periodontitis of ≤4 teeth	Tooth loss due to periodontitis of ≥5 teeth
Complexity	<b>local</b>	Maximum probing depth ≤4 mm Mostly horizontal bone loss	Maximum probing depth ≤5 mm Mostly horizontal bone loss	In addition to stage: II complexity: Probing depth ≥6 mm Vertical bone loss ≥3 mm Furcation involvement Class II or III Moderate ridge defect	In addition to stage III complexity: Need for complex rehabilitation due to: Masticatory dysfunction Secondary occlusal trauma (tooth mobility degree ≥2) Severe ridge defect Bite collapse, drifting, flaring Less than 20 remaining teeth (10 opposing pairs)
Extent & distribution	<b>Add to stage as Descriptor</b>	For each stage, describe extent as localized (<30% of teeth involved), generalized, or molar/incisor pattern			

Periodontitis grade			Grade A: Slow rate of progression	Grade B: Moderate rate of progression	Grade C: Rapid rate of Progression
Primary criteria	Direct evidence of progression	Longitudinal data (radiographic bone loss or CAL)	Evidence of no loss over 5 years	<2 mm over 5 years	≥2 mm over 5 years
	Indirect evidence of progression	% bone loss/age	<0.25	0.25 to 1.0	>1.0
		Case phenotype	Heavy biofilm deposits with low levels of destruction	Heavy biofilm deposits with low levels of destruction	Destruction exceeds expectation given biofilm deposits; specific clinical patterns suggestive of periods of rapid progression and/or early onset disease (e.g., molar/incisor pattern; lack of expected response to standard bacterial control therapies)
Grade modifiers	Risk Factor	Smoking	Non-smoker	Smoker <10 cigarettes per days	Smoker ≥cigarettes per day
		Diabetes	Normoglycemic/ no diagnosis of diabetes	HbA1c <7.0% in patients with diabetes	HbA1c ≥7.0% in patients with diabetes

## **CLASSIFICATION OF SYSTEMIC DISEASES AND CONDITIONS THAT AFFECT THE PERIODONTAL SUPPORTING TISSUES (ADAPTED FROM ALBANDAR ET AL.)**

1. Systemic disorders that have a major impact on the loss of periodontal tissues by influencing periodontal inflammation

1.1. Genetic disorders

1.1.1. Diseases associated with immunologic disorders

- Down syndrome
- Leukocyte adhesion deficiency syndromes
- Papillon-Lefèvre syndrome
- Haim-Munk syndrome
- Chediak-Higashi syndrome
- Severe neutropenia
  - Congenital neutropenia
  - (Kostmann syndrome)
  - Cyclic neutropenia
- Primary immunodeficiency diseases
  - Chronic granulomatous disease
  - Hyperimmunoglobulin E syndromes
- Cohen syndrome

1.1.2. Diseases affecting the oral mucosa and gingival tissue

- Epidermolysis bullosa
  - Dystrophic epidermolysis bullosa
  - Kindler syndrome
- Plasminogen deficiency

### 1.1.3. Diseases affecting the connective tissues

- Ehlers-Danlos syndromes (types IV, VIII)
- Angioedema (C1-inhibitor deficiency)
- Systemic lupus erythematosus

### 1.1.4. Metabolic and endocrine disorders

- Glycogen storage disease
- Gaucher disease
- Hypophosphatasia
- Hypophosphatemic rickets
- Hajdu-Cheney syndrome

### 1.2. Acquired immunodeficiency diseases

- Acquired neutropenia
- HIV infection

### 1.3. Inflammatory diseases

- Epidermolysis bullosa acquisita
- Inflammatory bowel disease

## 2. Other systemic disorders that influence the pathogenesis of periodontal diseases

- Diabetes mellitus (type 1), (type 2)
- Obesity
- Osteoporosis
- Arthritis (rheumatoid arthritis, osteoarthritis)

- Emotional stress and depression
- Smoking (nicotine dependence)
- Medications

3. Systemic disorders that can result in loss of periodontal tissues independent of periodontitis

### 3.1. Neoplasms

Primary neoplastic diseases of the periodontal tissues

- Oral squamous cell carcinoma
- Odontogenic tumors
- Other primary neoplasms of the periodontal tissues

Secondary metastatic neoplasms of the periodontal tissues

### 3.2. Other disorders that may affect the periodontal tissues

- Granulomatosis with polyangiitis
- Langerhans cell histiocytosis
- Giant cell granulomas
- Hyperparathyroidism
- Systemic sclerosis (scleroderma)
- Vanishing bone disease (Gorham-Stout syndrome)

## PERIODONTAL MANIFESTATIONS OF SYSTEMIC DISEASES AND DEVELOPMENTAL AND ACQUIRED CONDITIONS

### 1. Systemic diseases or conditions affecting the periodontal supporting tissues

Albandar et al. 2018 [link](#)

### 2. Other Periodontal Conditions

Papapanou, Sorel et al. 2018 [link](#)

Herrera et al. 2018 [link](#)

- a. Periodontal Abscesses
- b. Endodontic-Periodontal Lesions

### 3. Mucogingival deformities and conditions around teeth

Cortellini & Bissada 2018 [link](#)

- a. Gingival phenotype
- b. Gingival/soft tissue recession
- c. Lack of gingiva
- d. Decreased vestibular depth
- e. Aberrant frenum/muscle position
- f. Gingival excess
- g. Abnormal color
- h. Condition of the exposed root surface

### 4. Traumatic occlusal forces

Fan & Caton 2018 [link](#)

- a. Primary occlusal trauma
- b. Secondary occlusal trauma
- c. Orthodontic forces

### 5. Prostheses and tooth-related factors that modify or predispose to plaque induced gingival diseases/periodontitis

Erick & Caton 2018 [link](#)

- a. Localized tooth-related factors
- b. Localized dental prostheses-related factors

## Chapter 9:

### PROGNOSIS

Prognosis is the prediction of the probable cause, duration and outcome of a disease based on a general knowledge of the pathogenesis of the disease and the presence of risk factors for the disease.

Types of Prognosis :

Short term prognosis- where estimation is made for the next 3-5 years

Long term prognosis- where the teeth are expected to remain in health and function beyond 5 years

Therapeutic prognosis – deals with the response of tissues to treatment and successful arrest of disease process.

Prosthetic prognosis – indicate the ability of remaining teeth to support the prosthesis.

Prognostic factors are characteristics that predict the outcome of disease once the disease is present. In some cases risk factors are prognostic factors are the same . ex: diabetes and smoking.

Prognostic factors can be categorized into those that can be

- controlled by the patient
- those impacted by periodontal treatment
- those associated with systemic disease
- those are uncontrollable

Determination of prognosis:

- 1 excellent
2. good
3. fair
4. poor
5. questionable
6. hopeless

Excellent : no bone loss, excellent gingival condition, good patient co-operation, no systemic/environmental factors

Good: adequate remaining bone support, adequate possibilities to control etiologic factors and establish a maintainable dentition, adequate patient co operation, no systemic or environmental factors or if present well controlled.

Fair: less than adequate remaining bone support, some tooth mobility, grade I furcation involvement, adequate maintenance possible, acceptable patient co operation, limited systemic/environmental factors.

Poor: moderate to advanced bone loss, tooth mobility, grade I and II furcation involvement, difficult to maintain areas, doubtful patient cooperation, presence of systemic/environmental factors.

Questionable: advanced bone loss, grade II and III furcation involvement, tooth mobility, inaccessible areas, presence of systemic or environmental factors.

Hopeless: advanced bone loss, non maintainable areas, extractions indicated, uncontrolled systemic or environmental conditions.

Over all versus individual tooth prognosis

Overall prognosis	Individual tooth prognosis
Factors that may influence the overall prognosis include: <ul style="list-style-type: none"> <li>- Patient age</li> <li>- Current severity of disease</li> <li>- Systemic factors</li> <li>- Smoking</li> <li>- Presence of plaque &amp; calculus</li> <li>- Patient compliance</li> <li>- Genetic factors</li> </ul>	Determined after the overall prognosis and is affected by it.           Factors that may influence the overall prognosis include: <ul style="list-style-type: none"> <li>- pocket depth</li> <li>- attachment loss</li> <li>- bone remaining</li> <li>- mobility</li> <li>- furcation involvement</li> <li>- Gingival Recession</li> </ul>

Overall clinical factors:

1.Patient age: comparable CT attachment and alveolar bone – prognosis better for older

Younger patient – shorter time – more periodontal destruction.

2. Disease severity: determination of; -pocket depth, level of attachment, degree of bone loss, type of bone defect.

Prognosis for horizontal bone loss depends on the height of the existing bone.

Angular defects – if the contour of the existing bone and the number of osseous walls are favourable, there is an excellent chance that therapy could regenerate bone to approximately the level of the alveolar crest.

When greater bone loss has occurred on the surface of a tooth. The bone height on the less involved surfaces should be taken into consideration when determining the prognosis.

3. plaque control: bacterial plaque – primary etiologic factor associated with periodontal disease.

- effective removal of plaque on a daily basis by patient.

4. patient compliance and cooperation: refuse to accept the patient for treatment

- extract teeth with hopeless or poor prognosis and perform scaling and root planning on remaining teeth.

Systemic/ environmental factors:

1. Smoking : direct relationship: smoking and the prevalence and incidence of periodontitis

– affects severity

- Affects healing

- Slight to moderate periodontitis – fair to poor

- Severe periodontitis – poor to hopeless

2 . systemic disease/ condition: prevalence and severity of periodontitis significantly higher – type I and II diabetes.

- Prognosis dependent on patient compliance relative to both dental and medical status

- Well controlled patients – slight to moderate periodontitis – good prognosis

3. genetic factors: genetic polymorphism in IL -1 genes resulting in over production of IL – 1 $\beta$  – associated with significant increase in risk for severe, generalized chronic periodontitis.

-genetic factors also influence serum IgG2 antibody titres and the expression of Fc  $\gamma$ R II receptors on the neutrophil – significant in aggressive periodontitis.

- identification of genetic factors can lead to treatment alterations – adjunctive antibiotic therapy and frequent maintenance visits.

#### 4. Local factors:

- Plaque and calculus: - bacterial plaque and calculus – most important local factor in periodontal disease.
- Good prognosis – depends on ability of patient and clinician to remove etiologic factor.
- Subgingival restorations:
  - Contribute to – increased plaque accumulation, increased inflammation, increased bone loss
  - Subgingival margins: poor prognosis
- Anatomic factors: short tapered roots with large crowns, cervical enamel projections, enamel pearls, intermediate bi furcation ridges, root concavities and developmental grooves – predispose periodontium to disease.
- teeth with short, tapered roots and relatively large crown – poor prognosis

#### 5. Prosthetic /Restorative factors:

The over all prognosis requires a general consideration of bone levels and attachment levels to establish whether enough teeth can be saved either to provide a functional and aesthetic dentition or to serve as abutments for a useful prosthetic replacement of the missing teeth.

The overall prognosis and the prognosis for individual teeth overlap because the prognosis for key individual teeth may affect the overall prognosis for prosthetic rehabilitation.

When few teeth remain, the prosthodontic needs become more important and sometimes periodontally treatable teeth may have to be extracted if they are not compatible with the design of the prosthesis.

#### Prognosis of patients with periodontitis:

Chronic periodontitis: in cases where clinical attachment loss and bone loss are not very advanced (slight to moderate periodontitis) – prognosis- good.

The inflammation – controlled through good oral hygiene and the removal of local plaque retentive factors.

Aggressive Periodontitis: poor prognosis: Localized aggressive periodontitis: patient exhibits strong serum antibody response to the infecting agent contributing to localization of lesions.

Diagnosed early: can be treated conservatively with oral hygiene instruction and systemic antibiotic therapy. – excellent prognosis

Advanced diseases: prognosis can be good if the lesions are treated with debridement. Local and systemic antibiotics and regenerative therapy.

Generalized form: fair, poor or questionable prognosis due to generalized interproximal loss, poor antibody response and thus poor response to conventional periodontal therapy.

Periodontitis as a manifestation of systemic diseases:

It can be divided into 2 categories:

Periodontitis associated with hematologic disorders such as leukaemia and acquired neutropenia.

Periodontitis associated with genetic disorders such as familial and cyclic neutropenia down syndrome and hypophosphatais.

Primary etiologic factor: - bacterial plaque

Systemic diseases affect the progression of disease and thus prognosis.

Necrotizing periodontal diseases: (NUG, NUP)

In NUG: - primary predisposing factor- bacterial plaque

Disease – complicated by presence of secondary factors such as acute psychological stress, tobacco smoking, poor nutrition leading to immunosuppression.

With control of both bacterial plaque and secondary factors prognosis (NUG) – good although tissue destruction is not reversible.

NUP is similar to that of NUG, except the necrosis extends from the gingiva into the periodontal ligament and alveolar bone.

Many patients presenting with NUP are immunocompromised through systemic conditions such as HIV infection.

## Chapter 10.

### TREATMENT PLAN

Definition: it's the blue print for case management.

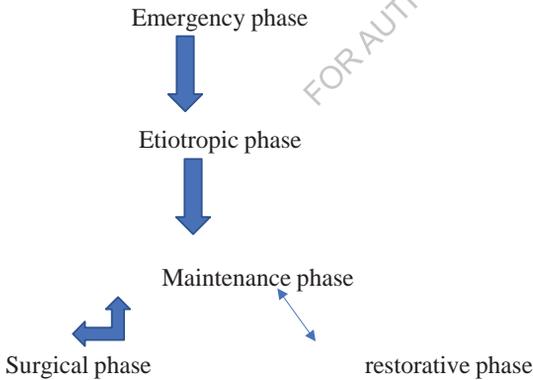
Treatment goals:

- reduction or resolution of gingivitis.
- Reduction in probing pocket depth.
- Elimination of open furcation in multirooted teeth.
- Individually satisfactory aesthetic and function.

Phases of Periodontal Therapy

- Emergency Phase
- Phase I – Etiotropic phase
- Phase II – surgical phase
- Phase III – restorative phase
- Phase IV – maintenance phase

Preferred sequence of Periodontal therapy



Emergency phase :

- Treatment of any type of pain
- Extraction of hopeless teeth.
- Draining of the abscess

### Phase I Etiotropic phase

- Cause related therapy
- Non-surgical periodontal therapy

Objective: elimination and prevention of reformation of bacterial deposition tooth and root surface.

This phase includes:

Diet counselling (specially in patients with rampant caries)

Removal of plaque retentive factors – it may be

1. Natural – crowding , developmental grooves, enamel pearls
2. Iatrogenic- poor margins or over contoured restorations

- Supra gingival scaling
- Subgingival scaling
- Root planning
- Occlusal therapy
- Antimicrobial therapy
- Correction of restorative and prosthesis
- Excavation of caries and restoration – temporary or final depending on whether the definite prognosis for the teeth has been arrived at the location of caries.
- Minor orthodontic movement
- Chemical plaque control (for acute conditions)

Evaluation of response to etiotropic phase (ideally after 4 to 6 weeks)

Rechecking for :

- Oral hygiene status
- Gingival inflammation and bleeding
- Probing depth
- Attachment level
- Calculus
- Caries

### Phase II- Surgical phase

1. Various periodontal surgical procedure.

Indication: where there is impaired access for scaling and root surface debridement like

- In deeper ( $\geq 5$ mm) periodontal pockets
- On wider tooth surfaces
- Presence of root fissures
- Presence of root concavities
- Furcation involvement
- Presence of faulty margins on subgingival restorations.

So it is used to – gain access for thorough scaling and root planning

- Establish a gingival morphology conducive to good plaque control.
- Reduce pocket depths
- Shift the gingival margin apically to plaque retaining restorations
- Crown lengthening

Contraindication:

- Patient who is uncooperative during cause related therapy should not proceed to surgery.
- Smoking – impair healing after surgery
- Absolute contraindication – medically compromised patients

Periodontal surgery may be classified as :

Access surgery- provide visual and technical access for thorough debridement

Resective surgery – removal of excess soft tissue in gingival overgrowth and apical relocation of gingival margin

- (a) Gingivectomy
- (b) Apical displaced flap surgery
- (c) Undisplaced flap with or without osseous resection

Regenerative surgery – to regenerate the periodontal attachment complex i.e. cementum, pdl and bone.

- (A) Flap surgery with flap graft
- (B) Flap surgery with osseous graft

Implant placement

Endodontic therapy

Re-evaluation of response to surgical therapy

-oral hygiene status

Gingival inflammation and bleeding

Probing depth

Attachment level

Phase III -Restorative phase

- Final restoration
- Fixed prosthesis
- Removable prosthesis

Evaluation of response to restorative therapy

- Oral hygiene status
- Gingival inflammation and bleeding
- Probing depth
- Attachment level
- Restoration status

Phase IV – Maintenance phase:

Periodic maintenance

For advanced periodontal disease – 3-4 times per year.

Otherwise in 6 months- checking for:

Plaque and gingival indices

Calculus

Attachment level

Pocket depth

Bleeding on probing

Recession

Maintenance recall procedures:

Part I – Examination

Oral hygiene status

Gingival changes

Pocket depth changes

Mobility changes

Occlusal changes

Dental caries

Restorative prosthetic status

Medical history changes

Oral pathologic examination

Radiographic examination

Part II- Treatment

Oral hygiene reinforcement

Scaling

Polishing

Chemical irrigation

Part III: Schedule next procedure

Schedule next recall visit

Schedule further periodontal treatment

Schedule or refer for restorative or prosthetic treatment

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### Classification for patient recall after 1 year

Classes given by Merin	Recall period	Oral hygiene	calculus	Occlusal problems	Complicated prosthesis	Pocket remaining	Teeth with $\geq 50\%$ bone loss	Presence of environmental, systemic or genetic predisposing factors
Class A	6 months to 1 year	Good	Minimal	absent	absent	absent	absent	absent
Class B	3 to 4 months	Poor	heavy	present	present	some	some	present
Class C	1 to 3 months	Poor	heavy	present	present	many	many	present

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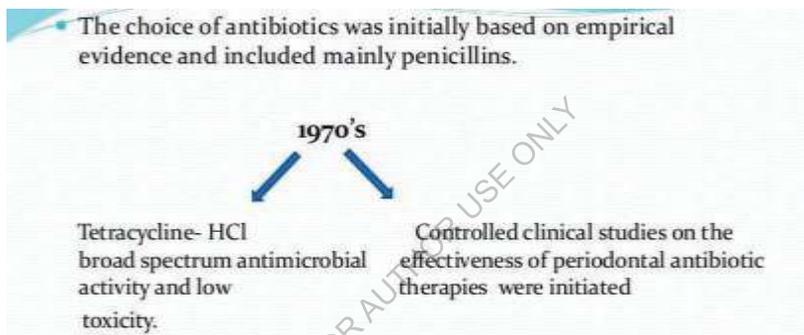
## Chapter 11.

### ANTIBIOTICS

The concept of antibiotic periodontal therapy centers upon the pathogenic microbiota, the patient, and the drug.

Antibiotics are a naturally occurring semisynthetic or synthetic type of antimicrobial agent that destroys or inhibits the growth of selective microorganisms generally at low concentrations.

Antibiotics do not remove calculus and bacterial residues and this is traditionally perceived to be an essential part of periodontal therapy.



#### Rationale of antibiotic Therapy

- Mechanical surgical treatment combined with proper oral hygiene measures can arrest or prevent further periodontal attachment loss in most individuals by reducing total supra-subgingival bacterial mass.
- Individuals continue to experience periodontal breakdown may be due to the ability of major periodontal pathogens like *P.gingivalis*, *A. a* comitans, *F nucleatum*, *T. denticola* bacteroids to invade periodontal tissues or to reside in furcations or other structures outside the reach of periodontal instruments or due to poor host defence mechanisms.
- Systemic periodontal antibiotic therapy aims to reinforce mechanical periodontal treatment and to support the host defence system in overcoming the infection by killing subgingival pathogens that remain after conventional mechanical periodontal therapy.
- The susceptibility of bacteria to antibiotics may be the key to the efficacy of systemic antibiotics in the treatment of periodontal diseases.

- Few chemotherapeutic agents can also reduce collagen and bone destruction through their ability to inhibit the enzyme collagenase.
- Patients with gingivitis or stable adult periodontitis usually respond well to mechanical periodontal therapy and derive little or no additional benefit from antibiotic therapy.

### **Guidelines for use of Antibiotics in Periodontal disease**

1. The clinical diagnosis and situation dictate the need for possible antibiotic therapy as an adjunct in controlling active periodontal disease as the patient's diagnosis can change overtime.
2. Continuing disease activity is an indicator for periodontal intervention and possible microbial analysis through plaque sampling.
3. When used to treat periodontal disease antibiotics are selected based on the patient's medical and dental status , current medications, and results of microbial analysis if performed.
4. Microbial samples may be obtained from individual pockets with recent disease activity or from pooled subgingival sample may provide a good representation of the range of periodontal pathogens to be targeted for antibiotic therapy.
5. Plaque sampling can be performed at the initial examination , root planning, re evaluation or supportive periodontal therapy appointment.
6. Antibiotics have also been shown to have value in reducing the need for periodontal surgery in patients with chronic periodontitis.
7. Systemic antibiotic therapy should be an adjunct to a comprehensive periodontal treatment plan.an antibiotic strength 500 times greater than the systemic therapeutic dose may be required to be effective against the bacteria arranged in the biofilms.
8. Slots et al described a series of steps using antibiotic agents for enhancing regenerative healing . they recommend starting antibiotics: 12 days before surgery and continuing for a total of atleast 8 days. However, the value of this regimen has not been well documented.
9. Haffaji et al concluded that data support similar effects for most antibiotics.

## **Classification of antibiotics:**

### I. based on chemical structure

Sulfonamides and related drugs: sulfa diazine and others, sulfones Dapsone (DDS), para amino salicylic acid (PAS).

Diaminopyrimidines.: Trimethoprim, pyrimethamine

Blactum antibiotics: penicillins, cephalosporins, monobactams, carbapenems.

Tetracyclines: oxytetracyclines, doxycycline etc

Nitro benzene derivatives: chloramphenicol

Aminoglycoside: streptomycin, gentamycin, neomycin

Macrolide antibiotics: erythromycin, oleandomycin, oxithromycin

Poly peptide antibiotics: polymyxin B, colistin, Bacitracin, tyrothricin.

Nitrofurantoin derivatives: Nitrofurantoin, furazolidone

Nitroimidazoles: metronidazole, tinidazole

Quinolones: Nalidixic acid, norfloxacin, ciprofloxacin

Nicotinic acid derivatives: isoniazid, pyrazinamide, ethionamide

Polyene antibiotics: Nystatin, Amphotericin B

Imidazole derivatives: Miconazole, ketoconazole, clotrimazole

Others: Rifamicin, clindamycin, spectinomycin, vancomycin, lincomycin, sodium fusidate, cycloserine, viomycin, ethambutol, thiacetazone, clofazimine, griseofulvin.

### II Based on mechanism of action

Inhibit cell wall synthesis: Penicillins, cephalosporin, cycloserine, vancomycin, bacitracin.

Causes leakage from cell membrane: polypeptides: polymyxins, colistin, citracin,

Polyenes: amphotericin B, Nystatin, Hamycin

Inhibit protein synthesis: tetracyclines, chloramphenicol, erythromycin, clindamycin

Cause misreading of m-RNA code (bind to 30 S ribosomes): aminoglycosides, streptomycin etc.

Interfere with DNA function: Rifampin, Norfloxacin, metronidazole

Interfere with intermediary metabolism : sulfonamides sulfones, Para amino salicylic acid, Trimethoprim, Pyrimethamine, ethambutol.

### **Periodontal diseases in which antibiotics can be used:**

Chronic Periodontitis: patients not responding to periodontal therapy (refractory periodontitis) and patients with recurrent disease.

Tetracycline, Doxycycline, metronidazole, clindamycin, Amoxicillin+clavulanic acid(Augmentin), Azithromycin, Metronidazole+Amoxicillin, Spiramycin

Aggressive Periodontitis: Localized aggressive periodontitis mostly involving aggregatibacteractinomycetemcomitans can be controlled or eradicated by systemic metronidazole-amoxicillin combination therapy, other antibiotics recommended for both localized and generalized aggressive periodontitis are: Tetracycline, Doxycycline, Minocycline, Metronidazole, Amoxicillin+clavulanic acid(Augmentin)

Table 1 frequently prescribed antibiotic therapies for the treatment of aggressive and refractory periodontitis:

Antibiotic	Dosage (Adult)
Metronidazole	500 mg t.i.d for 8 days
Doxycycline or minocycline	100-200 mg q.d for 21 days
clindamycin	300 mg t.i.d for 8 days
Ciprofloxacin	500 mg b.i.d for 8 days
Metronidazole+amoxicillin	250 mg t.i.d for 8 days (each)
Metronidazole + ciprofloxacin	500 mg b.i.d for 8 days (each)

Necrotizing periodontal diseases: Patients with moderate or severe NUG or necrotizing ulcerative periodontitis (NUP), local lymphadenopathy and systemic involvement need antibiotic therapy.

Antibiotics recommended are amoxicillin, metronidazole, combination of amoxicillin+metronidazole

Periodontal Abscess: antibiotic therapy is indicated for periodontal abscesses with systemic manifestations (fever, malaise, lymphadenopathy). antibiotics for the treatment of abscesses should be prescribed in conjunction with surgical incision and drainage.

Amoxicillin: loading dose of 1.0 g followed by a maintenance dose of 500mg /t. i. d for 3 days

- Followed by a patient evaluation to determine whether further antibiotic therapy or dosage adjustment is required.
- With allergy to  $\beta$ -lactam drugs: clindamycin: loading dose of 600 mg on day 1 followed by 300 mg/q.i.d for 3 days.

### **Combination and serial therapy:**

Since the subgingival microbiota in destructive periodontal disease consists of various putative pathogens that may differ in antimicrobial susceptibility, the use of a combination of two or more antibiotics may represent a valuable approach in periodontal chemotherapy.

Advantages:

- To broaden the antimicrobial range of the therapeutic regimen beyond that attained by any single antibiotic.
- To prevent or forestall the emergence of bacterial resistance by using agents with overlapping antimicrobial spectra, and
- To lower the dose of individual antibiotics by exploiting possible synergy between two drugs against targeted organisms.

Disadvantages:

Increased adverse reactions

Antagonistic drug interactions with improperly selected antibiotics. A bactericidal antibiotic ( $\beta$  lactam drugs or metronidazole) should not be used simultaneously with a bacteriostatic agent (tetracycline) because the bactericidal agent exerts activity during cell division that is impaired by the bacteriostatic drug.

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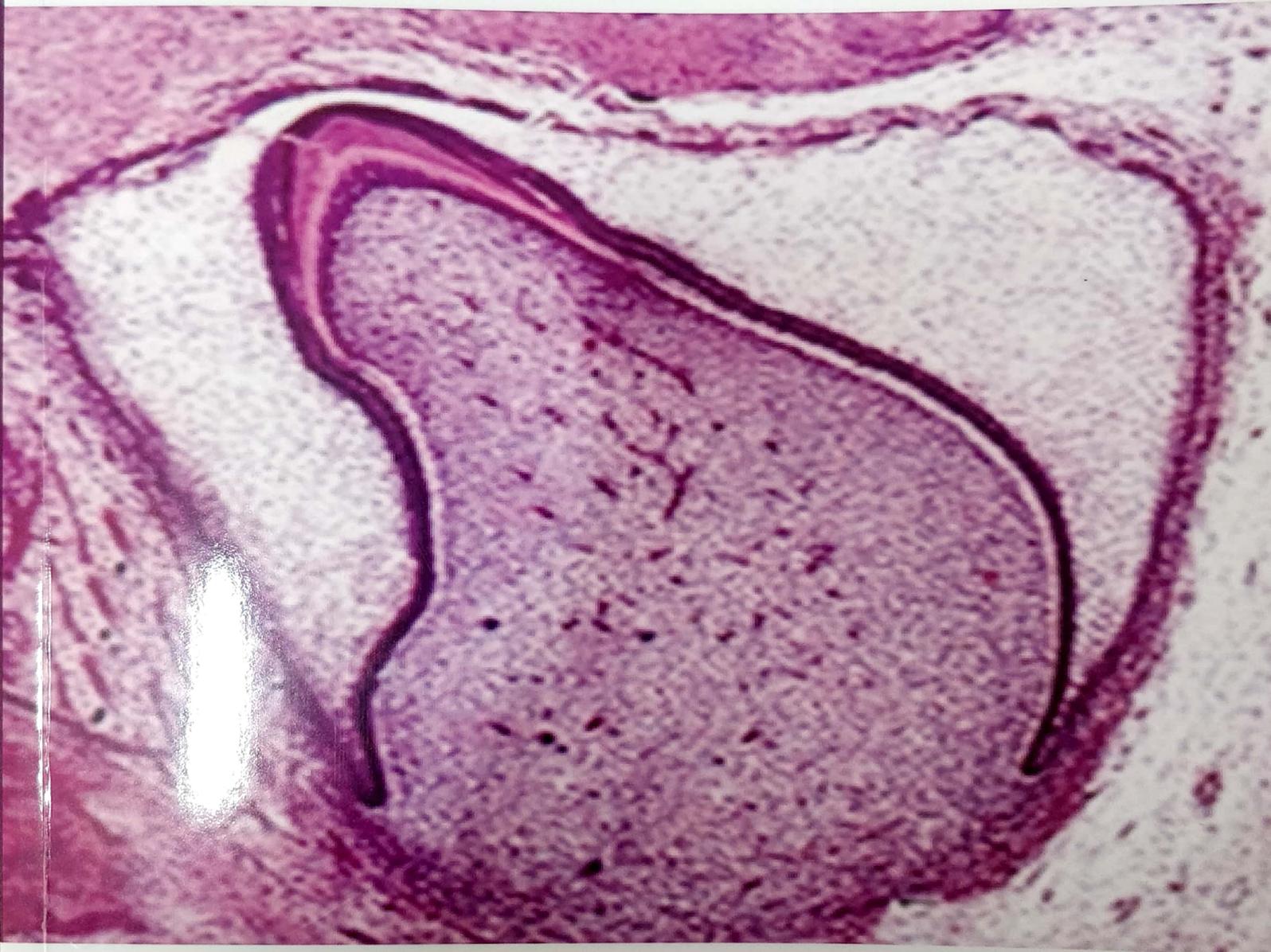


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# Textbook of Oral Embryology & Histology



**B Sivapathasundharam**

**2<sup>nd</sup>**  
Edition



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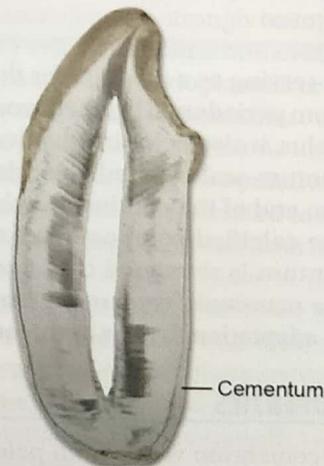
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## INTRODUCTION

Cementum is a hard, avascular connective tissue that covers the roots of the teeth. It was first demonstrated in 1835 by two pupils of the classical physiologist Jan Evangelista Purkinje. Cementum originates at the cervical portion of the tooth, where the enamel ends at knife edge. It continues till the apex of the root and surrounds the apical foramen (**Figure 8-1**). It may extend to line the dentinal wall in the apical portion of the root canal at times. Though cementum is considered to be a part of the tooth, it may also be considered as a component of the attachment apparatus, the periodontium, due to life-long incorporation of periodontal ligament fibers. It has resemblance in architecture to bone.

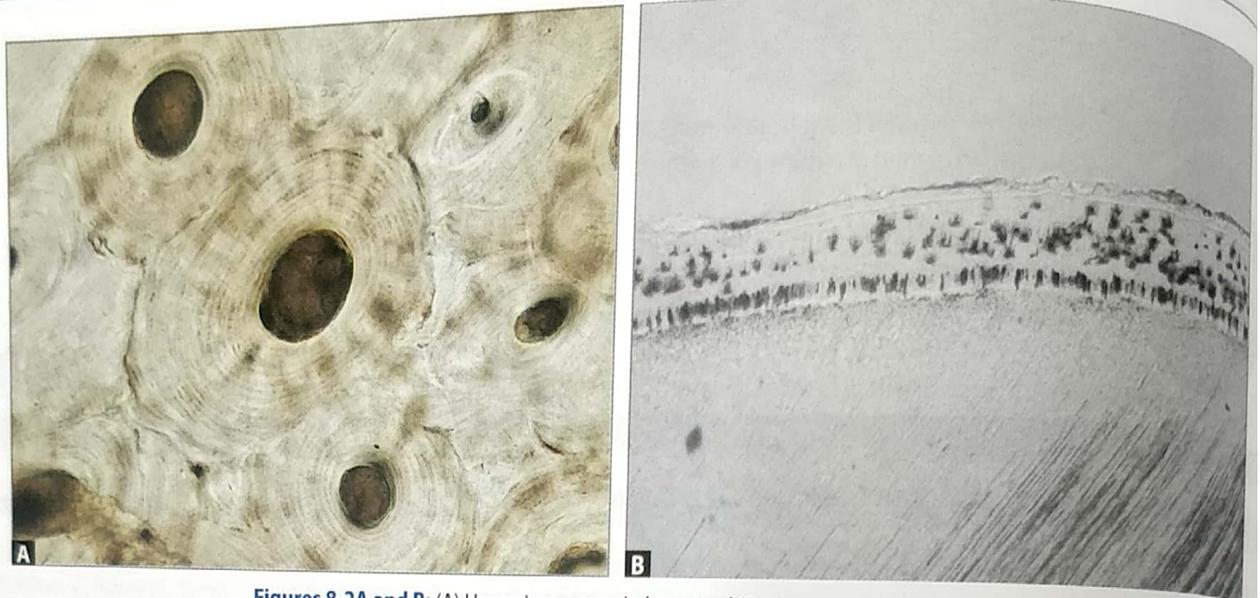
Cementum forms an integral part of the periodontium, which includes alveolar bone, periodontal ligament and gingiva. Cementoblasts are the cells responsible for cementum formation and are derived from dental sac or follicle.

Cementum gives attachment to the fibers of the periodontal ligament and firmly adheres to the dentin on its inner aspect. It is deposited throughout the life like dentin and there is always a thin layer of unmineralized cemental matrix on the surface. In healthy individuals, cementum is not visible clinically, since it usually covers the entire root which is embedded in the alveolar bone.



**Figure 8-1:** Ground section showing the cementum surrounding root dentin.

Cementum is an ectomesenchymal derivative and resembles bone in some physical, chemical, and structural characteristics. But bone is vascular while cementum is avascular and has no nerves in the matrix. Further, unlike bone, cementum lacks the Haversian system and has no



**Figures 8-2A and B:** (A) Haversian system in bone and (B) the avascular cementum.

marrow spaces (**Figures 8-2A and B**). Growth of cementum is by apposition similar to bone and involves remodeling, which is slower than bone. It can resist resorption better than bone, a feature that is important, and enables orthodontic tooth movement. The reasons attributed for this phenomenon include differences in the physicochemical or biological properties between bone and cementum, the properties of precementum, increased density of Sharpey's fibers in cementum, and the close proximity of the cell rests to the cementum layer.

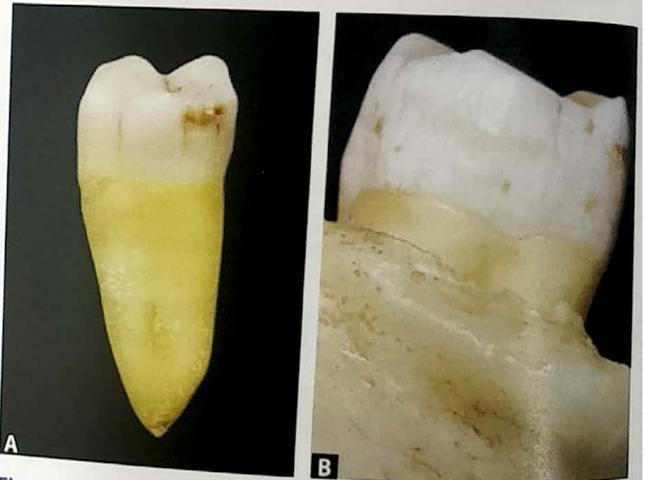
Osteoblasts have a role in the differentiation and stimulation of osteoclasts, which cause bone resorption. They respond to parathyroid stimulation in the resorption process. In contrast, cementoblasts do not respond to parathyroid hormone and other cytokines, which is suggested to be a reason for its resistance to resorption.

In addition to serving as a medium for the attachment of collagen fibers from periodontal ligament and in securing the tooth to the alveolus, it also helps in adaptive and reparative processes. Cementum seals the radicular dentin surface by covering the open end of the dentinal tubules. Some regard cementum as the calcified component of the periodontal ligament. Cementum is restricted to the root in humans, however, in some mammals, cementum may be present on the crowns as an adaptation to their herbivorous diet.

### PHYSICAL PROPERTIES

The color of the cementum varies from pale yellow to dark yellow. Unlike the shiny enamel surface, the cemental surface appears dull (**Figures 8-3A and B**). The color of the cementum is lighter than that of the dentin. On the radiograph, it appears less radiopaque than enamel or dentin. It appears less yellow and less translucent, when compared to bone, and it is difficult to differentiate cementum from bone based on the color alone.

Permeability of the cementum is more than the dentin but decreases with age. Permeability varies depending on the type of cementum.



**Figures 8-3A and B:** (A) Mandibular premolar showing the difference in the appearance of enamel and cementum; (B) Mandibular molar showing the similarity in color of the cementum and bone.

Hardness of the cementum is less than that of the dentin but similar to bone. The hardness of the dental hard tissues in descending order is enamel, dentin, and cementum.

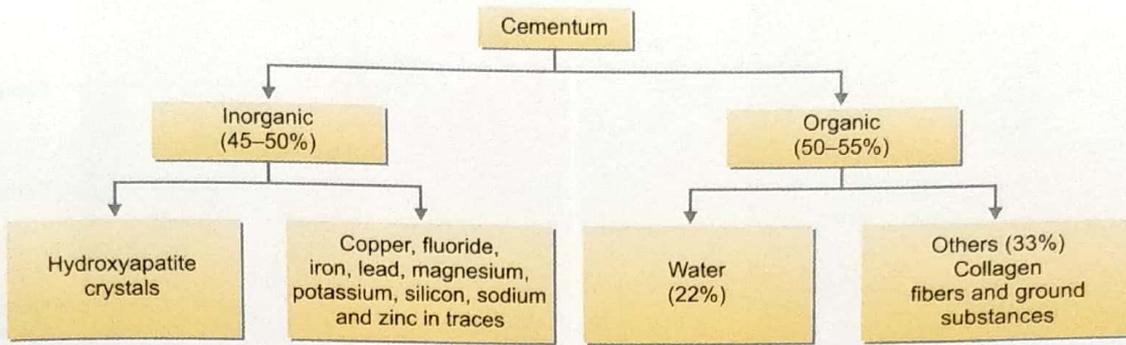
The thickness of the cementum varies between teeth and different regions of the same tooth. At the cemento-enamel junction (CEJ), it is thinnest (about 20–50  $\mu\text{m}$ ) and thickest at the apical region of all the teeth and the interradicular areas of the multirooted teeth (150–200  $\mu\text{m}$ ). The relative softness of cementum along with its thinness in the cervical area predisposes it to be removed easily by abrasion especially in the context of gingival recession.

### CHEMICAL COMPOSITION

#### Inorganic Content

Cementum is the relatively less mineralized tissue of the tooth. It has 45–50% of inorganic content and 50–55% of organic content, which includes 33% of organic and 22% of

Flowchart 8-1: Chemical composition of cementum.



water by volume (**Flowchart 8-1**). The inorganic content is composed predominantly of calcium and phosphate in the form of hydroxyapatite crystals, which are thin, plate-shaped, and similar to those of the bone (55 nm wide, 8 nm thick). Other forms of calcium are also present in cementum at higher levels than that of dentin and enamel. Trace elements such as copper, fluoride, iron, lead, magnesium, potassium, silicon, sodium, and zinc are also present in minute quantities. The trace element concentration is more on the external surface. Cementum has the highest fluoride content of all mineralized tissues, which attributes to its permeability. It is more in acellular cementum than cellular cementum.

### Organic Content

The principal organic component of cemental matrix is collagen. Type I collagen (comprises 90% of the organic content) is the predominant form of collagen present in the cementum. Other types of collagen associated with cementum include type III and XII. Type V, VI, and XIV have also been found in cementum in trace amounts. Additionally, it also has proteoglycans and glycoproteins.

The noncollagenous proteins of the cementum are similar to that of bone and they include bone sialoprotein, dentin matrix protein 1, dentin sialoprotein, fibronectin, osteocalcin, osteopontin, proteoglycans, proteolipids, tenascin, alkaline phosphatase, and many growth factors. Amino acid analysis of collagen shows that it is similar to that found in bone and dentin. Osteopontin is located in the incremental lines and sialoprotein in cemental matrix. Cementum-derived attachment protein (CAP) is located in the matrix of mature cementum and in cementoblasts. It is a 56 kDa or 65 kDa collagenous protein that promotes the attachment of the mesenchymal cells to the extracellular matrix (ECM). Bone sialoprotein and osteopontin plays an important role in mineralization process by binding collagen fibrils and hydroxyapatite. After mineralization, they serve to maintain the structural integrity of cementum. Cementum is rich in glycosaminoglycans, particularly chondroitin sulfate.

Cementum-derived attachment protein is seen only in cementum and not in bone. So this may be used as a marker to differentiate cementum and bone.

Similar to bone, cementum also contains transforming growth factor beta (TGF $\beta$ ), platelet-derived growth factor, fibroblast growth factor, insulin-like growth factor, epidermal growth factor, and various bone morphogenetic proteins (BMPs).

## CELLS OF CEMENTUM

### Cementoblasts

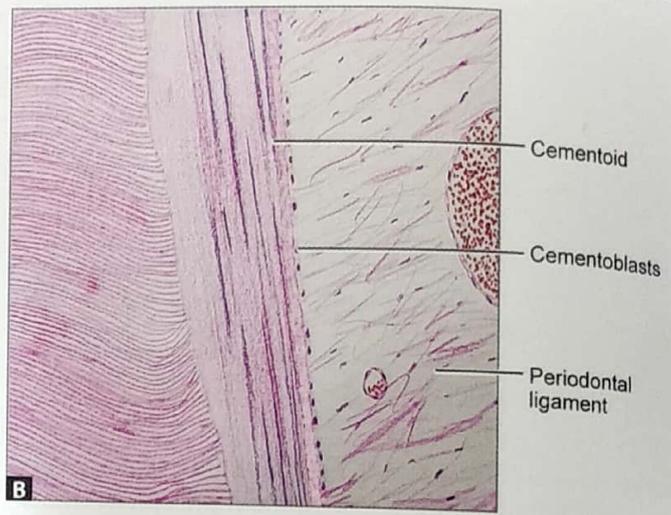
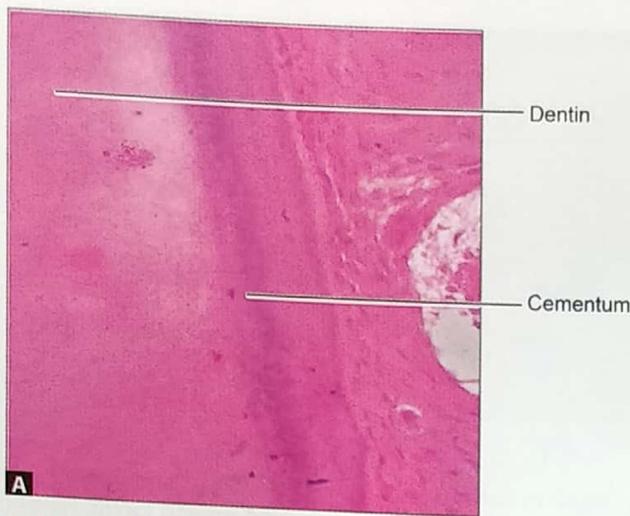
Cementoblasts are the cells responsible for the formation of cementum. During root formation, Hertwig's epithelial root sheath breaks up and the dental sac cells come in contact with the root dentin to differentiate into cementoblasts. They secrete the organic matrix consisting of collagen and protein polysaccharides. Later, they also take part in mineralization.

Cementoblasts usually line the cementoid (cemental matrix) between the attached portion of the periodontal ligament fibers (**Figures 8-4A and B**). They resemble osteoblasts and the size ranges between 8  $\mu\text{m}$  and 12  $\mu\text{m}$ . They are usually cuboidal to squamous in shape with a centrally placed large vesicular nucleus and prominent nucleoli. The cytoplasm of cementoblasts is strongly basophilic and similar to other secretory cells, it contains numerous mitochondria, Golgi apparatus, and rough endoplasmic reticulum.

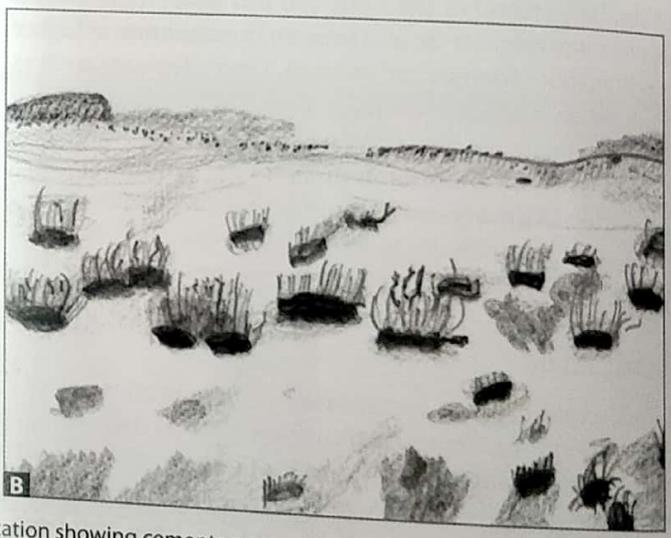
The secretory end of the cementoblast exhibits irregular borders. Many cytoplasmic extensions arise from the cell body of the cementoblast, which are called as cementoblastic processes. These processes are directed toward periodontal ligament as they derive their nutrition from it. Cementoblastic processes interdigitate with those of the neighboring cementoblasts. Cytoplasmic processes are short for the cementoblasts residing at the cervical third than those on the apical third. The active cementoblasts are round, plump cells with large number of organelles, and during the resting period they become flattened with less organelles and referred to as resting cementoblasts.

### Cementocytes

During the formation of cellular cementum, some cementoblasts become embedded in the unmineralized cemental matrix to become cementocytes. They are structurally and functionally similar to the osteocytes of the bone. They are present between layers of cementum and lie in spaces called lacunae. Cementocytes are cuboidal in shape



Figures 8-4A and B: (A) Hematoxylin and eosin stained section of cementum; (B) Schematic representation showing cementoid and cementoblasts.



Figures 8-5A and B: (A) Ground section; and (B) Schematic representation showing cementocytes with their processes facing toward the periodontal ligament.

with long cytoplasmic processes about 10-30 in number and residing in a tubular space known as canaliculi. The cell process may have contact with those of the neighboring cells and exhibit gap junctions. Most of them are directed toward the periodontal ligament as they derive their nutrition from blood vessels in periodontal ligament (Figures 8-5A and B). It has sparse organelles compared to cementoblast and are therefore considered to be resting or inactive cementoblasts. In contrast to the osteocytes of the bone, cementocytes are more widely dispersed and more randomly arranged. The diameter of the cell is around 8-12  $\mu\text{m}$ , while the length of cytoplasmic processes is many times longer than that of the diameter of the cell body.

Many of the lacunae do not contain vital cementocytes. With aging, the thickness of the cementum increases, so the cells which are in deeper portions get deprived of nutrition. In such lacunae, the cells undergo degeneration and the lacunae become empty. In ground sections, the cells are lost and replaced by air and debris in those voids, which give a dark appearance. In decalcified sections, the cementocytes in the lacunae are retained but appear shrunken.

The cementocytes in the deeper layer have fewer cytoplasmic organelles, dilated endoplasmic reticulum,

and sparse mitochondria indicating that these cells are degenerating or marginally active. Still deeper, there are definite signs of degeneration, characterized by cytoplasmic clumping and vesiculation.

Cementocytes are relatively inactive cells. They lay down some amount of matrix, which is present in perilacunar space or around the lacunae. They do not have any role to play in tissue homeostasis.

### Differences between Cementocytes and Osteocytes (Figures 8-6A and B)

Table 8-1 describes the differences between cementocytes and osteocytes.

### Cementoclasts

Cells responsible for the resorption of cementum are known as cementoclasts. They are also termed as odontoclasts and resemble osteoclasts of the bone. Cementoclasts are not seen normally, since cementum is less susceptible to resorption. However, cemental resorption is evident during shedding of deciduous teeth and in case of excessive orthodontic pressure.



Figures 8-6A and B: Ground sections showing: (A) Cementocytes in cementum; (B) Osteocytes in Haversian system.

TABLE 8-1: Differences between cementocytes and osteocytes.

Cementocyte	Osteocyte
Entrapped cells of cementum	Entrapped cells of bone
Present in apical one-third and intraradicular areas (cellular cementum)	Present throughout bone
Widely and randomly distributed. They are not found around the blood vessels to form osteon, since cementum is avascular	Regularly distributed, usually found around the blood vessels to form osteon and are relatively close to each other
Cell processes are directed toward periodontal ligament	Run in all directions
Less in number per unit area	More in number

Cementoclasts appear as vacuolated and multinuclear or mononuclear cells with large amount of ribosomes and mitochondria. Cytoplasm exhibits projections toward the resorbing cemental surface called as brush border or ruffled border (similar to osteoclasts). They are observed in the resorbing cemental surface in Howship's lacunae, similar to bone.

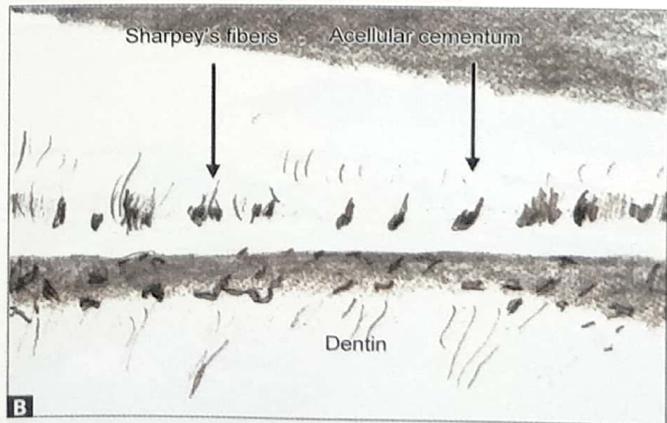
### FIBERS OF THE CEMENTUM

There are two types of fibers present in the cementum namely—intrinsic and extrinsic fibers.

*Intrinsic fibers* are collagen fibers laid down by cementoblasts. They are thin and short fibers with a diameter of about 1–2 μm and fully mineralized but cannot be identified distinctly in histological sections. They are present parallel to root surface and perpendicular to the extrinsic fibers.

*Extrinsic fibers* are collagen fibers of the inserted portion of the periodontal ligament secreted by fibroblasts of the periodontal ligament. They are directed either oblique or perpendicular to the root surface. The inserted portion of the extrinsic fibers is called Sharpey's fibers (Figures 8-7A and B). These fibers are thick, coarse, and present in bundles with a diameter of around 5–7 μm. The extrinsic fibers are more in acellular cementum. They are thick and fully mineralized. In cellular cementum, the outer portion of the extrinsic fibers is mineralized and the innermost cores are not mineralized.

Intrinsic fibers are usually not seen in ground sections. The extrinsic fibers are not seen in cellular cementum.



Figures 8-7A and B: (A) Ground section; and (B) Schematic representation of Sharpey's fibers in acellular cementum arranged in bundles perpendicular to cementum.

In contrast, they are seen as black spaces or thin black lines in ground sections, referred to as Sharpey's fiber spaces in cellular cementum. This is due to the air entrapment into the unmineralized cores, where the organic content is lost during the preparation of ground sections.

## STRUCTURE

Cementum can be viewed as a unit containing cementoblasts, cementoid, and fully mineralized tissue. Cementum is basically categorized into two types namely—cellular and acellular based on the presence or absence of cementocytes. However, in humans it is further categorized into the following types, based on the presence or absence of fibers and their types; (1) acellular, afibrillar cementum; (2) acellular extrinsic fiber cementum; (3) cellular intrinsic fiber cementum; (4) cellular mixed fiber cementum; and (5) mixed stratified cementum.

*Acellular afibrillar cementum* does not contain cementocytes and detectable collagen fibers. This cementum is sparsely distributed and is composed of mineralized matrix. It is usually seen in the cervical enamel or in between fibrillar cementum and dentin. It is formed after the pre-eruptive enamel maturation and shortly before or during tooth eruption. It is also formed after eruption. This is also called coronal cementum, since it is normally seen over enamel and dentin adjacent to the CEJ. It is formed due to the premature loss of reduced enamel epithelium, which leads to the differentiation of cementoblasts from the dental sac cells. These cementoblasts form fibril-free matrix comprised of afibrillar collagen onto the enamel surface, which subsequently mineralize. It may be deposited in the form of cemental spurs or cemental islands.

Cementum islands occur when a portion of reduced enamel epithelium is lost. The dental sac cells come in contact with the mature enamel to deposit cementum that does not contain fibers in its collagen matrix. It usually occurs coronal to the CEJ and is rarely seen in occlusal surface of posterior teeth.

*Acellular extrinsic fiber cementum* consists of inserted portion of periodontal ligament fibers (Sharpey's fibers) and

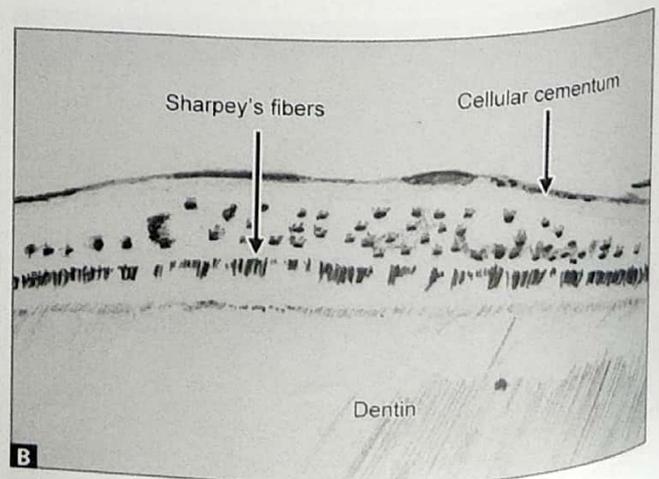
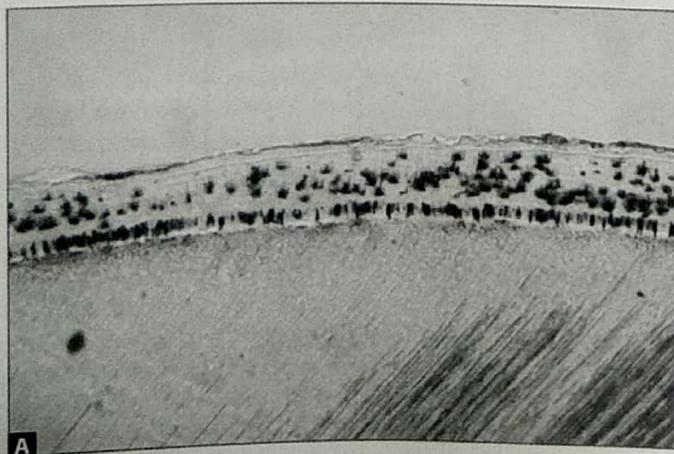
cementum devoid of cementocytes (**Figures 8-8A and B**). It is seen in single rooted teeth, where it extends from the cervical margin to the apical third. The extrinsic fibers are attached perpendicular to the surface of the cementum. The inserted fiber bundle is mineralized except for the inner core. The Sharpey's fibers run through the entire thickness of the cementum if it is thin. Upon further deposition of cementum, more amounts of fibers are incorporated into it. But the attachment of tooth to alveolar bone *per se* is limited to the most superficial portion of the cementum. Incremental lines are seen in a regular fashion and are closer together, since it forms at a slower rate. It is considered to be formed by the cells of the periodontal ligament fibroblasts. The ground substance is elaborated by cementoblasts.

*Cellular intrinsic fiber cementum* is comprised of cementoblasts and the collagen fibers secreted by them. It is more rapidly formed and less mineralized. This type of cementum is not formed during normal root formation; instead it is formed as a part of reparative process or on the unerupted or impacted teeth. In this type of cementum, collagen fibers intermingle with that of dentin. As cementum formation progresses, some of the cementoblasts get entrapped in the cemental matrix and become cementocytes. Collagen fibrils are haphazardly placed in the initial rapid phase, but subsequently they get oriented parallel to the surface.

*Cellular mixed fiber cementum*: As the name indicates, it contains cells (cementocytes), intrinsic fibers, (collagen fibers secreted by the cementoblasts), and extrinsic fibers, the inserted portion of the periodontal ligament fibers (secreted by the fibroblasts of the periodontal ligament).

It is predominantly a product of cementoblasts and formed at a faster rate and is relatively less mineralized. The intrinsic fibers secreted by the cementoblasts and the extrinsic fibers formed by the periodontal ligament intermingle with each other in a complex manner.

*Mixed stratified cementum* contains a mix of cellular intrinsic fiber cementum with acellular extrinsic fiber cementum in the apical third of the root and in furcation areas. This cementum is typed as mixed stratified cementum, the thickness of which ranges from 100 to 1000  $\mu\text{m}$ .



**Figures 8-8A and B:** (A) Ground section; and (B) Schematic representation of Sharpey's fibers in cellular cementum.

## CLASSIFICATION OF CEMENTUM

The classification of cementum according to three factors has been discussed in **Box 8-1**.

The location of cellular and acellular cementum is not definite. The acellular cementum usually extends from the CEJ till the apex and is present more in coronal half of the root, while the cellular cementum is located in the apical third. Occasionally, layers of cellular and acellular cementum may alternate in any pattern. Rarely, acellular cementum

### BOX 8-1: Classification of cementum according to three factors.

- Time of formation:
  - Primary
  - Secondary
- Presence or absence of cells within its matrix:
  - Cellular
  - Acellular
- Origin of collagenous fibers of the matrix:
  - Intrinsic fibers by cementoblast activity
  - Extrinsic fibers by incorporation of periodontal ligament fibers

Accordingly the cementum is categorized into the following types:

- Acellular afibrillar cementum
- Acellular extrinsic fiber cementum
- Cellular intrinsic fiber cementum
- Cellular mixed fiber cementum
- Mixed stratified cementum

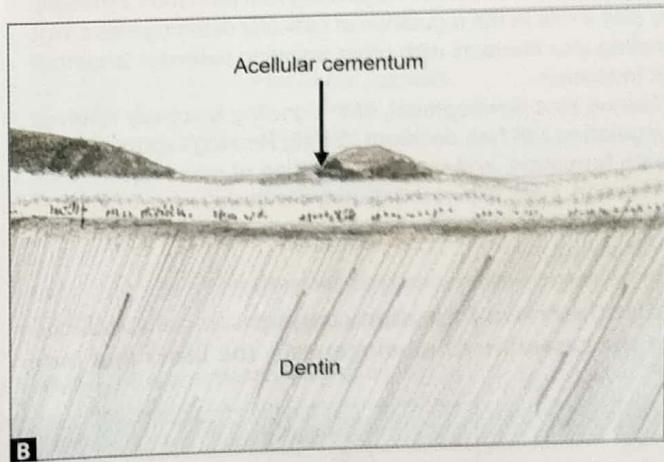
can be found on cellular cementum and cellular cementum is frequently found on acellular cementum (**Figures 8-9A and B**).

Cellular cementum comprises the entire thickness of apical cementum, being thickest at the apex, and contributes to the length of the root by its growth. The growth is in an appositional manner (**Figures 8-10A and B**).

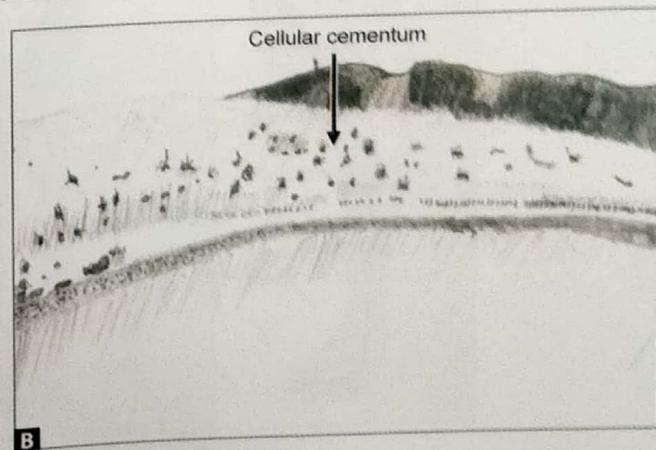
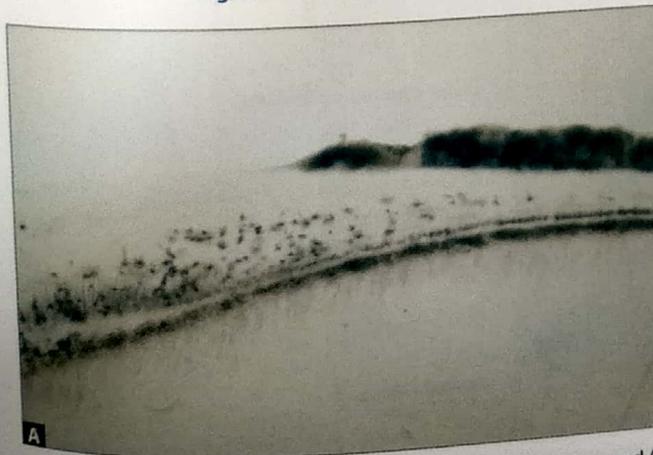
The collagen fibers of cellular and acellular cementum are arranged in a very complex manner with barely discernible pattern. The acellular cementum has mainly extrinsic fibers that are perpendicular to the root surface while the cellular cementum has both extrinsic and intrinsic fibers. The differing orientation gives different colors under polarized light (**Table 8-2**).

## CEMENTOGENESIS

Formation of cementum is known as cementogenesis. It starts pre-eruptively during the development of the root and it continues after root development and eruption. As long as the functioning periodontal ligament is present, cemental deposition continues throughout the life. Primary cementum thus appears to be the main tissue that attaches the periodontal ligament to the tooth, while the secondary cementum probably forms in response to the functional demands of the attachment apparatus.



**Figures 8-9A and B:** (A) Ground section; and (B) Schematic representation of acellular cementum.



**Figures 8-10A and B:** (A) Ground section and (B) Schematic representation of cellular cementum.

**TABLE 8-2:** Differences between acellular cementum and cellular cementum.

Acellular cementum	Cellular cementum
Cementocytes are absent	Cementocytes are present
First laid down	Laid down later
Also known as primary cementum	Secondary cementum
Seen in coronal half	Apical one-third and interradicular areas
Laid down slowly	Laid down rapidly
Incremental lines are thin and close	Incremental lines are thick and wide apart
Width 50 $\mu\text{m}$	Width 200–300 $\mu\text{m}$
Less permeable	More permeable
More mineral content	Less mineral content
Less intrinsic fibers	More intrinsic fibers
Cementoid layer is thin	Cementoid layer is thicker
Border between acellular cementum and dentin less distinct	Border between cellular cementum and dentin more distinct
Provides attachment for the tooth	Has an adaptive role in response to tooth wear and movement. Associated with repair of the periodontal tissues

*Wnt signaling* is important in regulating root formation, especially may play a role in the regulation of radicular dentinogenesis. *Wnt* signaling also interacts with other signaling pathways to control root formation.

During root development, BMP signaling is actively involved in regulating cell fate decisions, during Hertwig's epithelial root sheath formation, and the differentiation of odontoblasts. BMP 2, 3, 4, and 7 are expressed during the initiation of tooth root development. BMP signaling also controls the patterning of root development.

After the crown formation completes, more specifically after the cessation of amelogenesis, the inner and outer

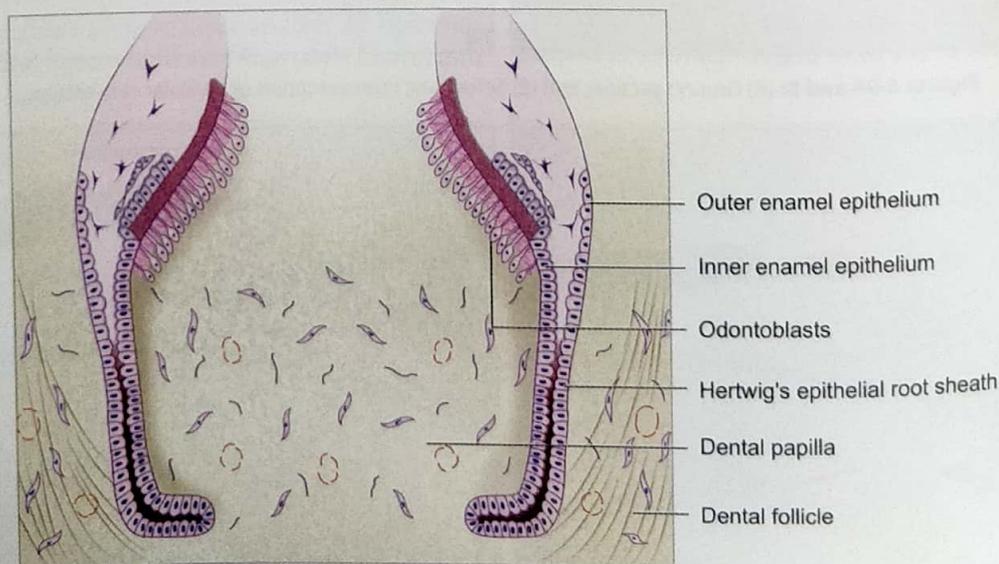
enamel epithelium of the dental organ proliferates toward the future root, as a two-layered sheet of somewhat flattened epithelial cells. This is called Hertwig's epithelial root sheath. This is devoid of stellate reticulum and stratum intermedium (Figure 8-11). Hertwig's epithelial root sheath is separated from the dental papilla and dental sac by basal lamina.

Root formation, which consists of the formation of radicular dentin and cementum, also involves epithelial-mesenchymal interactions, similar to crown formation. The cells of the root sheath induce the peripheral dental papilla cells to differentiate into odontoblasts. These odontoblasts secrete the organic matrix of the first formed predentin, which comprises of some collagen fibrils and ground substance. As the odontoblasts secrete the dentin matrix, they retreat toward the pulp. But at the initial few microns, they do not leave behind the typical odontoblastic process. This portion contains predominantly obliquely arranged collagen fibers and some perpendicularly oriented fibers with no clearly discerned dentinal tubules. This structureless layer of about 10  $\mu\text{m}$  thickness is known as hyaline layer. This layer is in contact with the root sheath for a while.

The epithelial root sheath cells are functionally active and secrete bioactive molecules, which play a major role in root formation. This is accomplished by the epithelial-mesenchymal interactions concerned with the induction of odontoblasts and cementoblasts and/or the mineralization process. These bioactive molecules of the root sheath cells consist of enamel-related proteins, which together with the hyaline layer form cementum-dentin boundary. Thus, this layer is contributed by both the epithelial root sheath cells and the odontoblasts.

Collagen I, bone sialoprotein, and alkaline phosphatase are cementoblast markers expressed by Hertwig's epithelial root sheath, which suggests that the Hertwig's epithelial root sheath directly contributes to the cementoblasts pool of the periodontal ligament through epithelial-mesenchymal transition (EMT).

Soon the Hertwig's epithelial root sheath is broken down or becomes perforated (probably by the programmed cell death), which results in contact between the newly formed radicular



**Figure 8-11:** Formation of Hertwig's epithelial root sheath.

dentin with the cells of the dental sac. This interaction enables the dental sac cells to differentiate into cementoblasts. These cementoblasts lay down a layer of cemental matrix (cementoid), which consists of collagen fibrils and ground substances (Figure 8-12). It is to be noted here that the fibrous component of the initial cemental matrix is not only derived from the cementoblasts but also from the cells of the dental sac. These initially formed fibrils intermingle with the fibrils of the hyaline layer. The subsequent mineralization produces a firm bond between the dentin and the cementum.

in the apical half or third of the root the specific areas of the matrix mature and mineralize without following a sequential pattern. Cementum formation continues in this fashion throughout the life.

Cementoblasts apart from secreting collagen fibers, also secrete other noncollagenous proteins, which include osteopontin, bone sialoprotein, cementum attachment protein, and growth hormones. These are implicated in cell differentiation, cell growth, cell migration, cell attachment, and mineralization.

Hertwig's epithelial root sheath does not completely degenerate during or after root formation but become the epithelial cell rests of Malassez and reside in the periodontal ligament (Figure 8-13). This may contribute to cementum regeneration and repair.

After the formation of hyaline layer, the odontoblasts migrate toward the inner portion of the pulp leaving behind the cytoplasmic process called odontoblastic process. The mineralization of the hyaline layer starts in the mid portion and proceeds both outward and inward. So the mineralization of the outermost portion (on the cemental side) is slightly delayed and progresses to cementum. Mineralization always lags several microns behind matrix formation. The mineralization of cementum is an ordered event and this

In the cervical third to one half of the root, the cementoblasts border the formed cementum as a cementogenic layer, since cementogenesis occurs in a sequential layered pattern. Beyond that, the cementoblasts get entrapped in the matrix they formed and become cellular cementum. This is because

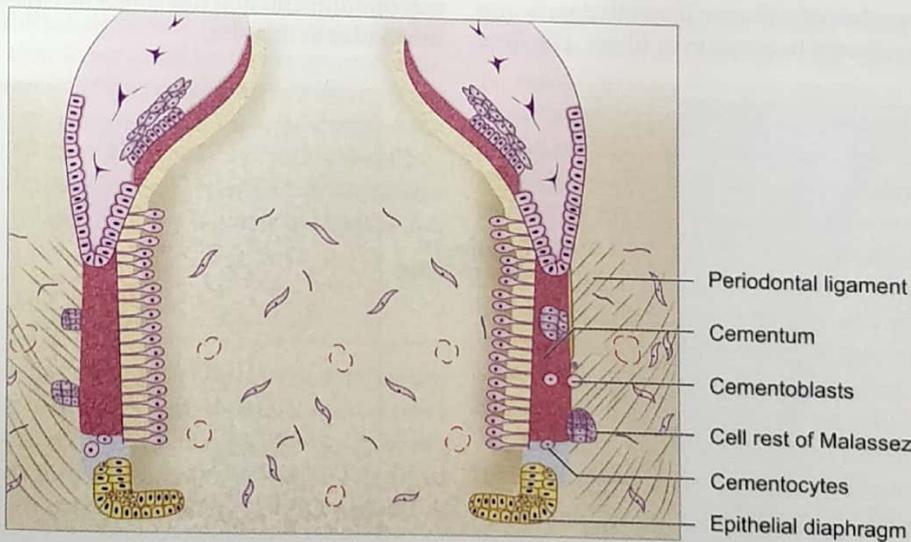


Figure 8-12: Hertwig's epithelial root sheath break down and cementum formation.

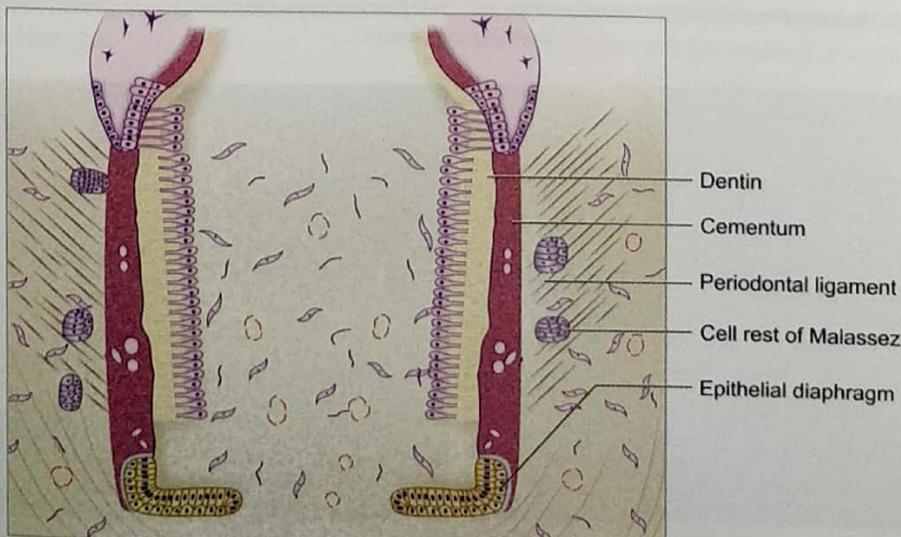


Figure 8-13: Cell rests of Malassez in the periodontal ligament.

involves deposition of mineral apatites on, in, and between the collagen fibers. These apatite crystals are needle and plate-shaped and morphologically similar to those of dentin and bone.

### CEMENTOID

The unmineralized cemental matrix known as cementoid, also called as precementum, covers the cemental surface. This cementoid tissue is lined by cementoblasts. The thickness of cementoid varies from 3 to 5  $\mu\text{m}$  and contains collagen fibers, ground substance, etc., and appears eosinophilic and amorphous under light microscope. During active cemental deposition, the thickness of cementoid increases.

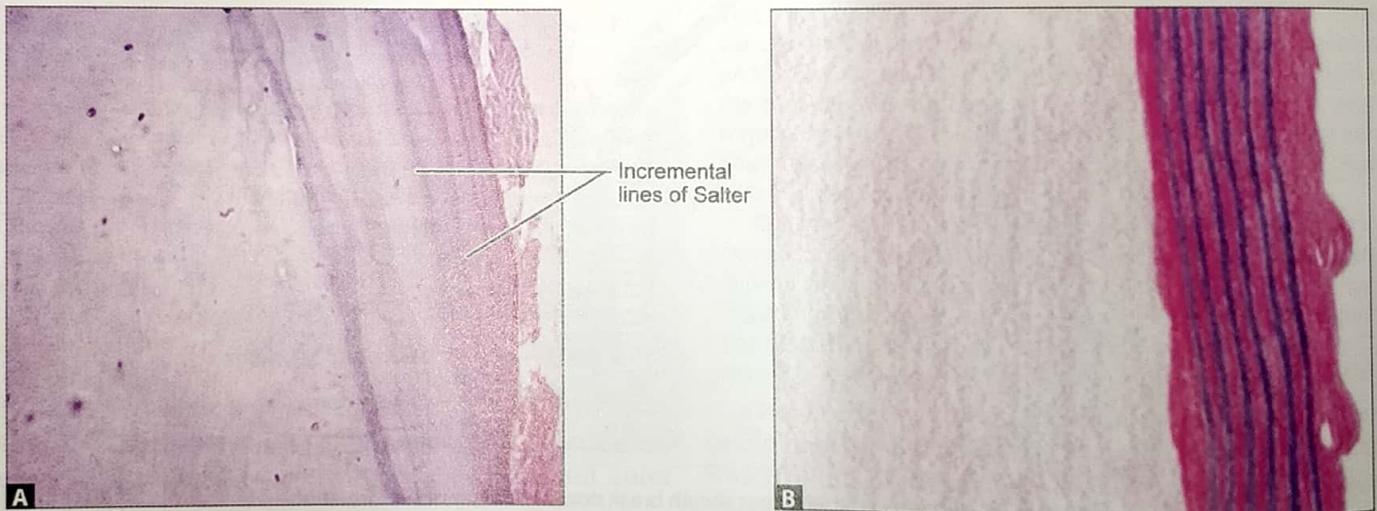
Growth of cementum is a rhythmic process and comprises of matrix (cementoid) formation and mineralization. As new layer of cementoid is formed, the old one mineralizes. Collagen fibers from the periodontal ligament pass between the cementoblasts and enter precementum to get embedded. These embedded fibers known as Sharpey's fibers in cementum serve to attach the tooth to alveolar bone. Each Sharpey's fiber has a number of collagen fibers that pass into the cementum and are referred to as extrinsic fibers. The fiber

insertion sites appear as 3–6  $\mu\text{m}$  hemispherical domes on the cemental surface.

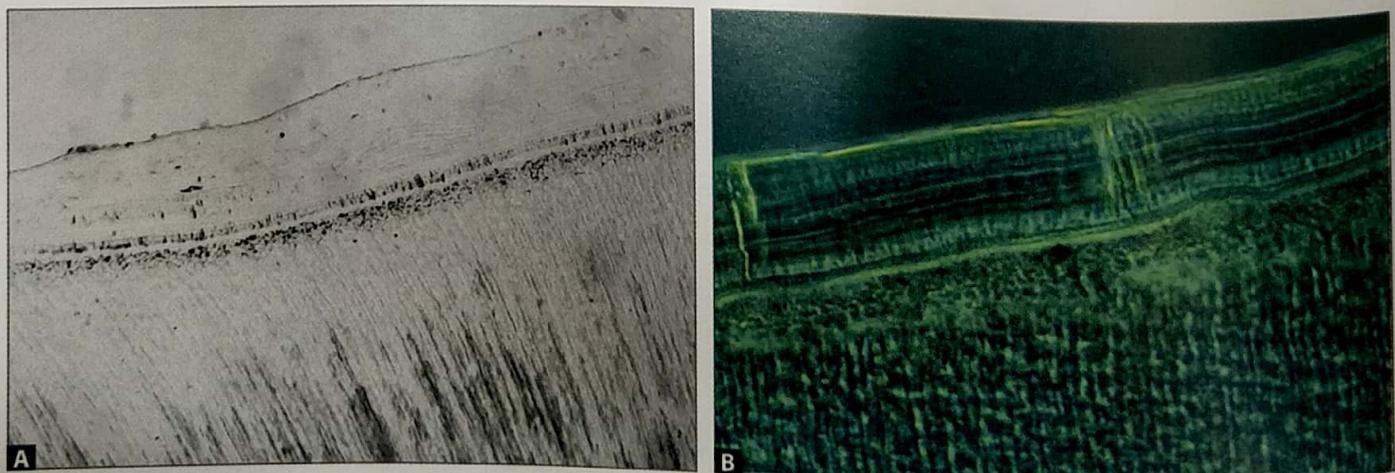
### INCREMENTAL LINES OF CEMENTUM

The rhythmic deposition of cementum (phases of activity and rest) is reflected by incremental lines. This rhythmicity is not regular as in enamel or dentin. Thus the incremental lines are unevenly separated and the precise periodicity between them is not known. These incremental lines are called as *lines of Salter* (Figures 8-14 and 8-15).

The incremental lines in acellular cementum are thin and close because it is laid down slowly, while the incremental lines in cellular cementum are thick and far apart as it is laid down rapidly. These incremental lines are formed due to disturbance in both matrix formation and mineralization. Histochemical studies have shown that the incremental lines in cementum are highly mineralized areas with less collagen and more ground substance than other portions of cementum. They are best visualized in decalcified sections. Recent evidences suggest that the incremental lines are rich in osteopontin and that this might aid the cohesion of the matrix molecules at this site.



**Figures 8-14A and B:** (A) Hematoxylin and eosin-stained section; and (B) Schematic representation showing the incremental lines of Salter in acellular cementum.



**Figures 8-15A and B:** (A) Incremental lines of cementum in ground section; and (B) under phase contrast microscopy.  
Source: (B) Dr Bala Subramanya Goutham and Dr Sujatha Ramachandra, KIIT University, Bhubaneswar, Odisha, India.

### ■ HYALINE LAYER OF HOPEWELL-SMITH

At the cementodentinal junction (CDJ) or in between the CDJ, a narrow band of clear hyaline layer is present. This is known as hyaline layer of Hopewell-Smith and is implicated in the attachment of dentin to the cementum.

This layer contains enamel matrix like protein and dentin proteins. After the break down of Hertwig's epithelial root sheath, the inner enamel epithelial cells form the hyaline layer. This occurs subsequent to the formation of radicular dentin. Periodontal ligament fibers are attached initially into this layer.

It is not known whether it has to be included in periodontium, since it appears to have a role in attaching cementum to dentin. The initial collagenous fibers of primary cementum are embedded within it and therefore could be considered in functional terms as a tissue of tooth support. It differs, however, for the fact that it has different developmental origin, which does not involve the dental follicle.

### ■ Attachment of Periodontal Ligament Fibers to Cementum

The fibers of periodontal ligament run into the organic matrix of cementoid that is secreted by the cementoblasts. Subsequent mineralization of the cementoid will incorporate the extrinsic fibers as Sharpey's fibers into the cementum. It has been estimated that for acellular extrinsic fiber cementum, there are approximately 30,000 principal fibers of periodontal ligament attached to the cemental tissue per square millimeter.

### ■ CEMENTODENTINAL JUNCTION

The interface between the cementum and dentin is of special importance, since it is formed by two different mineralized tissues. The CDJ junction is regular and smooth in permanent teeth, while some amount of scalloping may be seen in deciduous teeth. The attachment of cementum to dentin in either case is quite firm although the nature of the attachment is not fully understood. It is seen in decalcified and stained light microscopic sections but further details are not distinctly evident in electron microscope.

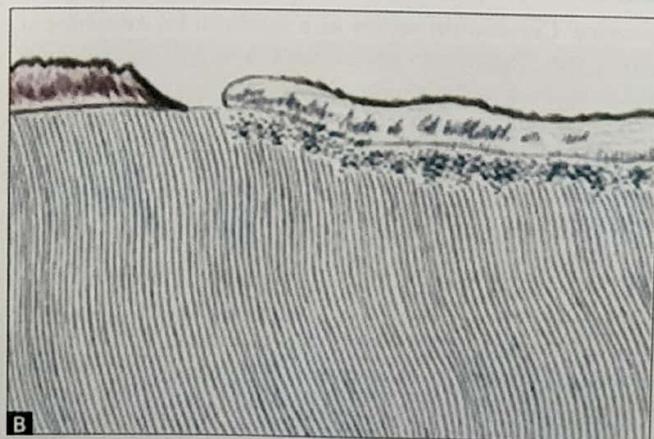
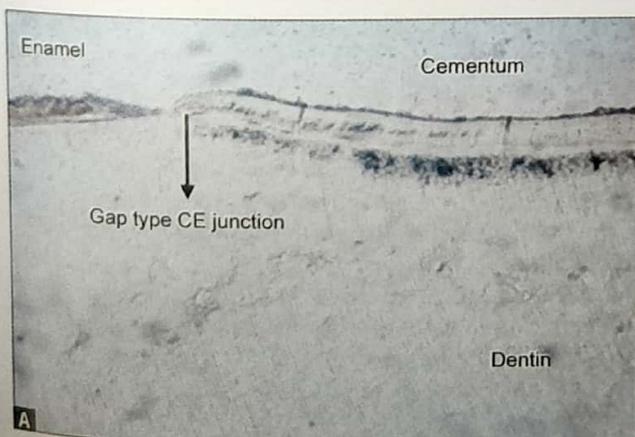
Sometimes, dentin is separated from cementum by a zone known as *intermediate cementum layer*, the thickness of which can be around 10–50  $\mu$ , and does not resemble either dentin or cementum. Usually, found in apical two-thirds of roots or molar and premolars and is rarely observed in incisors or deciduous teeth. It may be a continuous layer or present in patches.

Intermediate cementum is a form of secondary cellular intrinsic fiber cementum restricted to the apex of the tooth. It contains entrapped debris derived from either Hertwig's epithelial root sheath or odontoblastic layer. It is not involved in tooth attachment and has no functional significance. The term intermediate cementum has been incorrectly used to describe the hyaline layer. It is seen close to the dentin surface so it is suggested that it has got dentinal origin as this layer is said to contain dilated terminal endings of dentinal tubules. Branching spaces are sometimes seen in continuity with dentin.

### ■ CEMENTOENAMEL JUNCTION

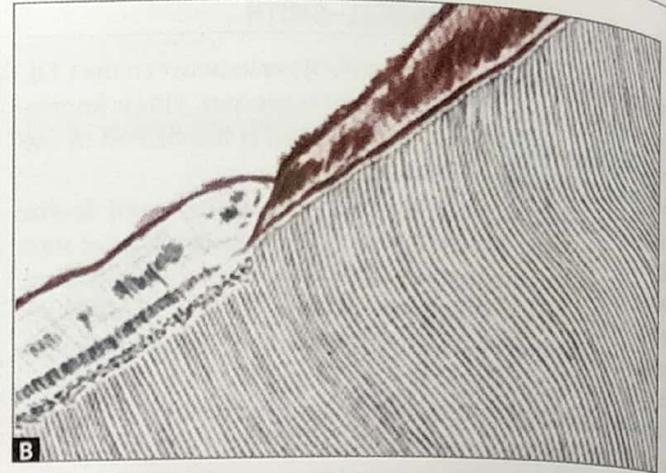
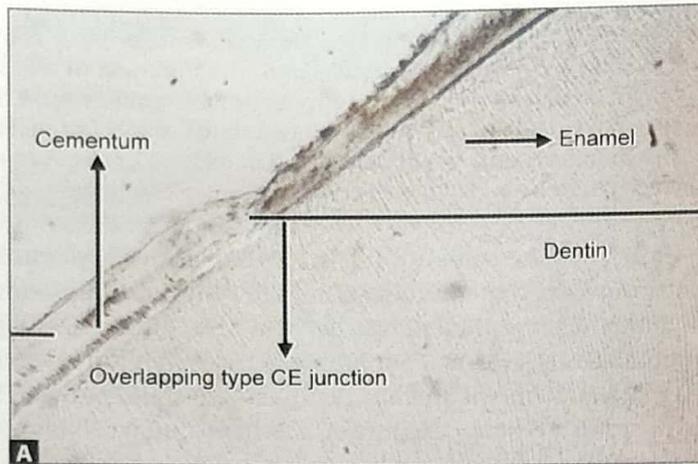
Cementum and enamel usually meet at the cervical region of the tooth and form the CEJ. In 10% of the teeth, they do not meet and the root dentin is exposed resulting in hypersensitivity and increased risk of dental caries (**Figures 8-16A and B**). This is attributed to the failure of degeneration of the Hertwig's epithelial root sheath in the cervical portion. As a result, the dental sac cells do not come in contact with root dentin to differentiate into cementoblasts to form cementum.

In 60% of teeth, cementum overlaps cervical enamel to a short distance (**Figures 8-17A and B**). This is attributed to the premature degeneration of reduced enamel epithelium covering the enamel at the cervical region. In such situations, the dental sac cells differentiate into cementoblasts and lay down a layer of cementum directly over enamel. This type of cementum is acellular and afibrillar. As described previously, it does not contain fibrillar collagen. If such afibrillar cementum remains in contact with connective tissue cells for a long time, fibrillar cementum with typical collagen fibrils (with 64 nm periodicity) may be deposited on it, thus the thickness of cementum over the cervical enamel increases.



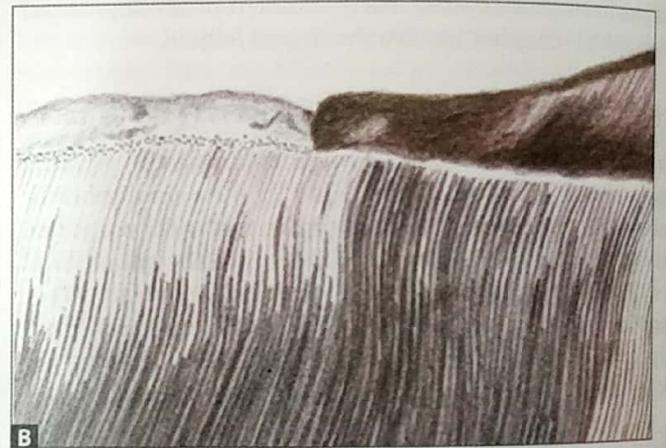
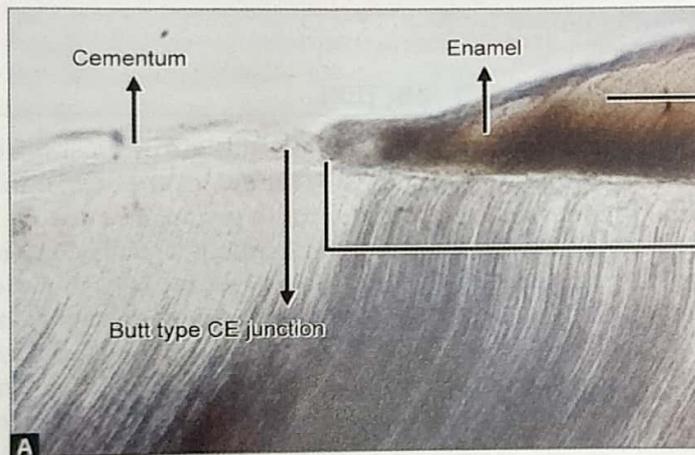
**Figures 8-16A and B:** (A) Ground section; and (B) schematic representation of gap type of cementsoenamel (CE) junction.

Source: (B) Dr Carmen Chuah Ming Ke.



Figures 8-17A and B: (A) Ground section; and (B) Schematic representation of overlapping type of cements enamel (CE) junction.

Source: (B) Dr Carmen Chuah Ming Ke.



Figures 8-18A and B: (A) Ground section; and (B) Schematic representation of butt type cements enamel (CE) junction.

Source: (B) Dr Carmen Chuah Ming Ke.

Cementum and enamel meet end to end as a butt joint with no overlapping in 30% of teeth (Figures 8-18A and B). The type of CEJ varies along the circumference of each tooth and above mentioned three types of junction may be present even in a single tooth.

### FUNCTIONS OF CEMENTUM

**Supportive:** Cementum serves as a medium for attachment of periodontal ligament to tooth and thus aids in attaching the tooth to the alveolus. Since dentin is made up of tubules, the periodontal ligament fibers cannot be incorporated into it directly. Cementum seals off the opening of the dentinal tubule on the outer aspect and provides attachment to the fibers of the periodontal ligament.

In cementum, continuous deposition and minimal resorption occurs in contrast to the bone, where deposition and resorption occurs alternatively in a rhythmic manner. Continuous cemental deposition has functional importance. Repeated apposition of cementum represents aging of tooth and functionally the tooth is as old as the last cementum layer laid down on the root surface.

Cementum enables reattachment of periodontal ligament and maintains the periodontal ligament width by continuous

deposition of cementum throughout the life. The periodontal ligament fibers shift in position due to forces, functional stresses, and get re-embedded by the cementum. Proximal wear or tooth loss causes tooth to be drifted or shifted in position and the periodontal ligament has to be realigned, for which cementum helps.

**Maintaining the occlusal relationship:** Shortening of the tooth occurs due to physiologic occlusal wear as in attrition and in pathologic conditions (e.g. bruxism). This is compensated by the cementum deposition at the apex thus allowing for functional adaptation.

**Reparative:** Damage to roots, like fracture and resorption, can be repaired by the deposition of new cementum. This repaired cementum is usually demarcated from normal cementum by repair lines.

As cementum is the slowest growing tissue compared to other periodontal tissues, it will be the last tissue to be added to root surface after occlusal loss.

### AGE CHANGES

Continuous formation of cellular cementum as age advances results in increase in the thickness. Increased thickness

occurs particularly in apical third and furcation areas of the root. Constriction of apical foramen and obstruction of the apical canal occurs because of the cemental deposition in the apical zone.

With aging, cemental surface becomes irregular due to calcification of some of the fibers of the periodontal ligament. Cementum resorption is also one of the characteristic features of aging. Cementocytes are viable in the lacunae near the surface. In the deeper portion, cementocytic lacunae appear empty.

### CLINICAL CONSIDERATIONS

Abnormal thickening of cementum is known as hypercementosis. It may involve single tooth or affect all teeth. Hypercementosis may be localized or generalized to involve the entire tooth surface (**Figures 8-19A and B**).

If the over growth improves the functional qualities of cementum, it is called cementum hypertrophy, while the term cemental hyperplasia is used when the growth occurs in nonfunctional teeth or if it is not correlated with the function.

Localized cemental hypertrophy is manifested by occurrence of a spur or prong-like over growth of cementum, usually seen in teeth, which are subjected to heavy masticatory stress. This is to provide increased surface area for the attachment of periodontal ligament fibers, thus complimenting its function.

Hypercementosis is associated with many neoplastic and nonneoplastic conditions. Generalized hypercementosis occurs in Paget's disease of the bone.

Hypercementosis occurs in nonfunctioning teeth, which may extend around the entire root or may be localized to small areas. They are characterized by reduced number of Sharpey's fibers embedded in the root.

Chronic periapical inflammation sometimes results in extensive hyperplasia, which may be circumscribed and surround the root like a cuff. Calcified knoblike or spherical projections found on the hyperplastic cementum are termed as excementoses, which are developed around degenerated or calcified epithelial rests.

Since cementum is avascular, it is resistant to resorption than bone and thus facilitates orthodontic tooth movement. The degenerative processes are affected by interference in

circulation. When tooth is moved by orthodontic appliance; the pressure side (direction to which the tooth moves) there will be bone resorption, while in the tension side, bone deposition.

Cementum may resorb due to severe trauma or excessive occlusal stress. Resorption may extend to involve root dentin in severe cases. The damage is repaired by deposition of cellular/acellular cementum or alternate layers of both. Repair lines demarcate the repaired tissue and the normal cementum. If the cementum deposited re-establishes the former outline of root, then it is referred to as anatomic repair. Functional repair is characterized by deposition of a thin layer of cementum on the surface of deep resorption, which does not reconstruct the former root outline and a bay-like recess remains. In such areas, the periodontal space is restored to its normal width by formation of a bony projection, so that proper functional relationship will result. The outline of alveolar bone in these cases follows that of the root surface.

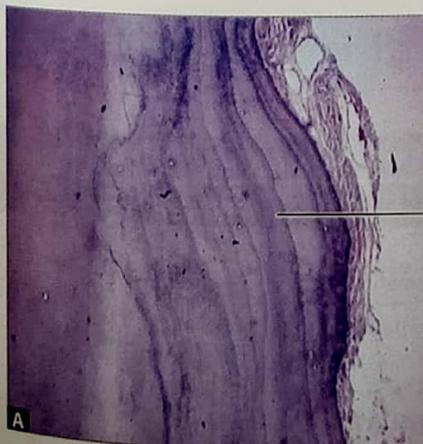
Root fracture may occasionally be repaired by the formation of cemental callus, but unlike fracture in the bone, this callus does not remodel to the original dimensions of the tooth. Teeth subjected to severe blow may result in tear of cementum usually at CEJ or in cementum or in dentin.

Hypercementosis can occur in tooth affected by chronic infection or subjected to excessive occlusal stress. The excess cementum formed, anchors the tooth tightly to the socket and may lead to fracture while extraction, thus emphasizing the need for preoperative radiographs.

Cementum is exposed through gingival recession. As only few layers of cementum cover the root, the exposed cementum is quickly worn off with mechanical friction, exposing the deeper dentin, and leading to extrinsic staining and dental hypersensitivity.

The incidence of cemental caries increases in older adults as gingival recession is a common feature in them. It is a chronic condition that forms a large, shallow lesion that slowly invades into dentin, and then into the pulp tissue.

Cementum, though resembles bone, does not contain nerves. Thus, cementum is nonsensitive. Scaling does not produce pain, however, if cementum is removed, exposure of the underlying dentin results in sensitivity.



**Figures 8-19A and B:** Hypercementosis: (A) Photomicrograph; (B) Radiograph.

Plaque and its byproducts can cause physical, chemical, and structural alterations in cementum in teeth with deep periodontal pockets. Cementum becomes hypermineralized due to calcium, phosphorus, and fluoride deposition from the oral environment in cases of pathologically exposed cemental surface.

Alteration in cementum surface is important in practice of periodontics, as it may interfere with healing during periodontal therapy. Various procedures (mechanical—root planning and chemical) are available to remove pathologically altered cementum, so that new cementum can be deposited.

The aim of regenerative periodontal therapy is to induce new cementum formation and restoration of soft tissue

attachment to the cementum. Cementum regeneration requires cementoblasts and molecular factors regulating their recruitment and differentiation are not completely understood.

A variety of chemotactic factors, adhesion molecules, growth factors, and ECM constituents participate together in the recruitment of cementoblast progenitors, their expansion, and differentiation. The mechanism by which selection of cementoblast progenitors is achieved is unclear, and it most likely involves specific integrins and signaling events.

Cementicles are spherical calcified masses made up of acellular extrinsic fiber cementum seen in the periodontal ligament.

### Points to Remember

- Cementum is a hard, avascular connective tissue that covers the roots of the teeth and forms an integral part of the periodontium.
- Cementum gives attachment to the fibers of the periodontal ligament and firmly adheres to the dentin on its inner aspect thus holds the tooth in the socket.
- Cementum is derived from dental sac or follicle and cells responsible for cementum formation are called cementoblasts.
- Cells of cementum include cementoblasts, cementocytes and cementoclasts.
- Cementocytes are the entrapped cementoblasts in the cemental matrix. They have cytoplasmic processes directed towards the periodontal ligament.
- Cementoclasts are the cells responsible for the resorption of the cementum. They are multinucleated cells and resemble osteoclasts of the bone.
- The fibers of cementum include; intrinsic fibers, the collagen fibers laid down by cementoblasts and extrinsic fibers, the inserted portion of the periodontal ligament.
- Cementum can be classified into two types, *i.e.* cellular and acellular cementum based on the presence and absence of cementocytes.
- The acellular cementum usually extends from the CEJ till the apex and is present more in coronal half of the root, while the cellular cementum is located in the apical third.
- Cementoid, also called as precementum is the unmineralized cemental matrix that covers the cemental surface.
- The incremental lines of cementum called as lines of Salter represent the rhythmic deposition of cementum (phases of activity and rest).
- A narrow band of clear hyaline layer called hyaline layer of Hopewell-Smith is present at the cementodentinal junction (CDJ) or in between the CDJ. This is implicated in the attachment of dentin to the cementum.
- Cementum and enamel usually meet at the cervical region of the tooth and form the cemento-enamel junction (CEJ). Overlap CEJ (60%), Butt CEJ (30%) and Gap CEJ (10%) are three types of CEJ.
- Functions of cementum include supportive, reparative and maintenance of occlusal relationship.
- Hypercementosis is abnormal thickening of cementum. It may involve single tooth or affect all teeth; may be localized or generalized to involve the entire tooth surface.

### PRACTICE QUESTIONS

1. Describe physical and chemical properties of cementum. Identify the types of cemento-enamel junction with well labelled diagrams.
2. Classify cementum. Describe in detail the histology of cementum and its clinical significance.
3. Describe the gross microscopic anatomy of cementum. Add a note on cementogenesis.
4. Discuss hypercementosis.
5. Discuss in brief types of cementum.
6. Describe the chemical composition of cementum.
7. Discuss Sharpey's fibers.

### MULTIPLE CHOICE QUESTIONS

1. **Avascular component of periodontium is:**
  - a. Alveolar bone
  - b. Periodontal ligament
  - c. Cementum
  - d. Gingiva
2. **Which calcified component of the tooth contains highest concentration of fluoride?**
  - a. Enamel
  - b. Dentin
  - c. Cementum
  - d. Pulp
3. **Primarily organic portion of cementum consists which of the following collagen fibrils?**
  - a. Type-I
  - b. Type-II
  - c. Type-IV
  - d. Type-VII

4. **Cementum is thinnest at which of the following site?**
  - a. Cementoenamel junction
  - b. Middle 3rd of root
  - c. Towards apex
  - d. DEJ
5. **Cementum is thickest at which of the following site?**
  - a. CEJ
  - b. Middle 3rd of root
  - c. Towards apex
  - d. DEJ
6. **Acellular cementum is found in which of the following area?**
  - a. Cervical and middle 3rd of root
  - b. Apical 3rd of root
  - c. Only in furcation areas
  - d. Only in cervical areas
7. **Cellular cementum is found in which of the following area?**
  - a. Cervical and middle 3rd of root
  - b. Middle 3rd of the root
  - c. Apical 3rd and furcation area of root
  - d. C-E Junction
8. **Intermediate cementum layer is predominately seen in which of the following areas?**
  - a. Cervical 3rd of molar and premolar roots
  - b. Apical 2/3rd of molar and premolar roots
  - c. Apical 2/3rd of canine root
  - d. Cervical 1/3rd of canine root
9. **In most instances, at C-E Junction:**
  - a. Enamel overlaps cementum
  - b. Cementum overlaps enamel
  - c. Cementum and enamel form butt joint
  - d. Cementum and enamel never meet each other
10. **Cementodentinal junction in deciduous teeth is:**
  - a. Straight
  - b. Irregular
  - c. Sometimes scalloped
  - d. Smooth
11. **The main difference between cellular cementum and acellular cementum is:**
  - a. Presence of cementocytes
  - b. Presence of Sharpey's fibers
  - c. Presence of lamellae
  - d. Presence of incremental lines
12. **Which of the following surrounds an apical foramen?**
  - a. Cementum always
  - b. Dentin always
  - c. Cementum and dentin
  - d. Cementum and enamel
13. **The embedded collagen fibers in cementum that radiate from periodontal ligament are called as:**
  - a. Circular fibers
  - b. Oblique fibers
  - c. Sharpey's fibers
  - d. Horizontal fibers
14. **Intrinsic fibers of the cementum is formed by:**
  - a. Fibroblasts of the periodontal ligament
  - b. Cementoblasts
  - c. Osteoblasts
  - d. Odontoblasts
15. **What is the primary function of cementum?**
  - a. Contributes to the size and strength of root portion of the tooth
  - b. Protects the root dentin
  - c. Furnish a medium for attachment of collagen fibers that bind the tooth to alveolar bone
  - d. It serves as major reparative tissue for root surface
16. **Which one of the following is not a function of cementum?**
  - a. Nutritive
  - b. Reparative
  - c. Supportive
  - d. Maintaining the occlusal relationship
17. **The condition where the overgrowth of cementum increase functional efficiency is called as:**
  - a. Cementum hyperplasia
  - b. Cementum hypertrophy
  - c. Cementoma
  - d. Cementoblastoma
18. **Calcified masses seen in the periodontal ligament are called:**
  - a. Denticles
  - b. Precementum
  - c. Cementoid
  - d. Cementicles

## ANSWERS

- |       |       |       |      |      |      |      |      |      |       |       |       |       |       |       |
|-------|-------|-------|------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| 1. c  | 2. c  | 3. a  | 4. a | 5. c | 6. a | 7. c | 8. b | 9. b | 10. c | 11. a | 12. a | 13. c | 14. b | 15. c |
| 16. a | 17. b | 18. d |      |      |      |      |      |      |       |       |       |       |       |       |

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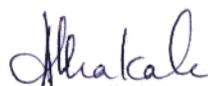
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# Study on Dietary Considerations of Wound Healing in Ayurveda

Sanjeev S. Tonni<sup>a\*</sup> and Amruta A. Wali<sup>a</sup>

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## ABSTRACT

Wound healing has been the burning problem in a surgical practice because of a remarkable increase in the number of traumatic cases. Nutrition plays an essential role in wound healing and wound care practices, and nutritional support needs to be considered a fundamental part of wound management. A wound causes a number of changes in the body that can affect the healing process, including changes in energy, protein, carbohydrate, fat, vitamin and mineral metabolism. Various Ayurveda literatures, particularly, Sushrut samhita, which is said to be an ancient textbook of surgery in Ayurveda, has mentioned about the diet for the person suffering from the wound, and the author said that diet plays a very important role in the wound healing process. Sushrut–The father of surgery has scientifically classified it in a systemic manner, whose wealth of clinical material and the principles of management are valid even today. Shalya tantra (surgical branch in Ayurveda science) is one of the important branch of ayurveda, in which surgical and para-surgical techniques has described for management of various diseases. Vrana is the most important and widely described chapter of Shalya tantra. Vrana (wound) is one of them, which have been managed by human being from starting of civilization. Under the circumstances, the first thing which the men came across was the injury from different sources which caused him the vrana. Vrana is seen as debilitating and scaring disorder, usually seen affecting the human being at any age. Well balanced nutrition plays an essential role in the wound healing. Objective of this article is to know the importance of diet and dietetic considerations during the wound healing process.

*Keywords: Ayurveda; vrana; wound healing; diet; nutrition.*

## 1. OVERVIEW

In this modern era, there is a remarkable increase in the number of traumatic cases, where the treating modalities like antibiotics, and local management is not sufficient for wound healing. Along with this, a well-balanced dietetic pattern is needed. Diet and Health are more connected in the area of wound care. Balanced diet plays an important role in wound healing process, as it enables quick reaction to the wound or trauma itself, as well as enhanced the healing capabilities throughout the curative process. Wound management is a significant and growing health burden on the community [1]. Delayed wound healing and wound infection place a substantial financial burden on health care systems, as a result of increasing dependency and increased hospital admissions. Chronic wounds also have a very large social and quality of life impact on individuals and carers [2]. Nutrition plays an essential role in wound healing and wound care practices, and nutritional support needs to be considered a fundamental part of wound management. Attending to nutrition in wound care is also cost-effective [3]. Poor nutrition before or during the healing process may delay healing and impair wound strength, making the wound more prone to breakdown. Neglecting the nutritional health of an individual with a wound can compromise the entire wound management process [3].

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## **2. PATHO-PHYSIOLOGY OF WOUND HEALING IN AYURVEDA**

“The destruction/break/rupture/discontinuity of body tissue/part of body, is called “Vrana [4,5]”.

### **2.1 Factors Influencing Wound Healing**

Certain factors will influence the wound during the healing process, which is explained in Sushruta samhita. They are General factors include vaya (Age), poshaka tatwa (Nutrients), and the diseases like madhumeha (Diabetic), paandu (Anemia), etc. 1. Local factors include twak sthaan (Position of skin), shalya vastu (foreign bodies), bhoota sanghaata (Infection), etc.

### **2.2 Healing Process in Open Wound Complete in 3 Phases**

In any type of open wound, three stages or phases are mandatory in healing process. They are as follows.

1. Inflammatory phase
2. Collagen phase or Proliferative phase
3. Maturation phase or regeneration phase/remodelling phase

Immediately following an injury, the healing process begins. A torn ligament or muscle is repaired, wounds heal, and bones mend. The healing process first involves getting rid of damaged tissue, then rebuilding healthy connective tissue in a step-by-step manner. The redness, swelling, heat and pain of inflammation are a natural part of the healing process. Many nutrients are involved in connective tissue repair and wound healing, such as amino acids, selective vitamins and minerals [6,7].

### **2.3 Diet and Wound Healing–An Ayurveda Aspect**

Ahara/Pathya (Food/Diet) plays an important part for wound healing, which may not heal well, if we cannot eat food, which is not having proper calories of proteins, vitamins and minerals, etc. The diet of a patient entertaining an open wound should preferably consist of laghu ahara (light dietetic articles) in small quantities. Food always should be taken freshly cooked with fatty articles (especially cow ghee). Above all digestive upsets should be avoided. Dietetic constituents, as prescribed by Sushruta, should be advised for quicker healing and avoiding the complications. Hot liquefied food (like manda/peya/vilepi type of gruel) prepared from old rice, mixed with cow ghee (Goghrita) in small quantity with meat soup (mamsa rasa), a good diet for wounded by which quick healing of wound occurs [8,9].

### **2.4 Nutrients Involved in Connective Tissue Synthesis & Wound Healing**

When there is damage to connective tissue, it is important to address the nutritional requirements for the synthesis of both the collagen fibers and the proteoglycans. Collagen fiber and proteoglycan synthesis are dependent on the supply of nutrient building blocks, such as amino acids and amino sugars. Vitamins and minerals are also needed for the many enzymatic reactions involved in connective tissue rebuilding. Some of the nutrients that are involved in connective tissue repair and wound healing are as follows.

### **2.5 Carbohydrates**

Carbohydrate is a major source of calories for use by the body, and its availability is essential to prevent other nutrients (e.g. protein) from being converted into energy. It is not clear how carbohydrate deficiency influences wound healing, but increased carbohydrate intake provides energy that is essential for optimal healing [2]. Carbohydrate sources include whole grain cereals, breads, rice and biscuits [10].

## **2.6 Protein**

Protein is essential for the maintenance and repair of body tissue. Depleted protein levels will cause a decrease in collagen development, slowing the wound healing process. Adequate protein levels will help achieve optimal wound healing rates [2,11,12]. Protein requirements should be calculated on an individual basis, and they should be monitored closely. This needs to happen along with the provision of calories, because if energy needs are not met the body will use protein for energy rather than for wound healing [11]. In slow to heal/ chronic wounds, a recommended daily intake of 1.5 g/kg/day will meet the protein needs of most individuals, but up to 3 g/kg/day may be appropriate for those with more severe wounds [11,13]. Sources of protein include red and white meats, fish, eggs, liver, dairy products (milk, cheese, and yoghurt), soy beans, legumes, seeds, nuts and grains [13].

Protein-energy malnutrition (PEM) is the most serious type of malnutrition—when there is an inadequate or impaired absorption of both protein and energy. PEM causes the body to break down protein for energy, reducing the supply of amino acids needed to maintain body proteins and healing and causing loss of lean body mass. Therefore, PEM may be directly linked to wounds that are not healing [12,14]. This cascade demonstrates the severely negative impact poor nutrition can have on chronic wound healing.

## **2.7 Amino Acids**

The collagen fibers are made up of long chains of amino acids, of which one-third is glycine. Proline, hydroxyproline and hydroxylysine are also prevalent. Some proline and lysine residues become hydroxylated by certain enzymes to form hydroxyproline and hydroxylysine. This hydroxylation reaction requires a reducing agent, such as ascorbic acid and alpha-ketoglutarate as a substrate.

## **2.8 L-Arginine**

L-Arginine is an amino acid that has several properties that enhances a number of the pathways involved in wound healing, such as its role in structural protein synthesis. As the body needs more protein during wound healing, the demand for normally nonessential amino acids, such as L-arginine, becomes essential. Dietary supplementation with arginine has been shown to enhance protein metabolism, helping to decrease muscle loss and collagen synthesis, which helps to increase the strength of the wound [1,3,14,15]. L-arginine is essential for the stimulation of the nitric oxide pathway, which is in turn important for collagen deposition in wound healing [15-17].

L-Arginine supplementation has also been shown to enhance the immune system and improve the secretion of growth hormone and insulin that are also involved in wound healing [3]. People with pressure ulcers who have been treated with supplements containing arginine show a significantly improved rate of ulcer healing [18,15]. L-Arginine is also effective in healing chronic ulcers in people with diabetes (ultimately helping to reduce leg amputations) [1].

## **2.9 Fats**

Fats, including mono and polyunsaturated fats, provide fuel for wound healing. Fats are a safe and concentrated source of energy. Fatty acids are a major component of cell membranes, and demands for essential fatty acids increase after injury [2]. Essential unsaturated fatty acids must be supplied in the diet as the body cannot synthesize enough for the needs of wounds [2]. The benefit of omega-3-fatty acid supplementation in wound healing is still not clear, and there is some evidence this may reduce wound strength [11,19]. Good sources of fats to promote wound healing include meat, full-fat dairy products, such as milk, cheese, butter, cream, yoghurt, ice-cream and oils and fats used in cooking or as spreads.

## **2.10 Vitamin A**

Vitamin A increases the inflammatory response in wounds, stimulating collagen synthesis. Low -A levels can result in delayed wound healing and susceptibility to infection [2,14]. It has also been

shown that vitamin A can restore wound healing impaired by long term steroid therapy or by diabetes. Serious stress or injury can cause an increase in vitamin A requirements. Vitamin A is found in milk, cheese, eggs, fish, dark green vegetables, oranges, red fruits and vegetables [13].

### **2.11 Vitamin C**

Vitamin C, or ascorbic acid, has multiple functions as a co-enzyme and co-factor in many of the body's biochemical pathways. As it relates to connective tissue, vitamin C is required for collagen fiber synthesis, a process vital for tissue repair and healing. Specifically, it is involved in the hydroxylation of proline to form hydroxyproline. Research by Patel [20] confirms that ascorbic acid acts as a specific inducer of the collagen pathway. A deficiency in vitamin C is associated with poor collagen formation and delayed wound healing [20]. Vitamin C is considered a very important water-soluble antioxidant. Additionally, vitamin C is capable of regenerating other antioxidants, especially vitamin E.

### **2.12 Vitamin E**

Vitamin E is a major antioxidant and functions to quench free radicals in most tissues. They predominantly affect polyunsaturated fats that compose the lipid portion of cellular membranes. The main rationale for vitamin E supplementation is to reduce the damaging effects of free radicals [20]. A number of conditions, such as chronic inflammatory disorders, injury to the central nervous system and connective tissue damage, are associated with free radical damage. It is thought that excess free radical production may also delay or prevent adequate healing. Vitamin E supplementation may reduce free radical damage and benefit wound healing and connective tissue repair.

### **2.13 Role of Minerals**

Zinc, Copper and Manganese for SOD induction: Superoxide dismutase (SOD) is an antioxidant enzyme. There are two forms of SOD: mitochondrial (contained within the mitochondria) and cytosolic (contained within the cytoplasm of the cell). Mitochondrial SOD is induced by manganese, whereas cytosolic SOD is induced by copper and zinc. Copper/zinc SOD (CuZnSOD) and manganese SOD (MnSOD) protect tissues by converting damaging superoxide free radicals into hydrogen peroxide, which is further catabolized by catalase into water and oxygen. In order for the SOD enzymes to function, there needs to be an adequate dietary supply of copper, zinc and manganese. Dietary zinc sources include red meat, fish and shellfish, milk products, poultry and eggs. Research suggests that raising the intake of minerals needed for SOD induction may improve SOD activity [21,22].

### **2.14 Iron**

Iron is part of the system that provides oxygen to the site of the wound; therefore iron (Haemoglobin) deficiency can impair healing. Iron deficiency can also result in impaired collagen production and strength of the wound [2,10,13]. Iron absorption from non-meat sources can be enhanced with vitamin C [13]. Zinc and iron compete for absorption, therefore, if someone is receiving supplements of both, the zinc and iron should be given with meals, but not at the same time [23,24]. Recommended iron intake for the general population is 8 mg/ day and for females aged 19-50 years, this increases to 18 mg/day [24]. The best sources of iron in the diet are red meat, offal, fish, eggs, whole meal bread, dark green leafy vegetables, dried fruits, nuts and yeast extracts.

### **2.15 Energy**

The main sources of energy for the human body and for wound healing are carbohydrates and fats. The main demand for energy from a wound is for collagen synthesis. Caloric needs for healing increase according to increasing size and complexity of the wound. For patients with wounds, energy requirements are estimated at 30-35 kcal/kg [13]. Energy requirements vary according to gender, age, activity and clinical status.

## **2.16 Other Important Factor–Fluid Maintenance**

Hydration is important in wound healing, as dehydrated skin is less elastic, more fragile and more susceptible to breakdown. Dehydration will also reduce efficiency of blood circulation, which will impair the supply of oxygen and nutrients to the wound [13]. One of the main risk factors for dehydration is poor oral intake. In long-term care, dehydration is one of the most common problems affecting good nutrition [23,24]. A general guide to providing fluids is 30-35 mL/ kg/day, with a minimum of 1500 mL or 6-8 cups/day [25]. Sources of hydration include water, juice, milk, ice-cream, yoghurt and soup.

## **2.17 Cow Ghee (Goghrita)**

Cow ghee gets absorbed easily and cross the cell membrane. It is also a concentrated source of energy having dietetic value, easier for digestion and absorption. Nutrients present in the ghee delivered to tissue easily. "Cow ghee is sweet in taste and cooling in energy, rejuvenating, good for the eyes and vision, kindles digestion, bestows lustre and beauty, enhances memory and stamina, increases intellect, promotes longevity, is an aphrodisiac and protects the body from various diseases" [26]. Cow ghee is used in most ayurvedic formulations. Cow ghee's regenerative properties are also useful for healing wounds and promoting the growth of healthy cells. This wound healing ability has also been clinically proven [27,28]. Cow ghee's cold, oily qualities help protect the body's mucous membranes and ensure its usefulness in any condition with burning sensations. Finally, on a practical level, ghee is rich in antioxidants, and hence, does not go rancid for a long time.

## **2.18 Pathya Ahara as Mentioned in Ayurveda (Diet to be Taken/ Followed)**

Purana shastika Shaali (old stored rice), Jaangala mamsa (less fatty chicken), Jeevanthi shaaka (leafy vegetable called *Leptadenia reticulata*), Tanduleeyaka shaaka (red variety of *Amaranthus* leafy vegetable), Vaastuka (green leafy vegetable, ie. *Chenopodium album*), Baalamulaka (tender radish), Vaartaka (Brinjal), Patola (bitter variety of snakegourd), Karavellaka (bittergourd/*momordica charantia*), Daadima (pomegranate), Grutha bhrusta amalaki (gooseberries fried in cow ghee), Saindhva lavana (potassium chloride), Purana sarpi (old stored cow ghee), Mung (Greengram/*Phaseolus mungo*), Vilepi (thick rice gruel), Srutha jala (cold water/potable drinking water). These vegetables and fruits are to be taken more during the wound healing process as mentioned in ayurveda.

## **2.19 Apathya Ahara as Mentioned in Ayurveda (Diet not to be Consumed)**

Nava dhanya (newly harvested grain/cereals), Masha (blackgram), Tila (sesum oil), Vishama bhojana (intake of food at inappropriate time), Ati-bhojana (excessive eating), Anista bhojana (undesirable food), Upavasa (fasting), Viruddha bhojana (incompatible food), Adhyashana (eating when previous meal is not digested), Kulattha (horsegram), Nishpava (variety of pea), Amla-lavana-katu rasa (sour/salty & pungent foods), Vallura mamsa (dried meat), Shushka shaaka (dried vegetables), Vasaa (animal fat), Sheetodaka (cold water), Madya (variety of alcohols) Asuri (mustard seeds), Mulaka (radish, which is not tender one) are pooyavardhaka (suppurative) and Doshajanaka (increases tridosha/humour). So these are to be avoided during the wound healing time as mentioned in ayurveda.

## **3. DISCUSSION**

Optimising nutrition is important to best practice care in wound management. The overall goal for the healthcare team should be to make sure the patient is in the optimum nutritional state to give wounds the best chance to heal [2]. This can be achieved by providing the individual with adequate calories and nutrients, preventing proteinenergy malnutrition and promoting wound healing [13]. Cow ghee's (Goghrita) widespread prevalence in ayurvedic medicines and treatments is due to its beneficial effects on the digestion, absorption and delivery of ayurvedic herbs, as well as its own healing properties. When the digestive capacity (agni) and life-essence (ojas) are weakened, the doshas(humours/tridosha) are disturbed, causing disease. Cow ghee's actions on both agni and ojas

are, hence, at the heart of all ayurvedic treatment. Cow ghee also nourishes and regenerates the body and mind, improving the overall quality of treatment. Our body produces new cells and tissues in a day. If our body doesn't receive proper nutrition and the building material may delay the wound healing.

#### **4. CONCLUSION**

Diet is considered as one of important factor for proper wound healing. Implementing the nutritional plan and providing appropriate nutritional support to the individual, helps to enhance the process of wound healing. There is a growing body of evidence and research demonstrating the vital role our diet plays in the healing of all types of tissue damage and inflammation. Eating a diet rich in fresh fruits, vegetables, seeds, legumes and whole grains will also help to ensure an abundance of phytochemicals, natural plant based chemicals that may promote health and healing. By combining knowledge of the wound healing process together with best practice provision of nutrition, healthcare professionals can help decrease the morbidity and mortality associated with chronic wounds, as well as reducing their cost and impact.

#### **COMPETING INTERESTS**

Authors have declared that no competing interests exist.

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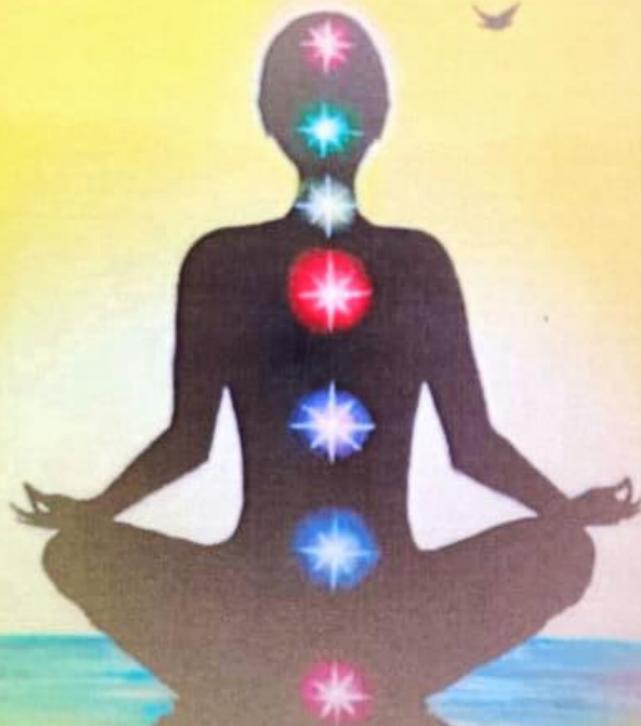
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# **YOGA THE ESSENCE OF LIFE**

**(Collection of Research Articles)**



**Editors : Dr. Rajani H. & Mrs. Joan Leela Madtha**

**Gunanidhi Research Institute, Dharwad**

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## Effect of Bhramari Pranayama on Voice Quality of Vocalists : An Open Clinical Trial

- Dr. Amrutha Kalyani

- Dr. Sanjeev S. Tonni

- Dr. T. Jayakumar

**Key-words :** *Bhramari Pranayama, Humming, Singing power ratio, Long term average spectrum, PRAAT, Voice*

### Introduction:

Human voice is the faculty that renders Man a unique distinction amongst other living creatures. It reflects one's own personality emotions and other gestures<sup>1</sup>. A pleasant good voice has a basic need of human, as it fetches a status in the society thereby determining the social success, individual professional success and advancement. A professional voice user is defined as an individual who depends on the use of his or her voice to earn a living.<sup>2</sup> Koufman and Isaacson defined four levels of vocal users. The first level includes elite vocal performers (singers, actors), the second level encompasses professional voice users (clergy, lecturers, telephone operators), the third level is made up of non-vocal professionals (other teachers, doctors, lawyers) and the fourth level consists of non-vocal non-professionals (labourers, clerks)<sup>3</sup>. Hence an effective voice is a goal worth pursuing.<sup>4</sup> A beautiful voice depends on three interconnected imperatives like Vibration, closure and lubrication linked to the vocal cords.<sup>2</sup>

Singing is defined as a sensory motor phenomenon that requires particular balanced physical skills such as respiration, phonation, resonance, and articulation.<sup>5,6</sup> These skills are often developed as a result of training and singing experience, thereby creating a distinction in physiological, acoustic, and perceptual parameters of the voices of singers compared with that of non-singers.<sup>5,6</sup> It's a well controlled and a co-ordinated neuromotor act which involves training of vocal muscles,

vocal cords and other structures and systems involved in the production of voice.<sup>6</sup>

For professional voice the voice governs their livelihood and social attraction.<sup>4</sup> There are various factors which affect the voice in routine and thereby affect their voice career. Various habits, emotional insecurities, trauma, sleep quality, hormonal changes and other vocal pathologies affect the quality of voice.<sup>7,8,9</sup> It is important that Level 1 Professional voice users should be trained to use vocal techniques appropriately to avoid or minimize any type of vocal trauma<sup>10</sup>.

In the physiology of voice production, Resonatory system plays an important role. Resonance determines the final form of speech or voice and is defined as the quality of sound produced during speech production. The resonatory system involves a generator and a resonator. The degree of tuning that exists between generator and resonator establishes pitch, intensity and the quality of resultant tone. Once the sound is generated at the level of the vocal folds (the sound source), it then, passes through a series of filters (the vocal tract,) that dampen and enhance the sound and make each voice unique and distinctive to the owner of the voice. The resonators associated with the voice production are the tracheobronchial tree, laryngeal cavity, pharyngeal cavity, oral cavity and nasal cavity.<sup>11</sup>

In speech and singing, vocal tract resonances usually determine the spectral envelope and usually have a smaller influence on the operating frequency. The resonances are important not only for the phonemic information they produce, but also because of their contribution to voice timbre, loudness, and efficiency of a good singing voice.<sup>12</sup>

Specialist voice care is essential for all patients, but it is very crucial for voice professionals as it governs their livelihood. Care of the performing voice requires a thorough understanding of the interaction between the anatomy and physiology of voice production, along with an awareness of the interrelationships between vocalisation, acoustic science and non-vocal components of performance.<sup>13</sup>

Hence maintaining the resonance of voice in singers is of great importance. Various therapies are advised to improve the resonance of the voice, most common being the Resonance Voice therapy (RVT). RVT uses a continuum of oral sensations and easy phonation, building from basic speech gestures through conversational speech. The goal is to achieve the strongest, "cleanest" possible voice with the least effort and impact between the vocal folds to minimize the likelihood of injury and maximize the likelihood of vocal health (Stemple et al., 2010). The program incorporates humming and both voiced and voiceless productions that are shaped into phrase and conversational productions (Verdolini, 1998, 2000). The techniques used in RVT are yawning, humming, singing the vowel E, using the plosive consonants, nasal consonants, vowel tuning, using large skips and pronouncing the consonants Z.<sup>14</sup>

Traditionally, Indian classical singing is broadly divided into Hindustani (Northern India) singing and Carnatic singing (Southern Singing). Hindustani singing involves projecting of singers voice over the accompanying instruments (heterophonic). To achieve this, a higher frequency of base note and an extensive frequency range is needed.<sup>15</sup> The later one is a classical South Indian style of music that involves rigorous training to produce an "open throated" loud, predominantly low-pitched singing, embedded with vocal nuances in higher pitches.<sup>16</sup>

Good singing voice demands an appropriate posture maintenance. Straight head, Relaxed shoulders, straight spine, firm abdomen, loose knees and suitable breathing techniques are the pre-requisites of good posture during singing.<sup>17</sup> These postures help in appropriate projection of voice, as per the need.

Yoga is one of the ancient sciences of Indian philosophy, which deals with a righteous way of living a life, because of the various evidenced based benefits fetched by yoga at five different levels of the body simultaneously viz. physical, mental, social, spiritual and intellectual level. Pranayama is a practice of yoga, which regulates breathing process, wherein an individual voluntarily controls his breathing abilities. *Bhramari Pranayama*, is a humming type of

*pranayama*, has beneficial effects on the human physiology like pulmonary functions, cardio-vascular functions and cognitive function which are supported by clinical research. In the act of breathing, Humming (one of the attribute of vocal music) is a phenomenon occurring due to the resonance of air in the passages of head, throat, and chest.<sup>18,19,20,21</sup>

The production of vibrating sound during the practice of this pranayama resonates the entire vocal tract by bringing the forward focus and gives the tactile vibratory sensation to the practitioner. This converts the entire aerodynamic energy into an acoustical form with more strength and ringing sensation in the voice. Also, this practice brings out the easy onset of phonation when practiced with good posture and relaxed manner.<sup>22</sup>

A study conducted by Usha et.al on investigating the effects of bhramari pranayama practice on the aerodynamic and acoustical measures of voice in healthy adult females revealed significant improvements in the maximum phonation duration for all the sustained vowels. This indicates that the practice of bhramari pranayama improved the respiratory phonatory coordination in the selected females and also that with extensive practice one can achieve breath control. The results of aerodynamic analysis revealed significant improvements in subglottal pressure, glottal airflow, pitch, and loudness after bhramari pranayama practice. Regular practice of pranayama including bhramari pranayama is reported to be efficient in improving the lung functions in pathological cases like traumatic spinal cord injury.<sup>22</sup>

Thus, so far the studies done on Bhramari pranayama, focussed on evaluating its effect on voice, in general population who may or may not have interest to possess an effective voice production. Hence, the present study aims to study the effect of Bhramari pranayama on prospective singers who aim for an effective singing voice.

### **Methods:**

**Design:** The study with pre test – post test study design which got the approval of Institutional Ethics Committee for Human Research (BMK/15/PG/SV/22) and which was registered under CTRI

(CTRI/2018/01/011218) was conducted in the Department of Swasthavritta and Yoga of KAHER's Shri B. M. Kankanawadi Ayurveda Mahavidyalaya, PG Studies, KLE Ayurveda Hospital and Medical Research Centre, Belagavi and All India Institute of Speech and Hearing, Mysuru, Karnataka, India.

**Participants:** 30 healthy vocalists fulfilling the inclusion and exclusion criteria, having the basic knowledge of Indian vocal music and consenting for the study were enrolled through a survey in music schools and other educational institutes in the region of Belagavi. Apparently healthy vocalists irrespective of gender, religion and occupation of the age 18-35 years were included in the study. Subjects with a history of respiratory and endocrine disorders, speech and hearing disorders, acute or chronic vocal disorders and with history of smoking, alcohol consumption were excluded from the study.

A total of 47 subjects were screened out of which 33 were enrolled 30 completed the study and 3 dropped out of the study.

### **Instrumentation:**

The U1 USB Windows and Macintosh compatible Dynamic Recording Microphone, with desktop mic stand and mic clip was procured from CAD Professional Microphones, USA was used to record the voice samples.

Recording and Analysis of voice samples was done using PRAAT 5.3.53 (Boersma & Weenink), Vaghmi (Voice and Speech system, Bangalore) and Computerized speech Lab (CSL, 4600) by Kay Elemetrics, NJ respectively at All India Institute of Speech and Hearing, Mysuru, Karnataka, India.

### **• Methodology:**

On a telephonic and a personal consent obtained by the authorities of the music schools, an education of *Bhramari Pranayama*, its health benefits and aims of the present study imparted in the respective music schools. A note of volunteering subjects was made and they were invited to visit the KLE Ayurveda Hospital, Belagavi for the participation in the study. The volunteers were given the telephonic appointment for the

voice recording priorly. On the arrival for, voice recording, the Patient Information Sheet (PIS) was given and the details of the study were explained to the participants, following which an Informed Consent (IC) was taken from the participants. The basic details of the participant needed for the study was procured as per the approved Case Record Form (CRF).

### **Voice recording:**

The voice of the consented and the eligible participants was recorded in a silent, closed room. The entire procedure of voice recording accounted to 20-30 minutes in the pre-noon time. The participants were made to sit on a knee height chair. They were instructed to relax at the time of recording and were instructed to perform various vocal tasks which were standardised to record the voice sample as per participant's comfort and capacity. The tasks included:

- **Phonation of vowel** ( i.e Prolonging the vowel utterance for more than 5 seconds continuously - three vowels /a/, /i/, /u/ , each for three trials.
- **A standard passage reading** in a language comfortable to the participants (Standardized English passage-Rainbow passage / Standardized Kannada passage-Bengaluru passage)
- **Singing Vandemataram song** with a standard tune.

The voice recording was done through a software named PRAAT-5.3.53 (Boersma&Weenink) and the microphone (being connected to the laptop), was kept 10-15 cm away from the subject's mouth, at approximately 30 degree angle. The voice was recorded in a mono sound recording channel, at a sampling frequency of 44100 Hz and 16 bit rate. The same procedure of voice recording was followed on Day 0 and Day 30 of the study period. The recorded samples were saved in the .wav format and used for analysis.

### **Intervention:**

On the day for the arrival for voice recording (Day 0), the subjects were demonstrated the practise of Bhramari Pranayama. The subjects practised 21 cycles of Bhramari Pranayama by attaining the Shanmukhi

mudra<sup>23,24</sup> everyday for 30 days in a well ventilated and a clean environment.

The re-recording was done on the 30<sup>th</sup> day after the practise, with the same vocal tasks performed and by maintaining the same standard recording protocols as before

### **Analysis of voice samples:**

The voice samples were analysed by the objective acoustic parameters like Long term average spectrum(LTAS) and Singing power ratio(SPR) at All India Institute of Speech and Hearing, Mysuru using PRAAT 5.3.53 ( Boersma & Weenink)., Vaghmi (Voice and Speech system, Bangalore) and Computerized speech Lab (CSL, 4600) by Kay Elemetrics, NJ .

### **Measurement of Singing Power Ratio (SPR):**

The recorded singing samples were transferred to the computer. Computerised Speech Lab (CSL 4500 model) from Kay PENTEX, New Jersey, and USA was used to estimate the SPR. The duration of the selected sample was 60-80 seconds. SPR was extracted from the Long term average spectrum (LTAS) using Hamming window. Energy peaks between 0-2kHz and 2-4 kHz were measured and the RMS values between these intervals were also noted (Figure 01). The Singing power was calculated by two methods:

- i. **SPR Ratio method:** The ratio was calculated by dividing the peak values and rms values from 2-4 kHz and 0-2 kHz.

$$\text{SPR} = \text{peak value of 2-4 kHz} / \text{peak value of 0-2 kHz}$$

$$\text{SPR} = \text{rms value of 2-4 kHz} / \text{rms value of 0-2 kHz}$$

**SPR Difference Method:** The difference was calculated by subtracting the peak values and rms values from 2-4 and 0-2 Hz

$$\text{SPR} = (\text{peak value of 2-4 kHz}) - (\text{peak value of 0-2 kHz})$$

$$\text{SPR} = (\text{rms value of 2-4kHz}) - (\text{rms value of 0-2 kHz})$$

### **Measurement of LTAS:**

The recorded singing samples were down sampled to 16kHz, sampling rate to make it compatible with the Vaghmi software using the

“Vaghmi Diagnostics” module. The Long Term Average Spectrum (LTAS) was estimated for each singing sample and the Alpha, Beta and Gamma values were measured for voice of each participant. The block duration was kept as 32 milli seconds for estimation of LTAS.

- Alpha value: Ratio of average energy between 0-1kHz / 1-5kHz
- Beta value: Ratio of average energy between 0-2kHz / 2-8kHz
- Gamma value: Ratio of average energy between 0-1kHz / 5-8kHz.

### **Measurement of Fundamental Frequency, Frequency range, Amplitude Range and Formant Frequencies of Vowels:**

The samples recorded at **44 kHz and 16 bits** were transferred to a computer and PRAAT software was used for the purpose of voice sample analysis.

#### **a. Mean Fundamental Frequency:**

The phonation samples of vowel /a/, /i/ and /u/ recorded for 5 seconds was considered for analysis of mean fundamental frequency (mF0) for each vowel individually. Passage reading samples for 25 seconds were considered for measuring the mean speaking fundamental frequency (mspkF0). The mean speaking fundamental frequency of voice was noted from the voice report of the sample from PRAAT software.

#### **b. Fundamental Frequency Range:**

The passage reading samples were considered for measuring the fundamental frequency range. The highest and the lowest value of the fundamental frequency for the sample were noted from the voice report and the range was calculated manually.

#### **c. Amplitude range:**

The singing samples (1minute 10s) were considered for measuring the Amplitude range. The highest and the lowest value of the intensity (Amplitude) for the sample were noted from the voice report and the range was calculated manually.

#### d. Measurement of Formant Frequencies of vowel /a/, /i/, /u/:

The phonation sample of each vowel was analysed in the PRAAT software. The second formant frequency (F2) for each vowel for three trials was noted and the mean for each trial was manually calculated. The values were noted for the parameter as mean Formant frequency F2 /a/ (mF2 /a/), mean Formant frequency F2 /i/ (mF2 /i/), mean Formant frequency F2 /u/ (mF2 /u/).

**Analysis of the Results:** The data was statistically analysed using the software SPSS version 21.

#### Observations:

In the study, it was observed that 70% of the subjects belonged to Hindustani Clan of music and 30% belonged to Carnatic clan of music. After the practice of 21 cycles of Bhramari Pranayama for 30 days 73.33%, 53.33%, 83.33% and 70% of subjects experienced improvement in the quality of sleep, attained vocal stability, vocal prolonging and pleasantness of voice respectively and 66.66% experienced reduction in the vocal strain.

20%, 3.33% and 3.33% subjects experienced mild headache, mild headache - heaviness and severe headache respectively after the practice.

#### Results:

*Bhramari Pranayama* showed a highly significant ( $p < 0.01$ ) effect on SPR rms and SPD rms of voice samples. (Table 01). *Bhramari Pranayama* showed a considerable effect on LTAS parameters and effect nearing to significance on beta value specifically (Table 02). It showed highly significant effect on Singing Amplitude range ( $p < 0.01$ ) and Lowest value of Singing amplitude ( $p < 0.01$ ) of the voice samples (Table 03).

Non-significant effect was witnessed on mean formant frequencies of vowels (Table 04), fundamental frequency (Table 05) and fundamental frequency range (Table 06) of voice samples.

## Discussion:

Improvement in the sleep quality of subjects of this study may be due to the release of nitric oxide by the practice of *Bhramari Pranayama* as its practice, releases nitric oxide in the body which helps in improving memory and behaviour by transmitting information between neurologic cells in the brain, apart from calming the brain by improving the quality of sleep.<sup>25</sup> Improvement in Vocal prolonging (attribute of singing voice involving respiration) may be due to improvement of various pulmonary functions by the practice of *Bhramari Pranayama*.<sup>21,26</sup> Attainment of the vocal stability after the practice of *Bhramari Pranayama* may be because the constant and repeated humming during *Bhramari Pranayama*.

Extension of the ranges of frequency and amplitude allow the vocalists to reach high and low pitches easily. In this study, reduction in the vocal strain may be due to the increase in the singing amplitude range which is witnessed significantly ( $p < 0.01$ ) in most of the subjects.

Pleasantness of voice may be due to the significant reduction in the lowest singing amplitude values, leading to reduction in the loudness of voice (perceptual attribute of amplitude) thus, making the voice more pleasant. Also (Carrien Vlot et al, 2016) pleasantness may be due to reduction of the vocal roughness and perturbation measures by the virtue of humming.<sup>27</sup>

The head ache experienced by the subjects could be due to vibrations that develop in the frontal, maxillary, and temporal regions of the head during humming and the heaviness could be due to the resonance effect that is produced in the head region due to humming in *Bhramari Pranayama*.

## Effect on acoustic parameters:

SPR is an objective measure which can quantify the resonant characteristics of vocal tract, indicate the acoustic characteristics and quality of resonant tuning in the vocal tract of a singing voice through the spectrum analysis. It shows a distinctive relationship with period of voice training.<sup>28</sup> In the present study, the Paired 't' test, has shown a

highly significant improvement in the root mean square value (rms) of Singing Power Ratio (SPR<sub>rms</sub> and SPD<sub>rms</sub>) *Bhramari Pranayama* involves a constant humming at the phase of exhalation, which might bring the resonance effect in the oral cavity and nasal cavity. Humming has a potential to improve voice quality by stabilizing the vocal fold oscillation, remove the perceptual vocal roughness.<sup>27</sup> The immediate effects of humming was shown to induce a long-term improvement on the perceptual vocal roughness, perturbation parameters, cause an increase in the contact quotient (CQ), a parameter reflecting the degree of vocal fold contact during phonation.<sup>27</sup> The present study as well, a constant humming during the exhalation might have caused the tuning of the vocal tract resonance, which is reflected by the significant improvement in the values of SPR<sub>rms</sub> and SPD<sub>rms</sub>.

Long Term Average Spectrum is a valuable tool for analysing running speech and singing and reveals the overall voice spectral characteristics. The LTAS contour reflects contributions from the voice source and the resonance or formant characteristics of the voice.<sup>28</sup> The Paired 't' test has shown improvement nearing to significance for the beta values of the LTAS. In the present study, similar to the SPR, beta value LTAS also represent the improvement in the resonant quality of the voice. Many studies establish that similar to SPR, LTAS is an effective tool to measure the voice quality.

Highest and lowest amplitude of voice refers to the loudest and a gentle voice respectively. The low singing amplitude could be responsible for the pleasantness of the voice experienced by the subjects. In the present study, we can infer that significant change in the singing low amplitude and singing amplitude range may be due to some improvement in the pulmonary functions by the practice of *Bhramari Pranayama*, which is well established.<sup>18,19</sup>

A formant frequency is a frequency at which the energy is boosted due the vocal tract shape and size. We may infer that reduction in the second formant values is due to the increased pharyngeal cavity that occurred during humming. This suggests that there could be an enlargement of pharyngeal cavity of the vocal tract, leading to the

improvement in voice after 30 days of practice of *Bhramari pranayama*.

Considerable changes are seen in the values of Fundamental Frequency and Fundamental frequency range may be because the Fundamental Frequency and Fundamental frequency range are concerned more with the phonatory system, rather than the resonatory and respiratory system. Thus, in the present study, *Bhramari pranayama* has shown significant effect on resonatory system followed by respiratory system, than on the phonatory system.

### **Conclusion:**

In the present study, the effect of *Bhramari pranayama* on the voice quality of vocalists was investigated. The results revealed that after the practice of *Bhramari pranayama*, there was significant improvement in Singing Power Ratio (SPR), thereby making its effect on resonatory system noteworthy. *Bhramari pranayama* has some considerable effect on the respiratory system and the phonatory system, which is evident by certain changes in the LTAS and formant frequency. *Bhramari Pranayama* improved the resonance characteristics of the voice and there by improved the quality of singing voice in the vocalists. Thus *Bhramari Pranayama* can be adopted as a vocal exercise for vocalists to improve the voice quality and ease the process of singing.

However, the same needs to be investigated in the disordered voice population with a control group and by advising longer duration of practice of *Bhramari Pranayama*. Further studies should address this issue in hyper and hypofunctional voice disorders.

### **Institutions involved in the work:**

- KAHER's Shri B M Kankanwadi Ayurveda Mahavidyalaya, PG Studies, Medical Research Centre and Hospital, Shahpur, Belagavi, Karnataka, India.
- All India Institute of Speech and Hearing, Mysuru, Karnataka, India.

**Conflict of Interest: NIL**

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### Tables

**Table 01: Effect of the intervention on SPR rms and SPD rms parameters.**

Parameter	Day 0		Day 30		't' Value	'p' Value	Significance
	Mean	SD	Mean	SD			
SPR rms	0.345	0.112	0.399	0.113	-3.565	0.001**	Yes
SPD rms	-11.82	1.953	-11.06	1.683	-4.064	0.000**	Yes

\* $p < 0.05$ , \*\* $p < 0.01$

**Table 02: Effect of the intervention on alpha, beta and gamma values of LTAS**

Parameter	Day 0		Day 30		't'	'p' Value	Significance
	Mean	SD	Mean	SD			
Alpha	10.02	4.533	9.574	4.523	0.996	0.328	N
Beta	17.34	4.013	16.31	3.321	2.485	0.019	Y
Gamma	31.44	3.913	24.04	3.397	1.041	0.306	N

**Table 03: Effect of the intervention on Sng-A0 Low and Sng -A0 range**

Parameter	Day 0		Day 30		't'	'p' Value	Significance
	Mean	SD	Mean	SD			
Sng-A0 Low	40.92	3.139	39.28	3.044	2.916	0.007**	Yes
Sng -A0 range	39.84	4.146	42.47	4.013	-4.247	0.000**	Yes

**Table 04: Effect of the intervention on Ff for F2 for /a/, /i/ and /u/**

Parameter	Day 0		Day 30		't' value	'p' Value	Significance
	Mean	SD	Mean	SD			
mFf For F2-/a/	1446.9	136.6	1425.4	156.6	0.816	0.421	N
mFf for F2-/i/	2789.4	296.8	2601.9	505.4	1.863	0.073	N
mFf for F2/u/	942.7	131.5	1007.6	176.4	-2.176	0.052	N

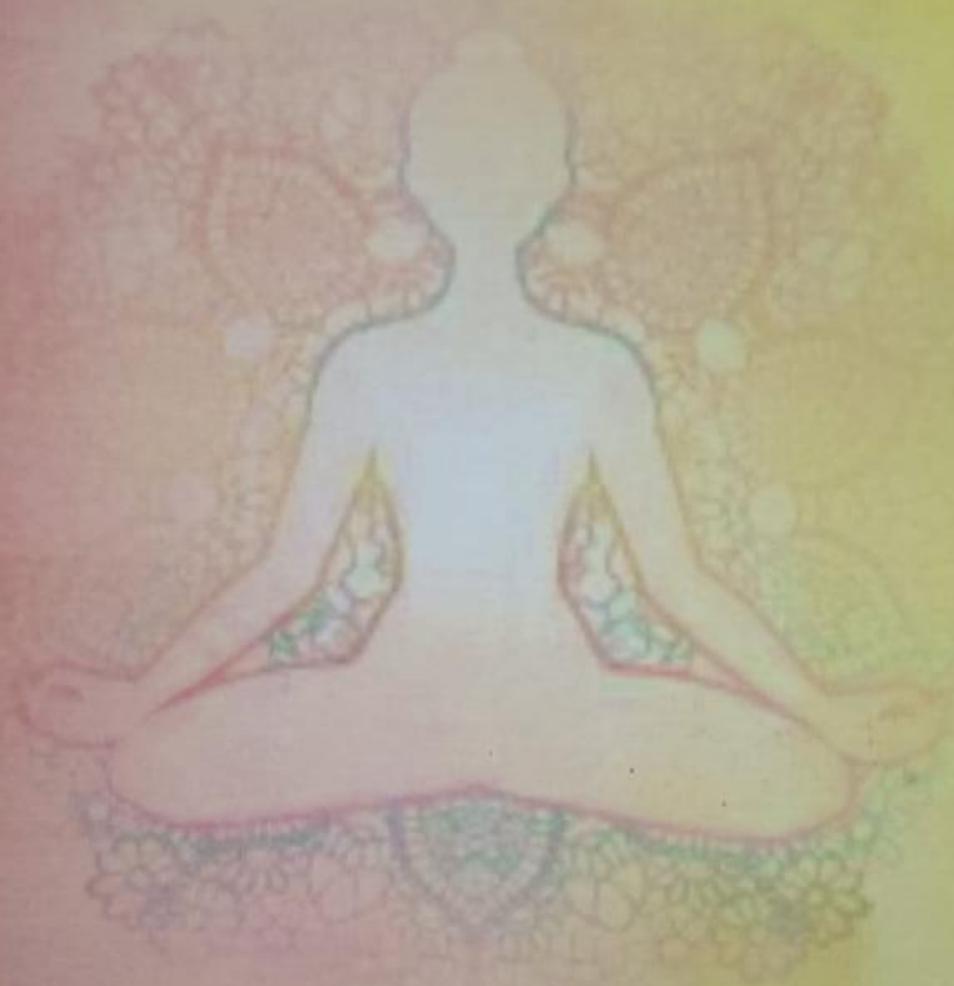
**Table 05: Effect of the intervention on mF0 for /a/, /i/ and /u/.**

Parameter	Day 0		Day 30		't'	'p' Value	Significance
	Mean	SD	Mean	SD			
mF0 for /a/	207.8	45.55	205.0	46.37	0.654	0.518	N
mF0 for /i/	213.2	50.15	217.7	47.80	-0.985	0.323	N
mF0 for /u/	220.7	48.34	222.0	48.82	-0.468	0.643	N

**Table 06: Effect of the intervention on Sng - F0 range**

Parameter	Day 0		Day 30		't'	'p' Value	Significance
	Mean	SD	Mean	SD			
Sng -F0 range	287.6	81.66	273.0	68.19	1.268	0.215	N

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## Event Report

# National Workshop on Quality Control of Herbal and Herbo-Mineral Preparations - An Event Report

“Pratyaksham Alpam, Analpam apratyakshamiti,” the famous quote which comes from Charaka Samhita Sutra sthana 11/7, stresses upon the need for continuous indulgence in research for the updation of the existing knowledge. There are many unexplored areas and concepts in our science, and the research tries to find an answer with a scientific basis for all our queries. “Paratantravalokanam,” i.e., collaboration with allied sciences, has become the need of the hour for translational research in the field of Ayurveda.

The Ayurveda pharmaceutical industries are flourishing today, and with the increasing demand for the herbal medicines, there is also an increase in the need for assuring quality and safety of raw drugs (herbals and minerals) and herbo-mineral formulations. In order to address this need and to train the Ayurveda professionals in quality control (QC) and research, the Central Research Facility (CRF) (AYUSH approved drug-testing laboratory for ASU drugs) of KAHER's Shri B.M. Kankanawadi Ayurveda Mahavidyalaya (BMK) has been regularly conducting workshops on analytical techniques. The 4<sup>th</sup> national workshop on analytical techniques was conducted by CRF on February 25–26, 2022, and the venue was CRF, BMK. The workshop was meant for PG, PhD scholars, and faculty of Ayurveda. Among the huge number of applications and inquiries received, eligible participants were selected based on their research background and interest in QC.

The 2-day national workshop was well attended and brought together 41 participants from different states such as Karnataka, Maharashtra, Telangana, and Andhra Pradesh. The first day of the workshop began with an inaugural function; the guest of honor was Dr. B. S. Prasad, President, Board of Ayurveda, NCISM, and Dr. V. Subhose, Assistant Director, CCRAS, Thiruvananthapuram. Dr. B. S. Prasad explained regarding the metamorphosis of the CRF into a centralized research unit over a period of 15 years. Initially, the Central Research Laboratory was established in 2006 in KAHER's Shri B. M. Kankanawadi Ayurveda Mahavidyalaya, Belagavi, with a mission to provide high-end research infrastructure and to train Ayurveda professionals as per the standard operating procedures in quality analysis of herbal drugs, so as to enable them to explore and validate Ayurveda principles. Later, many new units were added, and it came to be known as the CRF. Dr. B. S. Prasad complemented the efforts put forth by CRF in conducting research on diversified areas in

Ayurveda. He also stressed upon the importance of QC analysis of herbal and herbo-mineral preparations in the present era.

This was followed by a session on QC of herbal drugs and BMK initiatives by Dr. Giridhar Vedantam, MD (Ay), Research Consultant, CRF, BMK.

The delegates were then divided into three teams and trained under the following sessions:

Session one on hands-on experience with respect to extraction techniques, qualitative organic analysis, and demonstration of qualitative estimation technique using UV spectrophotometry. The session was engaged by Dr. Divya Khare, MD (Ay), Research Associate, CRF.

Session two was on section cutting techniques, powder microscopy, refractive index, pH determination, and thin-layer chromatography. The session was conducted by Dr. Ajit Lingayat, M. Sc (Medicinal Plants), PhD (Ay), Pharmacognosist, CRF.

Session three was with respect to tablet hardness testing, disintegration, friability test, NPST, and extraction by Soxhlet method. The session was guided by Dr. Veena Kupati, MD (Ay), Research Associate, CRF.

The teams were then shuffled for the next two sessions, and all the delegates were trained in these techniques.

The 2<sup>nd</sup> day of the workshop started with a visit to Dr. Prabhakar Kore Basic Science Research Centre, Nehru Nagar, Belagavi, where the delegates witnessed the research facilities of the KLE Academy of Higher Education and Research (Deemed-to-be University).

Then, the delegates were divided into two teams.

Session one with hands-on experience for basic physicochemical tests such as loss on drying, ash values, specific gravity, and qualitative inorganic analysis was conducted by Dr. Mahadev Gundkalle, MD (Ay), Co-Ordinator, ASU Drug Testing Laboratory, CRF.

In session two, the delegates witnessed the working of flame photometer and rota-evaporator with hands-on experience

Event Report

on fluorescent analysis of powder drugs. The session was guided by Dr. Giridhar Vedantam, MD (Ay).

Session three was a common session on demonstration of microbial limit test, total microbial load, and antimicrobial study which was conducted by Mr. Vinay P. S, MSc (Microbiology), Microbiologist, CRF.

The sessions were planned taking into consideration, the basic knowledge about QC required for a researcher in Ayurveda. Along with the hands-on training on basic analytical techniques, demonstration on some advanced equipment such as flame photometry for elemental analysis, UV spectrophotometry for quantitative analysis of phytochemicals, and techniques of microbiology studies was planned to develop the knowledge and skill component of the delegates. All the delegates showed enthusiasm and inquisitiveness. The queries raised by the delegates during the sessions were answered by the resource persons.

The pre- and posttest assessments of delegates were done by Google Forms. The feedback about the workshop was also taken. The posttest assessment and feedback analysis showed that the

workshop was successful in enhancing knowledge and skill of delegates about QC of herbal and herbo-mineral preparations.

The knowledge and skill gained during the workshop would help the delegates to understand the current needs of quality assurance and modifications required at different levels of manufacturing procedures. This would also help them in assuring the quality of herbal and herbo-mineral preparations in the industries, in setting up of an analytical laboratory and conducting advanced drug research. Understanding of basic analytical techniques and biochemistry and microbiology techniques would result in practical applications to prove theories of Ayurveda, which would open a new arena in Ayurveda research.

Valedictory function was conducted on February 26, for which Dr. Tanuja Nesari, Director, All India Institute of Ayurveda, New Delhi, attended as chief guest on virtual mode. She addressed the delegates and stressed upon the importance of drug testing with special reference to Guduchi species. Dr. Sunil Jalalpure, Principal, KLE College of Ayurveda, was another chief guest. He spoke about herbal drug evaluation



Event Report



Hands-on Training

Valedictory Function

CRF Team with Delegates

and QC aspects. Dr. Ishwar Kavalagi, Divisional Drug Inspector-Ayurveda, Belagavi Division, gave inputs regarding the regulations for QC of Ayurveda drugs.

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Nil.

**Conflicts of interest**

There are no conflicts of interest.

**DIVYA KHARE, GIRIDHAR VEDANTAM, MAHADEV B. GUNDAKALLE<sup>1</sup>, AJIT LINGAYAT, VEENA BABU KUPATI<sup>2</sup>**

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**Concise Book on**  
**Pharmacotherapeutics of**  
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## **Concise book on Pharmacotherapeutics of Ayurveda in Oncology**

Respected Sir/ Madam,

We are happy to present this “**Concise Book on Pharmacotherapeutics of Ayurveda in Oncology**”, based on the available literature in Ayurveda and contemporary Science on Cancer. This is an attempt made to elaborate Holistic Ayurvedic approach in contrast to conventional tumor treatment.

Ayurveda even after being one of the oldest systems of medicine, due to its concrete treatment principles still can be a ray of hope in oncology. As, this science instead of focusing on lesion/ tumor it focuses on the person. It emphasizes on uniqueness of an individual, variation of one patient to other so the treatment also to be with respect to individual's body but not the tumor only. Disease approach in Ayurveda in holistic way will boost cancer therapy. Medicines in Ayurveda can be used for achieving multiple goals like prevention of cancer, likelihood of cure or prolonging life when cure is not possible, management of symptoms or side effects of treatment. These can be well achieved with integrative practice with available effective treatment modalities mentioned in different medical sciences. Ayurveda can play an important role both in integrative method or even when used singly. Recent researches on herbs prove this with evidence. Today in the age of super specialization Ayurveda can also contribute in the field of oncology by exposing itself to such challenging conditions.

This book provides understanding of cancer as per contemporary and Ayurvedic science. Addresses interdisciplinary approach in Cancer management. Explains in detail about prevention, care and cure as per Ayurvedic Treatment Principles. Highlights various

pharmacotherapeutic formulations, single herbs and mineral/metal to boost immunity, to prevent and cope with several cancers. Lastly summarizes the therapeutic potential of some herbal drugs with recent research works supporting their anti-cancerous activity.

We hope the readers would receive this book open heartedly and be benefitted with this concise compilation on pharmacotherapeutics of Ayurveda in oncology.

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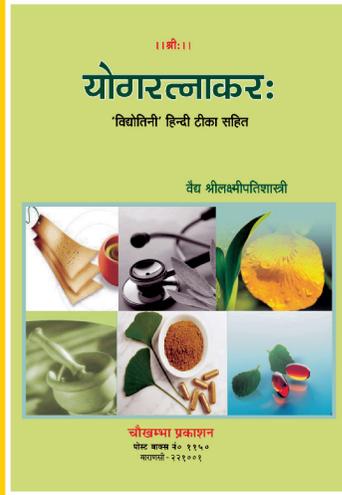
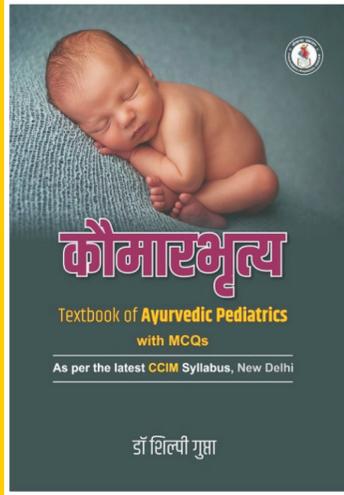
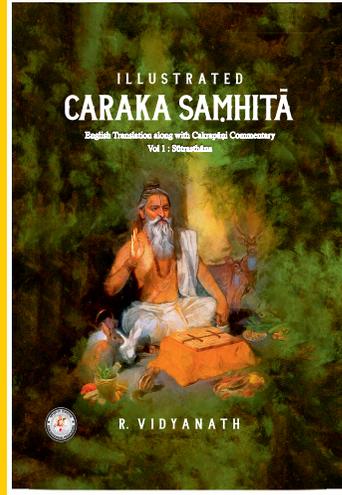
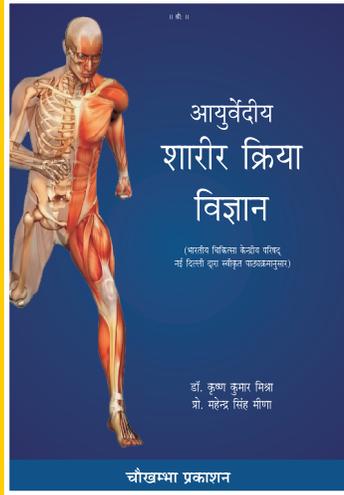
Vrukshayurveda activities like cultivation, conservation of medicinal plants, exploration of techniques mentioned in different books of Vrukshayurveda & newer cultivation techniques like Hydroponics. Author has given many invited talks on Vrukshayurveda. He has worked as Jury in Smart India Hackathon 2017 organised by Ministry of AYUSH held at Hubballi. He has worked as organizing secretary in NMPB sponsored programs like National level Medicinal plant Buyer's-Seller's meet 2018, 'Dravyadarshini'- Medicinal plant identification for Forest department start in 2021. Author's other areas of interest are application of basic principles of Dravyaguna vidnyan in clinical practice & ethnomedicine.

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Concept of Desha A Clinical Geography

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# Concept of Desha A Clinical Geography

Dr. Gurav Vinod S.



CHAUKHAMBHA PRAKASHAN

# QUALITY CONTROL AND STANDARDIZATION OF PHYTOMEDICINES



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PRAKASHAN  
ADVANCEMENT OF KNOWLEDGE

Edited Book

# Recent Trends In Medical Pharmaceuticals

(Volume 1)

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Dr. Ahmed G. Hegazi

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## About the Book

**Medical pharmaceuticals** include an extensive range of multidisciplinary subjects seeking to foster the integration of areas of knowledge that focus on all surfaces of drugs and therapies. Pharmaceutical sciences arrays from identification and control of organism causing disease, design of drug, formulation, clinical trial, metabolism, worth control and audit of drugs, manufacturing, plant-based source of medicines, food sciences, public, to environmental health for improving the quality of human life.

The Chapter of the compiled edited book contains advanced knowledge and updated research outcomes to update the readers. It touched on addressing the recent advancement of pharmaceutical sciences through the different approaches with the aim of the betterment of society and health well-being. Furthermore, its multidisciplinary environment in pharmaceutical sciences contributes valuably to other research areas like medical, biological, and chemical sciences.

The edited book aims to bring authors to one platform with the different subjects of Pharmaceutical sciences and share their knowledge for further research.

We hope that this book may interest a broad circulation for upgrading and acquiring the latest information for the extension of the learning.

Its continuous volume will come one by one to share more information and information on **Recent Trends in pharmaceuticals science.**

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## **Chapter-01**

### **AN OVERVIEW OF TECHNOLOGY TRANSFER AS A REGULATORY ASPECT**

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**ABSTRACT:** Technology Transfer is fundamental and crucial to the drug development process for new drug products. The great decision is based on that factor in which the concept or process is advanced from research and development-oriented scheme aimed towards the commercialization of the drug. The transfer could also be said to achieve success if the receiving section and the transferee can efficiently use the technology for profit. The achievement relies upon an understanding of the process or the capability to predict exactly the future prospects of a process. The main intension of this review article is to study the Regulatory aspects of technology transfer. This review article is mainly focused on the Consequence of technology transfer, the purpose for technology transfer in industries, barriers concerned with technology transfer, classification regarding technology transfer, facets of technology transfer, and steps among technology transfer.

---

#### **INTRODUCTION**

The terminology “Technology Transfer is the manner of interchange of technology and the invention from one area to a different area [1]. Across the pharmaceutical industry technology transfer states that the processes related to the fortunate movement of drug discovery to development and finally full-size promotion [2].

#### **The Consequence of Technology Transfer in the Pharmaceutical Industry**

- For the Transfer of technology from R&D to manufacturing site clear information is mandatory.

- To accentuate information on the transfer technology for the already available products among various manufacturing areas.
- This is required to enlighten particular procedures for technology transfer and contribution to continuous technology transfer.
- To establish an association among research institutes and profitable organizations. [3]

### **Purpose of Technology Transfer**

- **Inadequacy of manufacturing extent:** The technology introducer might have its own manufacturing equipment that is applicable to small scale operation and large-scale manufacturing operations.
- **Shortage of Resources to discharge Product Commercially:** For conducting the early stage analysis like animal studies and toxicology studies the inventor must-have resources. But for performing clinical studies the resources are not available.
- **Deficiency of Distribution and Marketing Competence:** The inventor would completely establish a technology and obtained product registrations and regulatory approvals.
- **Application in various fields:** To create an extra income the inventor may transfer the technology to someone else to use in another field that varies from the already applied field. [4,5]

### **Obstacles of Technology Transfer**

The Obstacles confronted in technology transfer as follows: -

- Lack of a persistent framework for the understanding of technology concept.
- Absence of procedures for receiving technology transfer in developing countries.
- In the progress of technology transfer, there is a lack of bilateral benefits.
- Unavailability of the persistent framework for analysis and evaluation of technology.
- Ergonomic aspects are failed to integrate the technology transfer.
- Lack of scrutiny to environmental and assessment of technological consequences.
- The feasibility study of technology transfer is limiting money evaluation.
- Misjudgment of the concept of technology usefulness.
- In the technology transfer process presence of ethical issues. [6,7]

### **Goals of Technology Transfer**

- Technology transfer is an advantageous step in the development cycle to commercial production of drug products.

- All the collected information is used as the grounds for the process qualification and continuous improvement of the product and manufacturing control strategy.
- The change of the data like the process, analytical data, or product between development and manufacturing plant.
- Various parameters and processes are controlled to justify the accepted parameters throughout the development. [8,9]

### Classification of Technology Transfer

**Mansfield (1975)** classified technology transfer into two types they are:

- **Vertical transfer** begins with preliminary research ending with clinical research to the manufacturing of new drug products.
- **Horizontal transfer** means the development and the application of technology utilized in one area, context, or institution to a different area, context, or institution. [10]

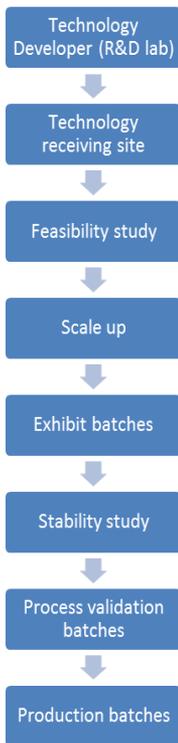
According to Sounder (1990) classification, vertical technology transfer is the progress of moving technology from one phase to another phase. vertical technology transfer is otherwise called as internal technology transfer. Horizontal technology transfer is possible to transfer technology at any stage of the lifecycle. Horizontal technology transfer is otherwise called as external technology transfer. [11]

Steenhuis (2002) categorized technology transfer into Material transfer, Capacity transfer, and Design transfer.

- The transfer of new material or products is denoted as **Material transfer**.
- Various types of instructions or guidelines are transferred to meet the numerous requirements of the product is called as a **Capacity transfer**.
- For improving the manufacturing of the product various designs and blueprints are transferred this is denoted as **Design transfer**. [12]

### Steps in Technology Transfer

Technology transfer is defined as the procedure for the transfer of information and technology fundamental to the production of drug products. The development of new drug undergoes many stages. The transformation of a pharmaceutical prototype towards a profitable product required the participation of a variety of individuals. Appropriate care should be taken to assure the quality of the product. During the early phase development, various parameters are considered such as critical and non-critical parameters, excipient availability, equipment, and production environment. There are numerous steps that encompass technology transfer. <sup>[13]</sup>



**Fig.1: Flow Chart of Technology Transfer in Pharmaceutical Industry [14]**

- 1. Development of Technology by Research & Development**
  - a. Design of Procedure and Choosing of Excipients by Research & Development:**  
The R&D department is responsible for selecting materials and design procedures for the development of the drug.
  - b. Determination of Specification and Quality by R & D:**  
The quality of the drug product must conform to the specifications of an innovator product that should be examined by the R&D Department. For manufacturing product and innovator products, various stability studies are performed to confirm the specifications.<sup>[15]</sup>
- 2. Technology Transfer from R&D to Production**
- 3. The R&D department is implemented the Technology transfer dossier that contains all the detailed information about the formulation and the drug product includes:**

**Master Formula Card:** MFC comprises a drug product name together with its MFC number, effective date, the strength of the formulation, generic name of the drug product, page number, and shelf life of the product.<sup>[16]</sup>

**Master Packaging Card:** Master Packaging Card consists of information regarding the material used for packaging of the product, packaging type, shelf life of the packaging, and stability of the packaging.

**Master Formula:** It describes the instructions for the manufacturing and formulation of the product. Manufacturing instructions provide the objective of environmental conditions and dosage form development.

**Specifications and Standard Test Procedure:** It is used to know about the active ingredients and excipients profile of the product, specification, in-process parameters, and finished product information.<sup>[17]</sup>

#### **4. Production Phase (Optimization and Production)**

##### **a. Validation Studies**

After conducting numerous validation studies production is started based on the manufacturing formula. The R&D department is responsible for the validation like process validation, cleaning validation, and performance qualification.

##### **b. Scale-up for Production**

This deals with the transferring of technology across the development of the processes and drug products. During the development of the process, it is necessary to investigate the production environment. Various operations are performed during the formulation of the solid dosage form. Technology transfer is implemented before the production begins.<sup>[18]</sup>

##### **c. Considerations of Different Parameters for Scale-up**

Different parameters like innovation, flexibility, cost, product quality is considered for successful technology transfer. Good communication is an important factor for successful formulation and process transfer.

##### **d. Selection of Method**

Based on the data from R&D the method for batch fabrication was chosen. The critical steps in technology transfer are granulation, blending, compression, and coating.<sup>[19]</sup>

#### **4. Technology Transfer Documentation**

The Document includes details of technology transfer towards transferred parties and transferring. From Research & Development to production every step must be documented and all commitments ought to be rectified. The Quality Assurance department is responsible for the approval of documentation for technology transfer.

##### **A. Development Report**

The R&D department is responsible for documentation. The development report clarifies the quality design for drug substances, specifications, and test methods. For approval, this report is not necessary. The development report encompasses:

- Data from the initial development stage to the final approval.
- Raw materials and components information.
- Manufacturing methods design.
- Changes are made in the vital processes and parameters.
- Specifications and test strategies for drug substances.
- The validity of the specification range for the dissolution test and contents impurity.
- Reports are checked. [20]

### **B. Technology Transfer Plan**

A technology transfer plan consists of complete procedures for individual transfer of technology, details regarding technology to be transferred, agenda for technology transfer and decision criteria for technology transfer. Before the implementation of the transfer, the transferring party must prepare the plan.

### **C. Report**

If the data is taken into the technology transfer plan only the technology transfer is completed. The data are assessed to confirm that the agreed criteria are met. Both transferred parties and transferring parties must document the report. [21]

### **Factors affecting Technology Transfer**

Seven factors are challenging towards establishing prerequisites for pharmaceutical technology transfers.

- A feasible and reachable market
- Suitable capital markets
- Quality of the relationship between industry and the government
- Appreciable economic governance, stability
- Accessibility of skilled employee
- Adequate regulation
- Understandable development precedence [22]

### **Facets of Technology Transfer**

The transfer of technology has occurred especially in the subsequent ways:

- Government laboratory to private sector firms
- Between private sector firms of the same country
- From academia to private sector firms
- Academia, government, and industry collaborations

#### **A. Govt. laboratory to private firms**

The Government labs will receive financial assistance and funds from the government for the conducting of research work and technology passes the private firms. So, this type is more advantageous.

#### **B. Among Private firms of the same country**

Due to a lack of financial resources or insufficient information this type of technology transfer takes place. The private firm establishes the technology is compensated by different firms.

**C. From Academics to private firms**

The academic firm develops specific technology and is accessible to various private sectors. By the cooperation of private sectors with organizations, money is often saved.

**D. Among Academy, Govt. and Private firms**

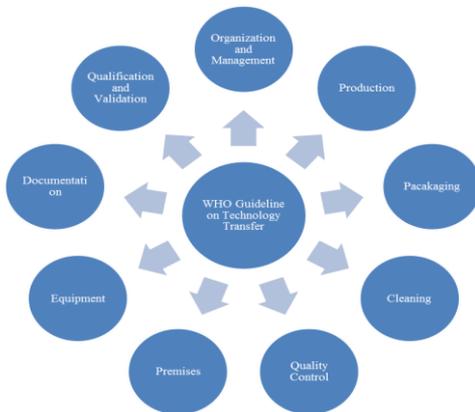
The government furnishes funds to the academic organizations for promoting technology this will be transmitted to the industry. [23]

**WHO Guidelines on Transfer of Technology**

Throughout the life cycle of the majority of medicines like the development of drug products, production, and launching into the market in all phases the processes are transferred to an alternate site.

This WHO guideline will be applicable to both manufacturing of active pharmaceutical ingredients, production, and packaging of finished pharmaceutical products, and carrying out analytical testing. [24]

Transfer of technology needs a plan and documentation utilizing the qualified and well-experienced person functioning in the quality system, with evidence of data regarding all areas of development, manufacturing, and quality control. Generally, there's a unit which manages the process, a receiving unit, and a sending unit. [25] The WHO Guidelines on the transfer of technology are mainly focused as shown in Figure 2.



**The WHO guidelines address the following areas at the Receiving Unit (RU) and Sending Unit (SU):**

- Transfer of development processes and Manufacturing of the drug product, packaging, and cleaning.
- Transfer of methods of analysis for quality control, and quality assurance.
- Competencies evaluation and training.

- Evaluation of premises and equipment.
- Documentation of all the data.
- Organization and control of the technology transfer.
- Qualification and validation of all the processes. [26]

### **Transfer protocol**

The technology transfer protocol must list the intentional consecutive steps of the transfer. The transfer protocol should encompass:

- Objectives
- Scope
- Key personnel and their duties.
- A parallel assessment of materials, processes, and equipment.
- The technology transfer steps with documented proof that every single crucial step had been sufficiently accomplished earlier than the subsequent commences.
- Identity of important control measures.
- For analytical methods design and acceptance criteria
- Details on the pilot batches, qualification batches, and process validation.
- Change control procedure for any process discrepancies confronted.
- Evaluation of the end-product
- Provisions for retaining samples of active ingredients, intermediates and finished drug products, and details on reference samples where appropriate.
- Conclusion includes signed-off approval by the project manager. [27]

### **Role of ICH guidelines in Technology transfer**

Technology transfer comprises of knowledge transfer, science, and risk-based principles inclusive of ICH Q8, Q9, Q10, Q11, and proficient processes to satisfy evolving commercial needs.

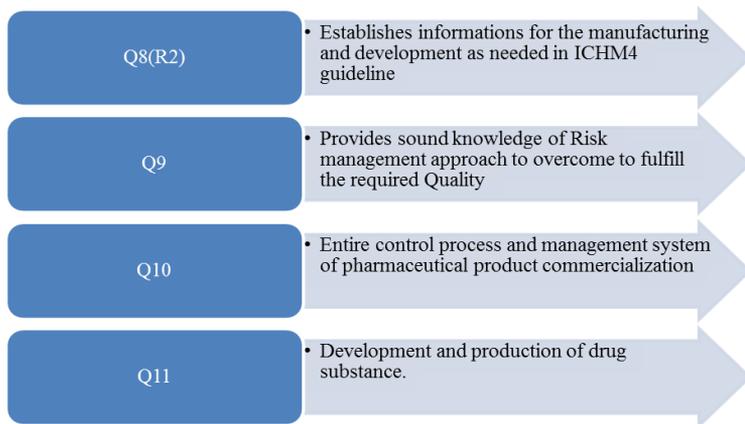
This determines the requirements for profitable Technology Transfer and offers guidance for the conduct of technology transfer, which might be separately tailored, relying on the sort and scope of the transfer. [28]

### **ICH Q10 Guidelines on Technology Transfers**

According to ICH Q10 guidelines, “The intention of technology transfer operations is to transfer process, and product information among the development and manufacturing sites, and within production sites to attain product realization. This information is the basis for the manufacturing of the product, monitoring strategies, process validation, and ongoing persistent improvement.”

To guarantee a successful technology transfer, pharmaceutical companies ought to create a collaborative improvement team must have the required qualification, knowledge, and skills to effect the transfer, originate a

written controlling methods to concentrate attention on crucial points in the process and equipment, review the process for inputs/outputs that might affect the quality of the product. [29]



## CONCLUSION

Transfer of information and technologies are necessary to meet the quality of the drug during production. Technology transfer might be investigated fortunately in case a receiving section can constantly reproduce the process. The three fundamental points to be discussed throughout the technology transfer are the plan, the persons concerned, and the production process. Technology Transfer offers a possibility to decrease the cost of drug discovery and development thus pharmaceutical enterprises seek technology transfer opportunity as it rates of failure, reduce risk, and costs. A collaborative work by the technology team leads to better outcomes initial and consistency runs resulting in the prior license, earliest launch, and an increased market share.

## CONFLICTS OF INTERESTS

Authors have no conflict of interest

## AUTHORS CONTRIBUTION

G.M. PAVITHRA,- Compilation of Data's and literature review  
MANORANJIH- Plagiarism correction and writing draft  
S. NAGALAKSHMI\*- Concept of creating, overall drafting

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## **Chapter-02**

### **NOSE-TO-BRAIN DELIVERY, A ROUTE OF CHOICE FOR TARGETING BRAIN TUMORS**

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**ABSTRACT:** Brain tumours are the most lethal type of cancer that is difficult to manage due to the inherent suboptimal bioavailability of the chemotherapy agent at tumour sites due to high levels of protection of physiological blood-brain and blood tumour barriers. Improving the permeability of these barriers would enhance the disease's clinical prognosis and promote patients' quality of life. To this end, scientists have conducted several studies to determine the most suitable route for CNS delivery. Most of which show that the nose-to-brain is proposed to be the most convenient, efficacious and clinically beneficial non-invasive means of delivering chemotherapeutic agents directly to the brain. Therefore, this study compares the therapeutic benefits of intranasal and other conventional brain delivery systems and further evaluates the clinical benefits of using different Nano carriers for brain tumour targeting. However, we surveyed the literature by conducting an in-depth search of the research keywords and their combinations in recognized scientific databases, primarily Science Direct, PubMed, Google Scholar, and Research Gate. Our findings have shown that the nose-to-brain delivery of chemotherapeutics is a breakthrough in bypassing the effects of BBB, BTB, and CSF barriers, improving the delivery of drugs to the brain for specific tumour targeting with desired clinical prognosis.

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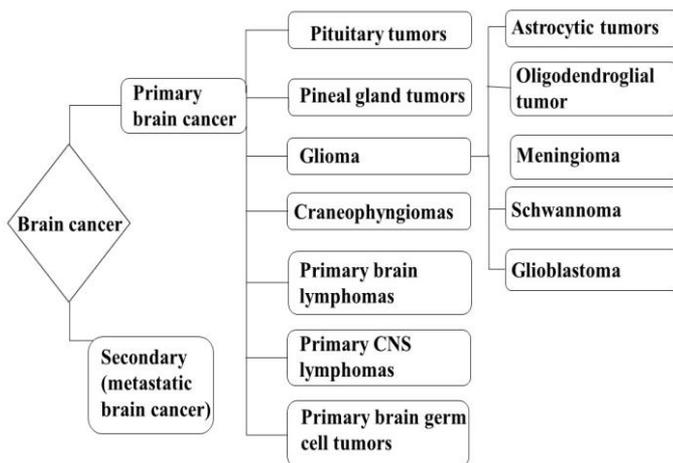
## INTRODUCTION

Edwin Smith was the first to discuss the central nervous system CNS's concept in his papyrus about 3,600 years ago [1,2]. Later, about 1,300 BC, the Ebers' papyrus described the concept of cancer and tumors. [3] Besides, Hippocrates identified some tumors in the crab's legs and called them "karkinos," in Greek words, meaning "crab/cancer," in English. [4] The global brain cancer incidence is higher in men than in women, in developed than under-developed countries with the incidence and mortality rates of 3.4 and 2.5 par 100,000. Albania has the highest prevalence of 7.5 par 100,000. [5] It accounts for 3% of all cancer globally. [6] Nevertheless, the significant risk factors are immune-imbances, hormones, family history, smoking, alcoholism, in addition to radiation, and ageing. [7] Primary, CNS tumors have been classified into; pituitary adenomas, gliomas, and primitive or vestibular neuroectodermal tumors, out of which 'glioblastoma multiform' (GBM) emerged as the most lethal type of CNS malignancy with 81% prevalence [8,9] and 12 – 15 months survival chance. [10] Moreover, the World Health Organization (WHO) graded the tumors into low-grade gliomas (grade I & II) and high-grade gliomas (grade III & IV), respectively [11]. However, the 'high-grade gliomas' of stage IV (Glioblastoma) is the most lethal type with less than a 5% survival rate [12], and more than 90% recurrence chances. [13] Nevertheless, the pattern of metastases and localization glioblastoma malignancy over time remains unclear. [14] It shows dynamic changes in morphological and structural forms. [15] Understanding these concepts will significantly increase the disease prognosis and the survival chances of the patients. [16] Henceforth, effective treatment of these malignancies is among the most challenging aspects in the pharmaceutical research field because blood-brain barrier (BBB), blood tumor barrier (BTB), and immunoregulatory mechanisms have become the rate-limiting steps for delivering chemotherapeutic agents. [17] Meanwhile, the contemporary management approaches that include surgery, radiation therapy [18] and Temozolomide (TMZ) have shown limited clinical benefits. [19] Bypassing the BBB through an invasive approach (using physical carriers) could compromise the brain functions and induce neurotoxicity. Therefore, a non-invasive (carrier-free) approach could increase drug permeability across the BBB to the target tumor. [20] Hence, new advances that could enhance the drug delivery across these barriers are highly needed. [21] The established literature proved that chemotherapeutic agents could effectively be delivered via the nose-to brain route through olfactory and trigeminal nerves. [22] The clinical benefits of using intranasal delivery outweigh other routes, most importantly, oral and parenteral, in CNS tumor targeting with a chemotherapeutic agent. [23] As we discussed in (table 3). However, the molecule meant for brain targeting

should be highly lipophilic non-ionized, less than 400 Da molecular weight, with an ionization constant range from 0.5 to 6.0 at physiological PH. [24] Nonetheless, the aforementioned features alone are not enough to provide sufficient pharmacokinetic effects that could permit a molecule to cross BBB efficiently. [25] Although, mucociliary clearance, enzymatic degradation of proteins and peptides result in suboptimal bioavailability of such biomolecule in nasal delivery upon intranasal delivery. [26,27] Perhaps, overcoming these hurdles will maximize the clinical benefit of the system. Nowadays, the potential technique for chemotherapeutic delivery enhancement for CNS tumor targeting is by encapsulating the drug into nanoparticles and administer them through the intranasal route.[28,29]. Nanoparticles has owed several advantages of optimization of drug pharmacokinetics to the compromisation of the physiological barriers enhancing the drug concentration at the targeted site. [30] However, nano-size features of different NPs boost their transcellular transport proficiency, optimizing the targeted therapy for specified brain-tumors. Therefore, several NPs have been used as drug carrier vehicles for brain tumor targeting via nasal route. [23,31] The review evaluates the clinical importance of employing nanocarriers in brain tumor targeting through nasal administration and simultaneously study the pros and cons of the therapeutic benefit of the intranasal and conventional delivery systems.

**Brain tumors**

Brain tumors have different classification types, most prominently; they have been classified into primary and secondary brain tumors [Figure 1].



**Fig. 1: Classification of brain cancer**

The primary tumors were categorized according to their originating tissues; gliomas, primitive, vestibular neuro-ectodermal, and pituitary adenoma. In contrast, the secondary tumors were characterized as metastatic tumors. [32,33] However, gliomas initiated from glial cells are the predominant types of CNS tumors that are associated with poor prognosis, including glioblastoma multiforms (GBMs) (which accounted for 81% of all brain tumors), astrocytomas (AS) oligodendrogliomas (OAs), among others. On the other hand, in the year 2004, the World Health Organization WHO further classified the CNS tumors into a four-point grading scale [ I-IV] based on histopathological parameters [34] as illustrated in table 1.

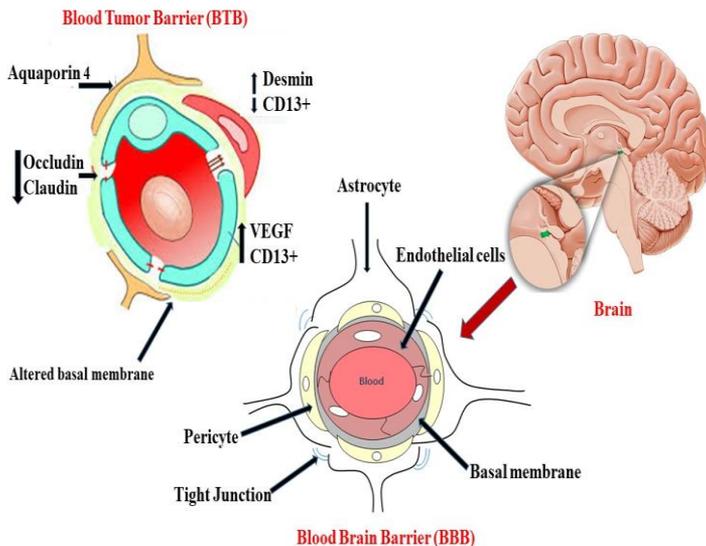
**Table 1: WHO grading of brain tumors**

WHO	Descriptive features	Members	Criteria	Ref.
Grade I	Slow proliferating non-malignant tumours, with high survival chances.	angiocentric glioma, pilocytic astrocytoma, and subependymal giant cell astrocytoma	Nil	[35]
Grade II	Slow proliferating tumours with a high-grade, recurrent tendency, they may be malignant or non-malignant.	chordoid glioma of the third ventricle, low-grade diffuse astrocytoma, and cellular and clear cell ependymoma	Cytological atypia (atypical cell)	
Grade III	Malignant tumours that might reoccur as a high-grade tumour	anaplastic astrocytoma, and anaplastic oligoastrocytoma	Mitotic and activity anaplasia	
Grade IV	Proliferate rapidly with high malignancy	Glioblastoma multiform GBM	Mitotic, activity anaplasia with necrosis, and microvascular proliferation	

**Rate limiting barriers for chemotherapeutic delivery to CNS**

Both blood-brain and blood tumor barriers are known as inherent barriers that limit the absorption and transport of molecules between systemic

circulation and the brain, which significantly reduces the bioavailability of pharmacological agents, reducing their clinical efficacy in treating various brain infections and disorders. As shown in [figure 2]



**Fig. 2: Blood-brain and blood-tumor barrier**

**The blood-brain barrier (BBB)**

Anatomically, the BBB consists of an inner endothelial layer containing several tight junctions (composed of claudin and occludin) layer encapsulated with the basal membrane, further encircled by the Astrocyte. Pericyte is wrapped in the basal membrane between the outer Astrocyte and the endothelial layer. However, the tight junctions are solely responsible for limiting the paracellular movement of substances across BBB. Whereas the basement membrane augments its protective effectiveness [36–39] However, BBB is highly selective in nature, allowing only specific molecules with unique physiochemical properties of tiny size (preferably “nano form”), the low molecular weight of less than 400 Da, ionization of 1.5 to 2.7 and intense hydrogen bonding. This selectivity restricts most drugs and bio-molecules from entering into the brain. [40–42]

**Brain tumour barrier (BTB)**

Brain tumour barrier refers to the tumour protective layer formed because of an anatomical and physiological alteration of BBB, due to new blood vessels that feed and oxygenate the growing tumour loosed-tight junctions

of the endothelial cells. These newly formed vessels had some tiny pores that prevented the permeation molecules, including hydrophilic ones. [43–45] However, the neoangiogenesis system is facilitated by overexpression of the Vascular Endothelial Growth Factor (VEGF), stimulated by hypoxic areas created from the metastatic tumour VEGF triggers tumour to metastases throughout the brain. As a result, these changes further limited the chance of chemotherapy agents' bioabsorption into the targeted brain tumour. [46]

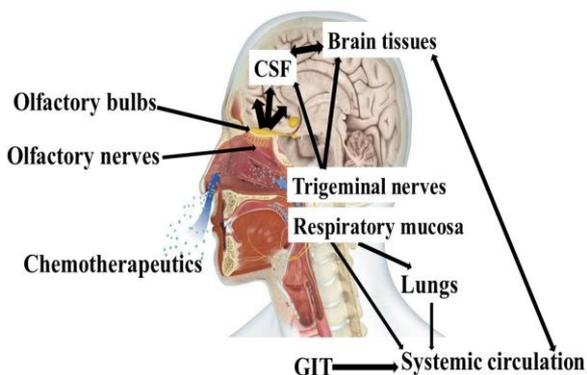
#### **Blood Cerebrospinal Fluid Barrier (BCB):**

Blood Cerebrospinal Fluid Barrier is the rate-limiting step for drugs and molecules absorption from the systemic circulation to CNS. Physiologically, the arrangement of choroid plexus' epithelium limits the molecular exchange from blood to CSF. Besides, the brain parenchymal cells formed arachnoid membrane (double layer) between the pia and dura mater, guided by tight junctions that enhance the integrity of the BCB and serve as the drainage system of CSF. However, this barrier the second most preventive barrier after BBB that limits the drug permeation to CNS. [47]

#### **Mechanism of intranasal delivery of chemotherapeutic agents**

Studying the anatomy and physiology of the nose and associated nerves are essential for understanding the nose-to-brain therapeutic delivery mechanisms and is necessary for developing the ideal formulation for brain targeting. [48] [49]. However, the nasal cavity is divided by the lateral and septal walls into two halves and supplies sensory and olfactory nerves; the olfactory nerves extend to the brain [50]. In contrast, the sensory innervation consists of the mandibular, maxillary, and ophthalmic zones of the trigeminal nerve. [51] The entire nose consists of three regions, namely the respiratory, olfactory, and vestibular areas. [52] Extension of the olfactory nerve ends in the olfactory bulb (chemosensory zone) where the drug's maximum concentration can be found in the brain. Interestingly, the olfactory bulb is directly connected to the brain, enabling the intraneuronal transport of a particular compound to different parts of the brain. Moreover, the olfactory mucosa supplies the skull in close vicinity to CNS. [53] Unfortunately, the molecules are delivered through an olfactory nerve in a delay pattern. Alternatively, the molecules infiltrate the pre-neural compartment of the cranial nerves and flow to the CSF, from where it permeates to different parts of the brain. [54] However, the trigeminal, olfactory and respiratory epithelia permit therapeutics to distribute to other brain sections. [55] S. Yadav et al. found the intranasal administration of cyclosporine A (CSA) nanoemulsion riched the brain at higher concentrations. It was also identified to have reached the brain through the olfactory bulb, hindbrain, and midbrain (via olfactory epithelium) through CSF. [56] R.G.Thorne et al. investigated the rat's CNS pathways involved

in delivering insulin-like growth factor -1 (IGF-I) via intranasal route; the researchers identified the two significant ways through which administered insulin [<sup>125</sup>I] distributed and concentrated in the rats' CNS and CSF. The "peripheral olfactory system" a system that links the nasal stream, olfactory bulbs, and anterior-brain portion. Whereas the "peripheral trigeminal system" channels nasal passage to brain stem and CSF. According to the authors' report, intravenous administration of [<sup>125</sup>I] to another group revealed similar results with that of intranasal but showed lesser CNS concentration than an intranasal pathway.[57] Shinde et al. investigated the potential for nose-to-brain delivery of atomoxetine (ATX) encapsulated in liposomes using in vivo rat model experiments. Following a gamma scintigraphy examination, the result indicated a significant distribution of the drug in the CNS. [58]. Therefore, good pharmacokinetics and physicochemical parameters of the drug determine its suitability for intranasal administration; usually, highly lipophilic unionized drugs that have low molecular weight are the desirable candidates for intranasal administration and hence could pass BBB through all these pathways. [59] As illustrated in [figure 3]



**Nanocarriers use for tumor targeting via nose-to-brain delivery system**

Nanocarriers transport the chemotherapeutic agents crossing BBB via several mechanisms, and they sustainably release the drugs to the brain. However, the FDA approved liposomes and dendrimers as a nanocarrier to deliver pharmacological agents to the brain and have been widely used to target different types of brain disease through surface modification with other polymers and proteins. [60]-[30] We summarized the literature of these in [Table-2]

**Table 2: Nanocarriers use for tumor targeting via the nose-to-brain delivery system**

Nanoparticles	Shape and Size	Mechanism of BBB circumvention	features	Limitations	Ref.
Liposomes	Spherical , concentric, Size 50-100 µm	Liposomes delivered the drug to the brain by permeating across the endothelial cells via endocytosis	bi-layered, phospholipids that can entrap both hydrophilic and hydrophobic drugs and it possessed different surface charges	Expensive ness, low drug loading capacity, and long term stability	[83]
Solid lipid	spherical in shape 1 and 1000 nm	It can permeate through the tight-junctions of the endothelium via a transcellular pathway and pass across the BBB	High drug loading efficiency, control releasing overcome the effect of mucociliary clearance & nasal degradation	High water content (70 to 99.9)%, Undesired drug load, leakage during storage	[84]
Polymeric NPs	10-1000 nm spherical or elongated	Polymeric NPs lodges the chemotherapeutic drug in the brain through passive or active transportation	Higher polydispersity index, stability, biocompatible biodegradable non-toxic, non-immunogenic and Inexpensive	Clinical application is limited by uncertain toxicity	[85]

Nanoparticles	Shape and Size	Mechanism of BBB circumvention	features	Limitations	Ref.
Nanoemulsion	globular size	Improve mucosal absorption and overcome nasal mucociliary clearance	Highly lipophilic, and permeation, low spherical size,	Unavailability of intranasal product,	[86]
Chitosan	<b>3.2-3.5 µm in diameter</b>	The increase in temperature enhances the gel formation and positive charges of chitosan interact with the negative charge of the mucosa that results in excellent retention and paracellularly cross the tight junctions of epithelial cells of BBB	Biodegradable, thermoresponsive, ease preparation, low toxicity, high stability and CNS delivery	Poor aqueous solubility	[87,88]
Dendrimers	three-dimensional structure of globular shape.	The penetration efficiency of dendrimers potentiates by conjugation	Undergo compositional changes in response to the environmental condition,	Extremely low water-soluble	[89]

Nanoparticles	Shape and Size	Mechanism of BBB circumvention	features	Limitations	Ref.
		with transferrin, D-glucosamine, leptin, and lactoferrin. The release depends on the PH and ionic strength of the media.	wide therapeutic applications		

### PRECLINICAL STUDIES

**In vitro trials:** Several studies have been carried out on the intranasal delivery of chemotherapeutics amongst Jeffrey J, et al.; demonstrated an in vitro experiment on rodents and primates models, in which the author examined the drug distribution in the rats’ perivascular space (PVS) and internal cerebral vessels using fluorescence imaging techniques, and the comparative study showed that the intranasal administration of the drug owed to have high distribution then intravenous administration. Therefore, the result indicated the potentiality of the intranasal route as an alternative way of delivering therapeutics for disease CNS targeting. [61] Using the Clone-6 (C6) rat glioma cell line, Khan A. prepared and administered Temozolomide chitosan-nano-formulation via the Wister intranasal route. A histopathological examination at the end of the study has revealed the high nanoformulation delivery efficiency due to the mucosal effect from the chitosan-nanogel that sustained drug release. Moreover, the drug found to have attained the optimal concentration in the brain. [1] Angel T. Alex, et al.; evaluated the permeation efficiency of the antineoplastic drug (carboplatin), the permeation of both Carboplatin-loaded nanoparticle (CP-NPs) and pure carboplatin formulation was determined using in situ, in vitro, and ex vivo evaluation studies. In ex vivo study, the authors isolated the new mucosal cell line of sheep and tested the two formulations; the study indicated that the CP-NPs have higher permeation efficiency than the pure formulation. Likewise, the in vitro study was conducted using the CP-NPs formulations, one containing higher and the other holding a lower

polymer concentration. After 72 hours of administration to 96- growing human glioblastoma cells, the result indicated the rapid, followed by sustained release pattern in both formulations. Although the formulation that contained the lower polymer concentration has shown to release faster, this demonstrated the importance of using fewer polymers in such nanoformulations. However, the in situ evaluation has shown better nasal permeation in CP-NPs then the pure formulation. Overall, the Carboplatin-loaded nanoparticle (CP-NPs) could be a breakthrough for targeting brain tumors using intranasal administration. [62] Kanazawa, T., *et al*; evaluated the safety and intranasal delivery efficiency of small interfering (siRNA) incorporated with modified block co-polymers-Tat nano micelles using rat modal. The in vitro study on glioma C6 cell-lines revealed high tumor inhibition upon intranasal delivery than intravenously injected formulation. Therefore, the author concluded that nose to brain rout is the most suitable means of targeting CNS disorders. [63] Maha N *et al.* formulated the intranasal Hyaluronic acid-based nanoemulsions of resveratrol and curcumin and evaluated their rats' CNS concentrations. The study result shows the drug's high concentration due to the mucoadhesive nature and BBB permeation ability in the nasal passage. [64] Co-administration of acetazolamide with 5-fluorouracil via intranasal and intravenous routes was evaluated by Author links open overlay panel T. Shingaki, *et al.* The concomitant administration through nose-to-brain route was found to have enhanced the drug concentration to 104% and 46% against intravenous administration of 5-uracil alone. [65] The study conducted by Hee-Yeon, *et al.*; showed a significant increase in temozolomide's anti-tumour activity (TMZ) after intranasal delivery to the rats bearing TMZ-resistant malignant gliomas. This means that temozolomide (TMZ) intranasal delivery could overcome the resistivity of oral TMZ-resistant malignant gliomas. [66]

### **In vivo trials**

J.H. Azambuja *et al.* administered siRNA-nanoemulsion intranasally to the Glioblastoma-induced Wister rats; the study's result showed a 60% reduction of glioblastoma tumor on the tested rat. [67] T. Sakane *et al.*, evaluated the perfusion of 5-fluorouracil (5FU) in the rats' CSF using in vivo models of Wister rats. The authors compared the intranasal and intravenous drug concentration in the CSF. The study result indicated that the drug's high concentration reaches the CNS via CSF upon intranasal delivery than intravenous. [65] Luxiang, *et al.*, conducted an in vivo evaluation of the efficiency of intranasal administration. The authors prepared and administered tyrosine kinase nanoparticles intranasally to glioma-induced rats. Upon examination, the study results indicated a maximum possible reduction in tumour size by facilitating the apoptosis rate, which is then observed in other preparation. [68] M. Colombo *et al.*

evaluated the intranasal delivery of kaempferol-loaded nanoformulation and mucoadhesive nanosuspension using in vivo rat model. Histopathological investigation of the rats treated with both formulations has shown the significant reduction in the size of glioma cells. However, kaempferol nanoemulsion induced apoptosis to a greater extent than mucoadhesive nanosuspension. [69] E. Sekerdag, et al. compared anti-glioma efficacy of 500  $\mu\text{M}$  PEGylated-farnesylthiosalicylic acid (FTA) on Wister rats for ten days intravenous and intranasal administration. After the post-treatment examination, the Nuclear Magnetic Resonance Imaging indicated the 55.7% reduction in tumor size. According to the study, there is no difference observed upon administering FTA via the intranasal or intravenous route. [11] Matthias Van et al. encapsulated the small interfering RNA (siRNA) in chitosan nanoparticles and administered it into Glioblastoma-induced mice intranasally. The author treated the mice with the prepared formulation for days 5, 8, 12, and 15. However, the immunofluorescence test performed on the 5th day post-treatment showed a significant reduction in tumor size. The author further observed a high concentration of drug in olfactory bulb upon in vitro intranasal delivery via the olfactory pathway, from where the drug possibly distributes directly to the CNS. [70] Darshana S. et al., administered both pure and Poly(lactic acid) (PLA) suspended nanoparticles of methotrexate via the intranasal route of two sub-grouped mice, each containing six members. The first group was treated with pure methotrexate has shown low bioavailability because the drug is highly hydrophilic in nature; consequently, it cannot cross BBB. On the other hand, the second group treated with PLA-methotrexate NPs has shown significant CNS concentration in both in vitro and in vivo evaluation after the pharmacokinetics evaluation. This is because the Poly(lactic acid) nanosuspension has the sol-gel-sol property that increases MTX's mucosal residence time; hence, the BBB penetration and CNS distribution. Lastly, the cytotoxic evaluation has shown no difference in toxicity among both the study participants. However, the authors proposed thermosensitive nanoformulation to be a gold standard for the formulation of antineoplastic drugs intended to target CNS tumors through the nose-to-brain route [71] A. Mangraviti, et al. have developed the polymeric nanoparticles incorporated with plasmid DNA to transfect "Human adipose-derived mesenchymal stem cells" (hAMSCs) through the intranasal route of glioma infected rats, as an alternative to viral transduction system. The in vitro evaluation revealed the significant reduction in glioma cells size more efficiently than the usual viral transduction method. While the in vivo experiment has indicated the possibility of high viability among the glioma bearing rats. [72] Hiroyuki Taki, et al. evaluated the anti-tumor and safety effect of camptothecin (CPT)-nano-micelles on intranasal administration using glioma infected

rats. The *in vivo* investigation revealed the evidence of tumor-shrinking and high viability chances on the treated rats. The author established the safety of the formulation at a high dose of 2 mmol/mL. [73] According to the sun et al. report, the CNS concentration of Methotrexate (MTX) encapsulated in chitosan microspheres was determined to be 118% upon intranasal administration to healthy Wister rats. While it was remained undetected when administered intravenously. [74] The study conducted by Pineda JR, et al.; proved the effectiveness of intranasal infusion of Temozolomide (TMZ) as anti-glioblastoma in nude mice. After the drug administration 3times a week for two weeks, a remarkable reduction in tumor size without alteration in the mice's sense of smell was observed. [75]

### **Clinical studies for intranasal brain tumor targeting**

DA Fonseca et al. performed a clinical evaluation for the effectiveness of intranasal administration of "perillyl alcohol" (POH) on 152, 26, and 5 different patients with a primary glioblastoma GBM, astrocytoma grade III AA and anaplastic oligodendroglioma AO, respectively. The drug was intranasally administered to the patients 4times daily, initiating a minimal dose of 66.7 mg/dose, and titrated to 533.6 mg/day. The study outcome after 4 years of the study indicated a favourable prognosis among the tested patients. However, 19% of them have been clinically under remission. Although 95% of the patients have developed rare nasal bleeding and soreness. [76] C. Fonseca, et al. conducted a phase I/II clinical trial to assess the safety profile of Perillyl alcohol (POH) on patients with relapsed malignant glioma. The author was administered the intranasal dose of 0.3% vol/vol containing 55 mg POH 4times daily and consecutively to 37 patients who had sub-grouped into 29 with Glioblastoma, 3 with anaplastic oligodendroglioma and 5 with astrocytoma grade III, for the period of 6 months. Upon completing the cohort study, the preliminary result indicated the safety, reliability, and non-invasive anti-tumor efficacy of POH. Clovis Fonseca, et al, had performed a clinical analysis on 67 patients with brain tumors the study evaluated the effectiveness of intranasal chemotherapy with Perillyl alcohol (POH) among glioma patients. The relationship between tumor size, localization, and relative treatment prognosis has been observed. Throughout the study period, the patients were categorized into some groups, in which 52, 10, and 5 patients bearing GBM, AA, and OA were recruited, respectively. A daily dose of 440 mg POH was maintained among the recruited patients. The author observed the longer survival chances and the promising clinical prognosis among the patients bearing recurrent malignant glioma, while those having lobar localization and peritumoral oedema have shown poor prognosis and low survival chances. Therefore, the study indicated the safety and tolerability of non-invasive chemotherapy and evident the definite relationship between the tumor

localization and clinical prognosis among glioma patients. [78] Clovis O. et al. the study on 62-year-old anaplastic oligodendroglioma patients, revealed the notable reduction in tumor proliferation following the four times daily administration of 1 0.3% POH intranasally. [79] However, Brazil trial further affirmed the clinical safety, tolerance, and efficacy of intranasal POH, in a study that recruited 37 recurrent malignant glioma-bearing patients; these patients were treated with four times daily intranasal 0.3% POH for several days. [80] Chen TC *et al.* evaluated the safety and anti-tumor activity of POH in a clinical trial phase I/II among the patients with recurrent Glioblastoma. The patient has received 4-times daily intranasal POH for 6months; the trial evidenced the maximum shrinkage in the bearing patients' tumor size with no toxicity and unwanted side effect. [81] Juliana et al. studied the clinical implication of POH's concomitant administration and ketotic diet among 32 patients with recurrent Glioblastoma. After four times daily intranasal administration of POH, 17 with ketotic and 15 without ketotic diet for a period of 3month. Subsequent clinical investigation of the recruited patients, most of the patients who received the concomitant chemotherapy of POH with ketotic diet, shows significant tumor inhibition with no toxicity. [82]

## CONCLUSION

It is no gainsaying that brain cancer is a severe disease characterized by an inferior clinical prognosis. There are overall limited survival chances for brain cancer patients perhaps;, the patients bearing Glioblastoma multiform (GBM) are more clinically affected since their survival chances are no longer than 15 months. Nevertheless, the optimum concentration of active drugs at the brain's targeted site is a prerequisite for effectively managing the disease or disorder. Unfortunately, several anatomical and physiological barriers need to be overcome before the therapeutic agent could reach the brain. Most importantly, blood-brain (BBB), blood tumor barriers (BTB), and blood-cerebrospinal fluid barrier BCB. The choice of the suitable route of administering such drugs became very challenging; the oral, intravenous, and intrathecal routes have failed to provide the desired bioavailability. However, the non-invasive course for delivering chemotherapeutics to the brain to target various CNS tumors needs to be studied. The nose-to brain delivery was an alternative route for delivering anticancer drugs to CNS, being non-invasive and highly efficient in bypassing the blood-brain and brain tumor barriers while limiting the systemic side effects.

Although the intranasal delivery mechanism is not well understood, several investigations have demonstrated the drug to have reached the brain mainly through the olfactory and trigeminal nerves. However, incorporating

nanoparticle and materials in the drug formulations has further enhanced the drug permeation across the BBB via the nose-to-brain route. Nevertheless, an extensive study on brain tumor targeting via the nose to brain rout will provide sufficient knowledge to aid the drug development and therapeutic outcomes of devastating brain tumors and other disorders. Therefore, nose-to-brain delivery of chemotherapeutics serves as the breakthrough for bypassing the effect of BBB, BTB, and CSF barriers. For that reason, designing the chemotherapeutics agents in the form of inhalational nanoformulation will enhance the clinical prognosis of CNS tumors and the patients' quality of life.

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### **CONFLICT OF INTEREST**

The author declared nil conflict of interest

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## **Chapter-03**

### **PLURONICS: A THERANOSTIC APPROACH FOR ONCOLOGY CARE**

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**ABSTRACT:** Cancer is one of the most common diseases in the world, killing over seven million people each year. The prognosis for cancer therapy has evolved dramatically during the last two decades. New advancements in cancer therapy are developing, which are mostly based on tumor molecular features. Modern cancer-centric therapy based on medicinal antibodies or small molecules has made cancer treatment more tumor-specific and less harmful. Medical therapy that are effective for cancer patients are badly needed. Nano-particulate structures with a pluronic foundation are novel platforms for the delivery of anti-cancer agents. Because of their pharmacological qualities and adequate physicochemical features, these structures hold significant promise for the progress of cancer treatment. This study seeks to provide a more complete description of the pluronic drug delivery mechanisms now available, as well as an explanation of pluronic as a medical polymer. Based on pluronic formulations, hydrophobic payload formulations and revised, tailored dispersion processes are discussed. This review provides an overview of the present state of the art in theranostic applications of polymer micelles targeting the microenvironment of cancer cells. There are also some parameters for the future scope and potential prospects.

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#### **INTRODUCTION**

Several technologies are being evaluated or have already been applied in clinical trials. Although nanomedicine aids in the development of

biocompatible materials for both diagnostic and therapeutic objectives, the bioengineering of extracellular vesicles and patient cells enabled the development of ad hoc systems and univocal targeting methodologies. The application of nanotechnology in the realm of medication delivery has resulted in the development of Nano medicines. Nano pharmaceuticals are certain to overcome the different barriers that the field of pharmacy is presently facing by providing various advantages, hence promising the possibility to develop new medications with fewer side effects [1,2].

Recent research has focused on developing functionalized therapeutic nanoparticles that are over-expressed in diverse cancer cells for specific biological reasons. Potential therapeutic benefits of engineered nanoparticles include the ability to transform undesirable physical and chemical properties of bioactive molecules into desired biopharmacology patterns; increase therapeutic distribution through biologic boundary areas; monitor bioactive agent release; increase therapeutic effectiveness by selectively administering therapeutics to biological targets; and integrate multimodal imaging and therapeutics. The multifunctional framework focusing on pluronic nanoparticles with the possibility of merging imaging with therapy as well as including multiple receptor targeting has provided new insights for cancer care employing innovative nanomaterial [3, 4].

### **Polymeric Nanoparticles and targeting pathways**

Polymeric nanoparticles (NPs) have piqued the interest of researchers in recent years due to their unique features arising from their tiny size. The benefits of using polymeric NPs as drug carriers include the capacity to shield drugs and other compounds with biological activity from the environment, as well as increase their bioavailability and therapeutic index. The word "nanoparticle" refers to both nanocapsules and nanospheres, which differ in form. Nanocapsules are made up of an oily core in which the medicine is normally dissolved, surrounded by a polymeric shell that regulates the drug's release profile from the core [5, 6, 7]. Nanospheres are made up of a continuous polymeric network that allows the medicine to be maintained within or adsorbed onto their surface. The progress of nanoparticle-based clinical treatment approaches has resulted in substantial pharmacological advances that have reduced side effects and enhanced the safety, resolvability, Pharmacokinetics, and biodistribution of cytotoxic medicines. Polymeric nanoparticles are still used in cancer therapy because they provide an excellent platform for studying both hydrophilic and hydrophobic medicines [8, 9, 10]. However, most medications are released into the extracellular matrix; their efficacy is dependent on tissue diffusion, and their usage is limited due to their low in vivo specificity. As a result, the most recent site-specific targeting of nanoparticles represents a promising advancement in cancer science. Table 1 contains a number of instances of polymeric nanoformulation [11]. To optimize anticancer drug

biodistribution, nanoparticles (NPs) have been created with appropriate size and surface properties to extend their circulation duration in the body.

There have been two primary approaches to tumor targeting: passive and aggressive targeting. Passive targeting benefits from pathophysiological features of sick tissues, mainly tumors, whereas active targeting by the drug carrier initially employs passive targeting to gather in the tumor zone and then attach to the target cells utilizing ligands to internalize the NPs to the cells [12-15]. The passive targeting of medicines via nanocarrier is affected by the tumor microenvironment, the increased permeability and retention (EPR) effect, and tumor pH. Tumor cells multiply and expand faster than normal cells once formed. In active targeting by combining medicine or a nanocarrier with a cellular targeting motivation known as ligands, therapeutic medication can be produced with or without the usage of coupling agents. These target moieties have a high affinity for cell surface antigens (for example, receptors) and can be used to distinguish between normal and malignant cells depending on receptor or antigen expression levels [16-19]. In humans, the application of targeted Herceptin NPs aided in the differentiation of positive and negative cell breast cancer epidermal growth factor 2 (HER2). In over-expressed cells, the effective targeting of HER2 receptors with NPs has been demonstrated [20]. The particular features of cancer cells may be utilized in the creation of a tailored delivery system. Cancer cells, for example, commonly overexpress tumor antigens, carbohydrate-like structures.

**Table 1: Drug-loaded polymer nanoparticles in clinical trials or clinical use [4-8].**

Product	Drug	Applications	Status
Abraxane	Paclitaxel	Breast cancer, non-small cell lung cancer, pancreatic cancer	Approved
BA-003	Doxorubicin	Hepatocellular carcinoma	Phase III
Mitoxantrone-loaded Polybutylcyanoacrylate (DHAD-PBCA-NPs)	Mitoxantrone	Hepatocellular carcinoma	Phase II

Product	Drug	Applications	Status
ProLindac	Dichloro(1,2-diaminocyclohexane)platinum(II) DACHPt	Advanced ovarian cancer	Phase III
ABI-008	Docetaxel	Metastatic breast cancer, prostate cancer	Phase II
ABI-009	Rapamycin	Solid tumors	Phase II
ABI-011	Thiocolchicine dimer	Solid tumors, lymphoma	Phase II
BIND-014	Docetaxel	Non-small cell lung cancer	Phase II
Cycloset	Camptothecin	Solid tumors, rectal cancer, renal cell carcinoma, non-small cell lung cancer	Phase II
CALAA-01	siRNA targeting	Solid tumors	Phase I
Docetaxel-PNP	Docetaxel	Solid tumors	Phase I
Nanotax	Paclitaxel	Peritoneal neoplasms	Phase I

### Pluronics

Some Decades ago, the Baden Aniline and Soda Factory (BASF) developed Ethylene oxide-propylene oxides (EO-PO) based block of Copolymers under the brand names Pluronics and Tetronics (also known as Poloxamers and polyamines, respectively) under the trade names Pluronics and Tetronics [21]. Poly Ethylene Oxide (PEO) is a hydrophilic section that contributes 70% of the block copolymer, whereas PEO is a water-soluble nonionic class A-B A and B-A-B triblock copolymer, where A is (PEO) and B is polypropylene oxide (PPO), which is hydrophobic and contributes 30% of the block copolymer [22]. Because the monomers of the copolymer blocks (polar and nonpolar, for example) are chemically different, the block

copolymers are amphiphilic and induce active surface characteristics. The block separation produces interesting nanostructures that are spontaneously generated by solution (self-assembly). Poloxamers revealed an amphiphilic nature in aqueous solutions based on their PEO water solubility and PPO insolubility. As a result, hydraulic are the PEO bricks and hydraulic are the PPO stone. Their size and composition, as well as their adsorption, have made them helpful in a variety of applications, including medication distribution, nanoparticle creation, cosmetics and emulsion formulations, effective ink/pigment dispersants as flexible anti-biofouling shielding, and so on [23-30]. Poloxamers are often explored in clinical studies. The vast range of biological uses for the multiple pluronic F127 (PF127) kinds has piqued the curiosity of researchers. Poloxamers are available in a wide variety of molecular weights and PPO/PEO ratios. Table 2 [31] contains examples of commercially available Pluronic®. They have high cell compatibility and do not pose severe problems. The beneficial characteristics open the way for the approval of various linear PEO-PPO-PEO triblock in the food, pharmaceutical, and agricultural industries by the US Food and Drug Administration (US FDA) and the European Medicines Evaluation Agency (EMA) [31-33].

### **Impact of Pluronic on drug resistance pathway**

#### **Inhibition of P-glycoprotein (Pgp) drug efflux system**

Pluronic enhanced cytotoxicity in anthracycline drug-resistant malignancy, doxorubicin, appears to be connected to the actions of copolymers on the transport of the Pgp drug efflux system. This is supported by the discovery that doxorubicin accumulation can be significantly increased in intracellular resistant cancer cells expressing Pgp [34, 35]. There were no differences in drug consumption in the presence of Pluronic in non-Pgp-expressing carcinogenic cells, indicating that the Pgp-controlled transportation pathways in Multidrug-resistant (MDR) cells were particularly impacted by copolymers.

#### **Effects on other drug transporters**

The evidence that the Pgp efflux pump may inhibit pluronic block copolymers alone is growing. There is an increase in data. Pluronic can therefore also impede these conveyors, resulting in enhanced fluorescein aggregation in Panc-1 cells [36]. Other organic anion carriers, notably Multidrug resistance-associated Protein (MRP2), have been shown to appear in Panc-1 in recent years.

#### **Effects on drug sequestration within cytoplasmic vesicles**

Drug in MDR cells can be sequestered inside cytoplasmic vesicles and then expressed from the cell until the drug can work as predicted on the cell, which is another potential hurdle in the treatment of immune-mediated malignancies [37-41]. H1-Adenosine Triphosphate (ATP), an ATP-based

pump, protects unusually high pH gradients across organelle membranes, resulting in drug sequestration in MDR cells [42]. Pluronics have been demonstrated to be capable of hyper-sensitizing various MDR cancers, enhancing antitumor activity by 2 to 3 times that of antineoplastic drugs. A dose-dependent investigation revealed that the action below the CMC was caused by free unimer chains.

**Table 2: Structural Features and CMC of Some Poloxamers (Pluronic®) commercially available [31].**

Copolymer	Molecular weight (Da)	Total Average Polyethylene oxide units	Total Average Polypropylene oxide units	Hydrophilic-lipophilic balance	Critical Micelle Concentration (mm)
L10	3200	7.3	49.7	12 – 18	---
L35	1900	21.6	16.4	18 – 23	5.3
F38	4600	83.6	15.9	> 24	---
L42	1630	7.4	22.5	7 – 12	---
L43	1850	12.6	22.4	7 – 12	2.2
L44	2200	20.0	22.8	12 – 18	3.6
L61	2000	4.55	31.0	1 – 7	0.11
L62	2500	11.4	34.5	1 – 7	0.40
L64	2900	26.4	30.0	12 – 18	0.48
P65	3400	38.6	29.3	12 – 18	---
F68	8400	152.7	29.0	> 24	0.48
F77	6600	105.0	34.1	> 24	---
L81	2750	6.3	42.7	1 – 7	0.023
P84	4200	38.2	43.5	12 – 18	0.071
P85	4600	52.3	39.7	12 – 18	0.065
F87	7700	122.5	39.8	> 24	0.091
F88	11400	207.3	39.3	> 24	0.25
L92	3650	16.6	50.3	1 – 7	0.088
F98	13000	236.4	44.8	> 24	0.077
L101	3800	8.6	59.0	1 – 7	0.0021
P103	4950	33.8	59.7	8 – 12	0.0061
P104	5900	53.6	61.0	12 – 18	0.0034
P105	6500	73.9	56.0	12 – 18	---
F108	14600	265.5	50.3	> 24	0.022

Copolymer	Molecular weight (Da)	Total Average Polyethylene oxide units	Total Average Polypropylene oxide units	Hydrophilic-lipophilic balance	Critical Micelle Concentration (mm)
L121	4400	10.0	68.3	1 – 7	0.0010
L122	5000	22.2	69.0	1 – 7	---
P123	5750	39.2	69.4	7 – 12	0.0044
F127	12,600	200.5	65.2	18 – 23	0.0028

### Effect on glutathione (GSH) and glutathione S transferases system (GST)

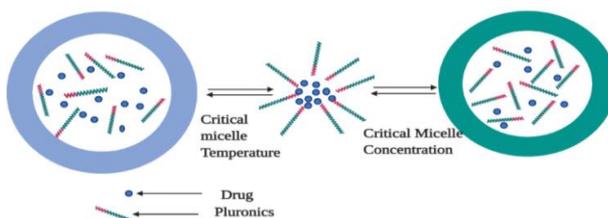
In terms of numerous substrates, multidrug resistance-associated protein (MRP) prescription flush transporters are intimately connected to the detoxification process in MDR cells [37]. Pluronic block copolymer impacts on GSH/GST devices are also being studied. For example, after exposing Madin-Darby Canine Kidney (MDCK) cells expressing PRP to several drug resistance routes, including P85, significant declines in both GSH and GST intracellular levels were detected.

### Pluronic self-assembly

In an aqueous medium, pluronic concentration and temperature are primarily regulated. The process has been dubbed lyotropic micellization in concept and thermotropic micellization in laboratory tests. If pluronic is coupled with water, it is good for the PEO block but detrimental for the PPO block; pluronic are micelles in an aqueous shape based on pluronic concentration and temperature, as seen in fig. 1 [43]. The pluronic solution behavior with the coarse grain model has already been discussed [44, 45]. The L44 monolayer behaved in a brush-like manner, allowing water to reach the whole PEO area. In contrast, it appears that the PPO air-region-oriented unit is designed to reduce water contact. The fact that all PEO blocks are accessible to water and the central PPO block is exposed to vacuum via a U-shape conformation is particularly interesting [46]. When the number of unimers reaches the Critical Micelle Concentration (CMC), self-assembly produces micelle, polymer, and lyotropic liquid crystalline phases [47, 48].

Complex molecular interactions between micelles, bulk solvents, and micelles are part of the process [49]. Very hydrophobic pluronic do not micellize, resulting in unstable vesicular formations in the cloud stage (20 percent PEO). At room temperature, the hydrophobic, somewhat atomized copolymers form narrowly dispersed micelles of the heart. According to calorimetric differential scanning investigations, the migration of unimers to micelles is an endothermic process. As the temperature rises, its nature shifts from hydrophilic to hydrophobic, implying that critical micelle

temperature (CMT) trumps CMC [50]. The hydrophobicity of the PEO and PPO blocks rises at higher temperatures due to reduced chances for H bond formation (the fraction of anhydrous methyl groups). The shift in aggregate hydrodynamic size can be used to test for temperature-dependent micellization and de-micellization [51].



**Fig.1: The development of pluronic micelles in the watery medium according to Pluronic and temperature concentration [42].**

### Aggregation behavior of pluronic micelles

Micelles often grow around the cloud point in the presence of salt or undergo a metamorphosis to rod-like assembly [52]. Temperature, additive existence or hydrophobicity, and copolymer concentration are the primary determinants of these changes. Additives such as electrolytes (inorganic salts, ionic liquids), nonelectrolytes (urea, sugar, alcohol), and amphiphilic chemicals (hydrotropes and ionic surfactants with low molecular weight, as well as other copolymers) [53-57]. Dehydration of the PEO–PPO interface by additions having favorable interactions with water reduces the CMC or CMT. Micellization of mixed solvents, on the other hand, provides increased solubility for copolymers. Alexandridis and colleagues, for example, demonstrated a twofold rise in CMC P105-F127 with the addition of 40v/v percent ethanol in water [58]. Pluronic solution behavior can also be altered chemically. Neutral hydrophilic blocks can be cationized or anionised depending on requirement [59]. Major modifications in step actions were seen in pentablock copolymers consisting of poly (N-isopropyl acrylamide) and poly (lactic acid-co-glycolic acid) and distinct end blocks [60, 61]. Mixed pluronic structures with ionic surfactants generate tiny micelles that are surfactant-rich and enhance surfactant concentration [62].

### Solubilization of drugs in pluronic micelles

Medicines with limited water solubility continue to be a challenge, especially considering the rising trends in molecular synthesis with high

molecular weights, melting temperatures, and lipophilicity [63]. The breakdown of poorly soluble anticancer medicines limits bioavailability. This may be largely avoided by employing micellar structures. Because of its low immunogenicity and unique core-shell architectures, pluronic metabolism is suitable for both topical and systemic delivery. Micelles can be administered without danger of embolism. The hydrophobic core allows for the incorporation of several therapeutic products, while the hydrophobic corona protects against aggregation, protein adsorption, and solubility locus, and coordination of the loaded molecules is dependent on their composition and relative hydrophobicity [64-65]. The first is mostly dependent on the existence of pluronic, hydrophobic blocks.

### **Pluronics and drug specific targeting**

High-affinity contacts can accelerate the trafficking of drug transporters in the extracellular area from tumor interstitial to target cells. This can be accomplished by using ligands that exhibit preferential binding on the cancer cells surface to an elevated molecular target. By removing the target cells from within, this approach enhances cell absorption, reduces off-targeting effects, and magnifies therapeutic advantages. Anti-compound targeting, although its great specificity, is restricted in large-scale development due to their enormous molecular sizes, immunogenicity, and complexity. Its huge size makes carrier trafficking difficult, especially in solid tumors [66-65]. Low molecular weight chemicals, on the other hand, are affordable, non-immunogenic, and have greater density control on the carrier's surface. To attack ligands, pluronic terminal hydroxyl groups were employed. The method entails the direct binding of ligands to more volatile aldehyde, carboxylic acid, and primary amine terminals, as well as the formation of hydroxyl groups. The latter can bind molecules that are responsive to stimuli and targets. Crosslinkable groups are frequently added into the hydrophilic block to minimize premature drug-loaded release that would otherwise occur due to excessively diluting micelles during demicellization. Despite phase change, pluronics with low CMC values have been chosen as biological response modifiers, as seen in fig. 2. Pluronics raised cytosolic reactive oxygen levels in the cytoplasm, which led in a pro-apoptotic signal being amplified or resistance to acupuncture in MDR cells being diminished [66]. Pluronic unimer, which is built into mitochondrial membranes, has also been proposed to modify membrane structure as a result of increased cytochrome C and reactive oxygen species (ROS) levels, which contribute to mitochondrial death. Pluronic P85 in combination with Doxorubicin (DOX) and Breast Cancer Resistance Protein (BCRP) plays an important function in enhancing pro-apoptotic signaling and restricting anti-apoptotic cell machinery in MDR cells. DOX, on the other hand, will activate both the pro-apoptotic signal and the cellular defense against sensitive DOX cancer cells [68].

**pH responsive micelles**

As a result of their journey from the circulation into the tumor microenvironment, cells, and subset cells, the carriers have distinct pH changes. While their surroundings is somewhat acidic (6.5 to 7.2), pH on endosomes (5.5–6.0) and lysosomes (4.0–5.0) has been documented [69, 70]. The objective is for drug cleavage and release to take place on later endosomes or lysosomes, as well as tumor tissue [71-73]. The acid-labile bonds ketal, acetal, hydrazone, imine, cis aconytil, and orthoester were investigated. Conjugates built with pH-sensitive linkages outperform those focused on the behavior of lysosomal proteases. The synthetic solution necessitates the medication's direct attachment to or entrapment in pH-sensitive block micelles through pH.

The first was demonstrated by covalently attaching curcumin to hydrophilic blocks of F68 via a cis-aconytil anhydride connection. Another technique employs the covalent relationship of pH-responsive poly (-amino ester) as a biodegradable polymer. While low pH allows medications to be released into cells, the major problem remains enhancing micelle affinity for cancer cells. This is possible because to the recent showing of recognizable ligands on micelles by Xu et al. Tumor cells that overexpress sialic acid residues in the extracellular domain might be a target for such transporters. In comparison to free doxorubicin, hybrid micelles increased tumor inhibitory potency by more than 3.4 times. Similar alterations in the anti-tumor action of pH-sensitive proteins were reported after folic acid attachment [74].

**Redox sensitive micelles**

Cancer cells' uncontrolled growth and high metabolic rate lead to the formation of reactive oxygen species. ROS accelerates cancer mutation rates and creates erratic signals [75]. At the same time as the intracellular and extracellular redox cells are actively configuring their states, a safety device is acting. GSH, a tripeptide-containing thiol (-glutamyl-cysteinyl-glycine), is produced and efficiently regulates the latter. GSH acts as a bridge between electrical, free radical, and ROS neutralization [76, 77].

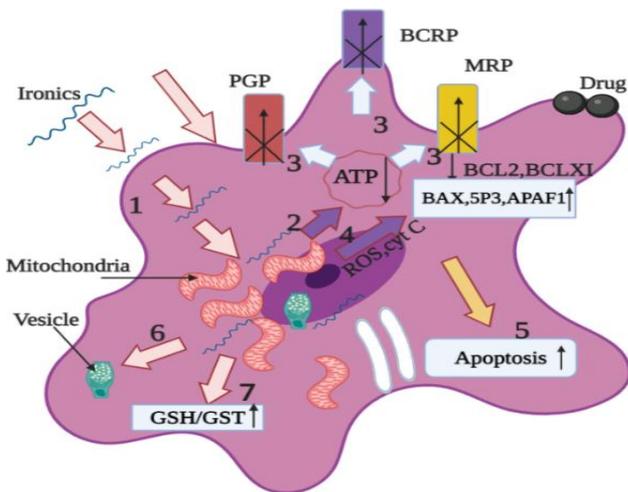
**Ultrasound-sensitive micelles**

Acoustic waves can regulate reversible endothelial permeability and focused medication release at the tumor location. Tumor simulation and drug release activation can both be done at the same time here. By using ultrasound-induced interference, the tumor interstitium will discharge a large payload within the pluronic micelles. The disintegration of micelles and the release of the payload proved that the power output change may be regulated remotely [78]. The copolymer was created by combining azide-completed PEO and alkyne-completed PPO, resulting in a junction site with 1, 2, 3 triazole movement and four ester bonds. A change in average micelle diameter has been utilized to demonstrate the shattering of intersections

produced by High-Intensity Focused Ultrasound (HIFU) (from 26 nm to 90 nm).

**Radiation responsive micelles**

PDT employs a chemical photosensitizer (PS), which when exposed to a certain wavelength creates singlet oxygen and other ROS in tumor cells. These radicals are produced during the molecular interaction of active PS with intracellular oxygen. The metabolism of tumor and healthy cells distinguishes them. Through the oncogenic transition, increased metabolic and mitochondrial dysfunction permits cancer cells to experience higher oxidative stress. PDT also has anti-cancer effects through vascular shut-down, cell membrane destabilization, local immune system activation, and tumor antigen injection into infiltrating immune cells. The transformation of sole-to-gel can overcome burst release and rapid clearance of tumor area micelle [79-81].



**Fig. 2: Effect of Pluronic in MDR cancer cells: (1) entrance of Pluronic, (2) ATP depletion, (3) drug efflux inhibition, (4) cytochrome C release and elevation of ROS in the cytoplasm, (5) pro-apoptotic signaling elevation and lower anti-apoptotic defense, (6) inhibition on the glutathione/glutathione S-transferases detoxification system, and (7) elimination of drug sequestration within cytoplasmic vesicles.**

**Pluronic micelles as drug solubilizing/ stabilizing carrier**

Polymeric micelles enable for the incorporation and protection of weakly water-soluble medicines into biological media, and they aspire to give

effective treatment and targeting capabilities [82-87]. Several studies have demonstrated that combinations of pluronic and other polymers can boost the cytotoxicity of anti-cancer bioactive compounds with MDR in tumor tissues [88, 89]. The self-assembly capability of PF127 in the form of micelles was also evaluated for drug delivery targeting. Nanoparticle-sized pluronic micellar structures that may encapsulate hydrophobic agents on the surface of a nanoparticle inside the micelle's wide core or conjugate hydrophilic moieties. Because of the thermal reactive properties of the pluronic, it may also be employed to create hydrogels in situ [90-94].

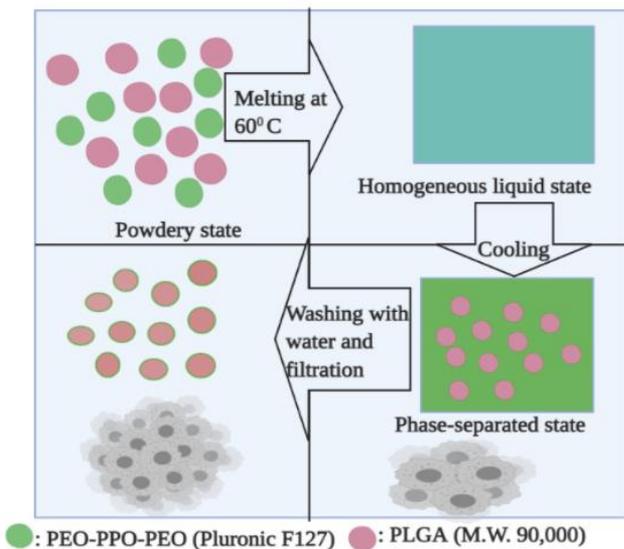
Hydrogels are appropriate in situ for both local and systemic medication delivery. In the realm of drug delivery, pluronic substances are easily mixed, blended, or absorbed by other common polymers such as chitosan, Polylactic Acid (PLA), PLGA, and so on. Polymeric micelles form at lower levels and have stronger thermodynamic and kinetic resilience than normal surfactant micelles in terms of tolerating thermodynamic therapeutic dilution, as well as increased drug solubilization and stabilizing ability [95-96]. Furthermore, micelles with PEO hydrophilic blocks are sterically stabilized, making macrophages less likely to eat them [97]. Drug entrapment in the micellar structure restricts bond access to an external medium, resulting in a substantially lower drug-copolymer bond hydrolyze rate than for usual drug-polymer conjugates. Even though the micelle influences cellular and body distribution, only liberated drug molecules are expected to be medicinal in a mechanically confined environment [98].

Paclitaxel (PTX) was thermally transformed into Pluronic-based NPs with a core/shell structure in a combination of Pluronic F-68 and liquid polyethylene glycol (PEG; molecular weight: 400). For nanoencapsulation PEG containing PTX, Liquid PEG and Pluronic F-68 are employed as PTX solubilizers. Furthermore, emulsions of PEG containing PTX and liquidized Pluronic F-68 were created at the nanoscale level by extracting the melted mixture at a transition temperature. The PEG-containing PTX pluronic F-68 nanoencapsulation was completed by cooling the liquid combination to 0 °C. FE (field emission)-Scanning Electron Microscopy (SEM), cryo-transmitting electron microscopy (TEM), and size distribution analysis clearly demonstrated the development of the PTX-equipped Pluronic NPs with core/shell structure. Due to PEO blocks in pluronic F-68, the prolonged circulation in the bloodstream of the PTX-charged Pluronic NPs, resulting in better tumor tissue targeting ability, was projected to be greater than that of the surfactant-based PTX [94, 98].

#### **Core shell nanoparticle as pluronic composite**

A temperature-induced phase transition is created for a PTX carrier in a combination of PLGA and Pluronic F-127 core/shell NPs with PLGA core and pluronic shells [99]. The liquidized combinations of PLGA, PTX, and

Pluronic F-127 were created at 600 degrees Celsius on a stepwise basis in response to temperature changes, resulting in a temperature drop to 250 degrees Celsius. Based on the PLGA and Pluronic F-127 activities. SEM was utilized to monitor the phase-separated condition and identify the PLGA center. When this combination was distributed in water, the Pluronic-coated PLGA NPs (core/shell NPs with PLGA core) were inhibited in the aqueous environment. The formation of PLGA NPs with pluronic coating is depicted in Fig. 3. The liquidized pluronic F-127 was used as a solvent to create PLGA NPs without the usage of a hazardous organic solvent. Unlike pluronic F-12, pluronic-coated PLGA NPs with a core/shell structure were not evaporated throughout the preparation process. For small drugs, the PTX and Docetaxel (DTX) models were chosen, while for protein-based treatments, the VEGF and HGH models were chosen. They had both PTX and DTX. The presence of a Pluronic coating on the liposome core surface facilitated the release of the model drug, resulting in a pattern of continuous release of both model medicines [100].

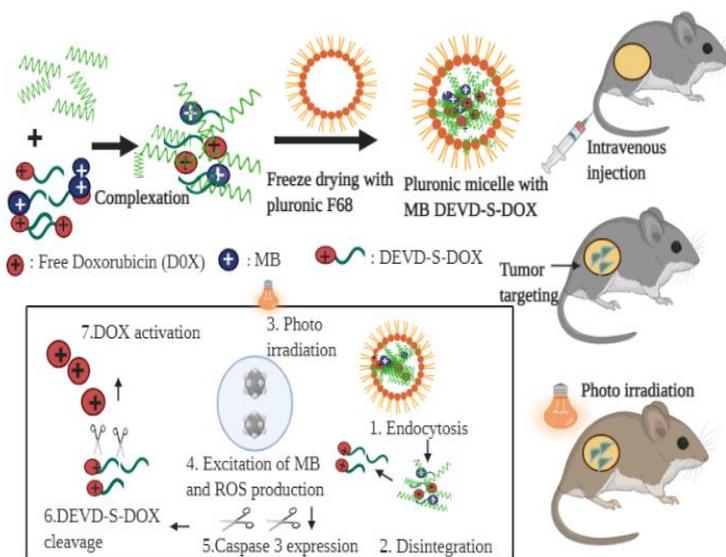


**Fig.3: Temperature-induced phase transition in the melt mixture of PLGA and Pluronic.**

**Building blocks with pluronics for targeted chemotherapy**

Traditional chemotherapy's shortcomings, such as a lack of specific tumor targeting and drug resistance, have been addressed by NP, and therefore

traditional chemotherapy has been enhanced [101-103]. Promising carriers of these pluronic NPs have been found in targeted cancer treatment. Polymeric micelles have been generated as a result of Pluronic micellization in aquatic solution, and their cores have been employed as depots for various therapy agents and diagnostic procedures [104]. Because the pluronic F-68 was primarily shielded by the surface of NPs and PEOs, pluronic NPs were projected to be kept in systemic circulation for a longer penetration and retention impact (EPR). This is a must. The in vivo biodistribution in the tumor can explain the increased targeting effectiveness around the tumor. In Phase II clinical trials, esophageal adenocarcinoma was examined for the antitumor efficacy of the DOX formulation, which was made up of pluronic (L61 and F127) and DOX [105-107]. This approach was developed to evaluate the multifunctional features of the DOX-controlled pluronic/heparin-np-system. After photo irradiation, the release of MB or DEVD-S-DOX from the NP resulted in the presence of MB or DEVD-S-DOX in the tumor-tissue mixture (fig. 4). Table 3 depicts many clinical studies employing Pluronic® polymer-containing formulations. Pluronic and heparin NPs were anticipated to concentrate in tumor tissues due to the EPR effect [108,109].



**Fig.4: An illustrative description of chemo-photodynamic combination therapy.**

**Table 3: Some examples of Pluronic®-containing formulations in clinical trials [108].**

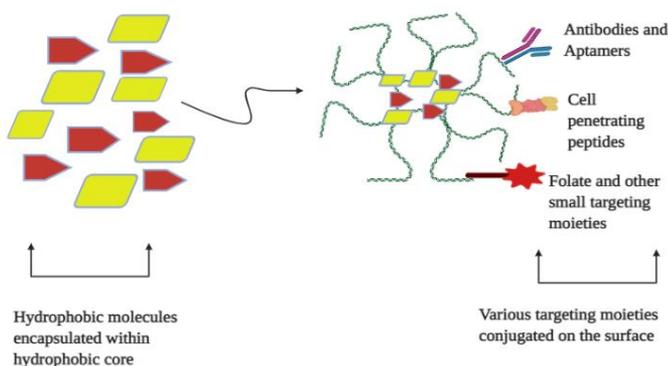
Industry/sponsor	Pluronic® containing formulation	Use	Stage
Supratek Pharma Inc.	SP1049C: Doxorubicin + Pluronic® L61 and F127	Advanced esophageal adenocarcinoma	Phase III
Mast Therapeutics, Inc.	Purified Poloxamer 188 (based on Pluronic® F68)	Vaso-occlusive crisis	Phase III
British Columbia Cancer Agency	Topical amitriptyline 2%, ketamine 1%, and lidocaine 5% in Pluronic® lecithine organogel	Neuropathic pain secondary to radiation therapy	Phase III Completed
CoDa Therapeutics, Inc.	Nexagon®: Pluronic® gel	Persistent corneal epithelial defects	Phase II
Sancilio and Company, Inc.	SC401B (Pluronic® F87 as a surfactant)	Severe hypertriglyceridemia	Phase III
Valentis	VLTS-934 (Pluronic® Poloxamer 188)	Peripheral vascular disease	Phase II Completed

**Pluronic a therapeutic molecule**

Tolerance is the most difficult obstacle to the success of chemical agents. Resistance is largely caused by efflux pumps that reduce pharmacological therapeutic intracellular levels [110]. Pluronic systems can alleviate the therapeutic resistance caused by Efflux. Several investigations have found Pluronic changes that cause lower efflux activity in the lipid microenvironment of P-gp. The pluronic polymers reduce the membrane microviscosity, which allows chemotherapy drugs to enter cancer cells. Furthermore, pluronic destabilizes the mitochondrial membrane and causes considerable ATP depletion in cancer cells. According to the Kabanov research group, pluronic can inhibit the mitochondrial electron transport chain (Complexes I and IV), potentially increasing the ROS level within the target cancer cells [111]. High ROS disrupts the usual arrangement of the mitochondrial membrane and causes the release of apoptotic mediators. Pluronic cytochrome-mediated release c, Apoptosis-Inducing Factor (AIF),

and Endonuclease G can rapidly activate additional apoptotic mediators within the programmed cell death protocol.

Another important function of pluronic as a medical polymer is the reduction of metastasis. Normal therapeutic compounds have a minimal effectiveness in metastatic malignancies. Pluronic polymers with medium hydrophilic-lipophilic equilibrium (HLB) have been shown to inhibit cancer cell migration and invasion. A pluronic effect was found to significantly prevent lung metastasis in the 4T1 tumor-carrying mice model [112]. Surprisingly, pluronic Antimetastatic properties are connected to a reduction in matrix metalloproteinases (MMP) control, such as MMP-9. Furthermore, the above-mentioned study found that the combination of pluronic and doxorubicin had significant synergistic anti-metastatic action. In another study, P85 pluronic copolymer micelles containing 5-Fluorouracil (5FU) were created for colon cancer suppression [113]. A novel pluronic F68 conjugated delivery mechanism was recently developed [114]. Concerning naked medicines, the efficacy and toxicity of these micelles were suitable. Gemcitabine is a 70-gent anti-cancer medication that is used in a variety of chemotherapy regimens. Dinarv and the research team present a unique chitosan-pluronic oral delivery technique. Hydrophilic shells of pluronic nanoparticles can be employed to conjugate target moieties such as folates, aptamers, and monoclonal antibodies (fig. 5). There are various folate-conjugated pluronic frameworks for the transmission of paclitaxel and doxorubicin, which has demonstrated significant tumor aggregation folate cross-connected pluronic frameworks [115-119].



**Fig.5: Pluronic based delivery system; a novel platform for formulation of hydrophobic molecules and targeted delivery.**

**Pluronic as a theranostic approach**

Nanoscale theranostic agents, such as polymeric micelles, are often investigated as possible gold standards in a personal medicine setting for the simultaneous diagnosis, treatment, and tracking of tumor progression [110]. In comparison to standard treatments, theranostic functional pluronic polymer micelles have showed enormous potential in terms of improving and tracking medicine distribution after injection, which can increase therapeutic efficacy and decrease off-target toxicity. Recent research has found that the tumor microenvironment (TME), which includes malignancy, invasion, and metastasis, is a key regulator of cancer progression [111, 112]. A fundamental biological mechanism in which cohesive and polarized epithelial cells give way to nonpolarized and highly mobile mesenchymal-like cells is still an essential component of epithelial-mesenchymal transfer [113].

Nanomedicine's unique design remains important since tumor obstacles to drug accumulation (altered flow, thick matrix, efflux pumps, etc.) are many and extremely effective. The employment of nano-caregivers, decorated with the most appropriate targeting vector and therapeutic substance, all chosen in light of genetic knowledge for the recipient, is a method of effective transmission to the cells involved, while the protection and efficacy of the therapy are extensive [114, 115]. The hydrated pluronic PEO shell generates sterical repulsion and results in a protein adsorption strength barrier that is highly activated [116-123]. Table 4 shows several instances of pluronic micelles used in cancer detection. It therefore reduces the creation of protein corona, which adds to the nanocarriers extended blood circulation and bio-imaging performance for theranostic purposes (fig. 6) [124,125].

**Table 4: Overview of some pluronic micelles for cancer diagnosis; theranostic approach**

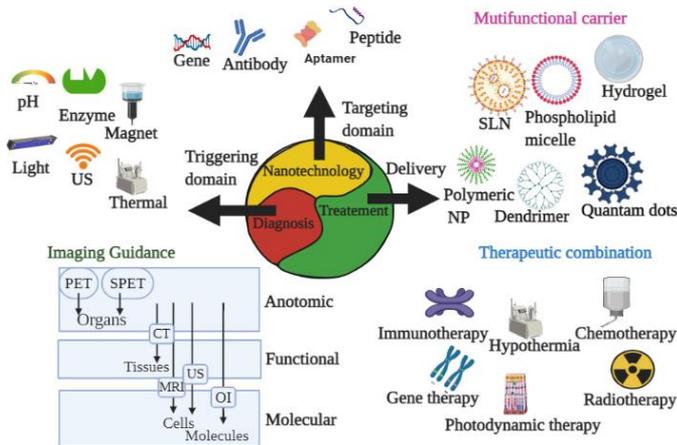
Pluronic	Imaging						Reference
	Agent Model	Modality		Drug	Theranostic		
		Result			Purpose		
Pluronic F68	Cyanine 5.5 (Cy5.5) dye	NIR	DT X	HIFU	in vitro SCC-7 cells, murine	Targetable/	127

Pluronic	Imaging					Reference
	Agent Model	Modality Result	Drug	Theranostic		
	Purpose					
				in vivo male C3H/HeN mice	PMs triggering release into tumor cells occurs under HIFU exposure through nonthermal mechanisms, which increase the therapeutic effect.	

Pluronic	Imaging						Reference
	Agent Model	Modality	Drug	Theranostic			
	Result			Purpose			
F127	β-thiophene-fused-BF2 azadi-pyrromethene (aza BDTP)	NIR	PTX	Photoacoustic imaging and photothermal	<i>in vitro</i> 4T1 cells, mouse	Co-loading of aza-BDTP and PTX (BDTP/PTX micelles show promising <i>in vitro/in vivo</i> results as nanotheranostic vehicles.)	128
					breast cancer cell line		
F127	AuNPs	NIR	PTX	chemo-photothermal	<i>in vitro</i> MDA-MB-231 cells	In <i>vitro</i> and <i>in vivo</i> studies using the combined strategy. (The pluronic-PLL-Au micellar carrier can cause a synergistic effect that is promising	129
				therapy			

Plur onic	Imaging						Refer ence
	Agent Model	Modality Result		Drug	Theranostic		
	Purpose						
					<i>in vivo</i> female Balb/c nude	for chemo- photother mal therapy.)	
F127	AuNPs IR780 iodide	NIR 105	IR7 80	photod ynamic and photo- thermal therapi es and surface - enhanc ed reso- nance Raman scatteri ng	<i>in vitro</i> C26 cells, murine colon carcino ma cell line	The use of the AuNPs- F127- IR780 micellar system indicates synergisti c effects by simultane ous photodyn amic and photother mal activity.	129

Pluronic	Imaging					Reference
	Agent Model	Modality	Drug	Theranostic	Purpose	
	Result					
P123 F127	rhodamine-B dye	NIR	Verteporfin	Photodynamic therapy	in vitro MCF-7 cells, human breast cancer cell line PC3 cells, human prostate cancer cell line	Multifunctional pluronic P123/F127 mixed micelles show promising results for the encapsulation and delivery of the photodynamic therapy.



**Fig. 6: Multifunctional theranostic and bio imaging nanosystems. PET, positron electron transmission; SPECT, single photon emission**

**computed tomography; CT, computed tomography; MRI, magnetic resonance imaging; NPs, nanoparticles; US, ultrasounds; OI, optical imaging [125].**

The Pluronic P94 was investigated for its ability to guide radionuclide infusions intravenously and intratumorally [126]. In the hybrid Single-Photon Emission Computerized Tomography (SPECT)/ Computed Tomography (CT) imaging pluronic F68 micelles integrating Near-Infrared (NIR) Cy 5.5 and DOX have been proven to be beneficial in the diagnosis and treatment of targets. Pluronic F127 is not affected by protein adsorption.

### **CONFLICT OF INTEREST**

None

### **AUTHOR'S CONTRIBUTION**

The manuscript's first draft was written by P.R.R and P.M.D. has examined and revised it. The published version of the work has been reviewed and approved by all authors.

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## **Chapter-04**

### **IMPACT OF CLINICAL PHARMACIST TO IDENTIFY RISK FACTORS OF SELF-MEDICATION PRACTICES AMONG ELDERLY IN BANGALORE- A SURVEY**

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**ABSTRACT:** Self-medication is defined as the exploit of an item for consumption without proper therapeutic supervision and no prescription to indulge a disease to promote health. Self-medication usage has been triggered by a few criteria like economic, political, cultural factors, and the practice is becoming a major, health problem among the public worldwide. The main motto of the study was based on the Impact of clinical pharmacists to identify risk factors of self-medication practices among the elderly. It is a community-based, Prospective, cross-section, and observational study. The purpose of our research was to examine the risk factors of self-medication practices amongst older adults. Various studies revealed that self-medication practices are standard throughout the world. Prevalence of self-medication is 84.21% practices subsist high in this study was comparable prevalence has been reported in studies conducted among Nepal 81.9%, Southwestern Nigeria 91.4%. In the present study, a self-medication practice among the elderly is about 10% but in other reports is about 16.9%. The principal objection related to self-medication practices was fever and headache (40%), followed by cough (22.63%), pain, and chills (14.73%). In this study the medicines that are used presently for self-medication were analgesics (25.26%), antipyretics (19.47%), and antibacterial (13.68%).The study concluded that the majority of the study participants had self-medication (84.21%). The

study found that the conditions such as fever, headache, infection, etc. were the main ailments for the participants that took to self-medication the most recurrently used class of drugs were analgesics (25.26%), antipyretics (19.47%), and antibacterial (13.68%).

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## INTRODUCTION

Self-medication is defined as the utilization of a product without Physician prescription or medical consultation to prevent or to treat a disease to promote health significance at that point in time.[1] According to WHO's definition, self-medication involves the consumption of medicinal products by the consumer to treat self-diagnosed disorders or symptoms and continued use of medication prescribed by a physician for chronic or recurrent diseases symptoms.[2] A study in 2000-2004 confirmed a drastic rise of self-medication habits in the last years from 17% to 35.5%.[3] Globally constant rise in self-medication has subsisted provoked by a few criteria like economic, political is the strategy is becoming a significant public health problem.[4] However, there is a variation in the prevalence of self-medication practices among a few countries relative to the variations in socioeconomic aspects, dissimilarities in health care systems such as compensation rules, access to health care, and medicine dispensing policies.[5] In specific, over-the-counter (OTC) drugs are of confirmed efficacy and safety; their indiscriminate use improper knowledge of the interactions in extreme age groups and special conditions such as pregnancy and lactation can have profound implications.[6-7] For decreasing the threat of antibiotic resistance, a limitation of self-medication practices of antibiotics is required[8].

## AIM AND OBJECTIVES

The plan of the study was based on identifying the reasons for the Practices of Self-Medication among the elderly and creates awareness to prevent the unnecessary usage of medicines without a prescription.

## METHODOLOGY

**Study sample:** The sample size considered is [N= 190 Patients.]

**Study Design:** It is a Community -based, Prospective, cross-sectional, and observational study.

**Study Period:** The current study was performed for duration of 8 months, from July 2019 to February 2020.

**Study site:** The study was performed in a few areas of Bangalore.

## STUDY CRITERIA

### Inclusion criteria:

People around the age group of 18-55 years and who are ready to participate were included.

**Exclusion criteria:** People below the age group of <18 and above the age group of 55 were excluded. People who were not qualified to participate were excluded.

### SOURCE OF DATA

#### Method of collection of data:

All the samples assuring the inclusion criteria were selected after explaining the study to the subjects. Tool of data collection Structured interviewing questionnaire was designed to collect data.

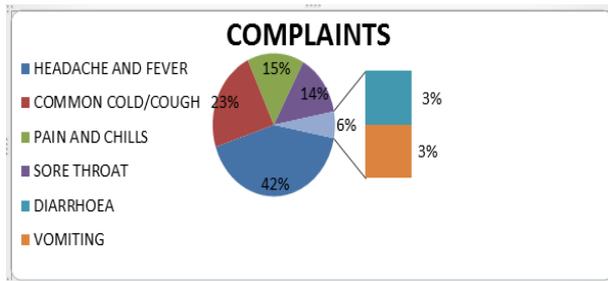
**Statistical tools:** Data were collected from the patient's chart and was subjected to analyzed by performing descriptive statistics. The obtained data was tabulated and analyzed by using inferential and descriptive statistics.

## RESULTS

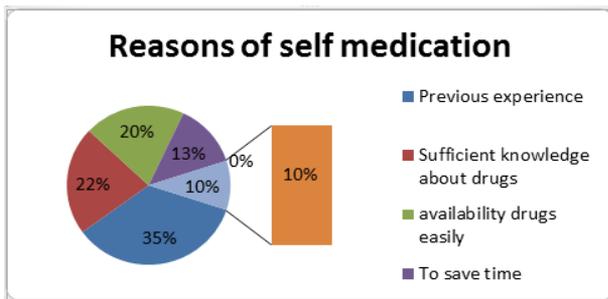
**Table 1: Basic demographic details of the patient**

S.NO	DEMOGRAPHIC DETAILS	NUMBER	PERCENTAGE
1.	GENDER		
	MALE	67	35.26%
	FEMALE	123	64.73%
2.	AGE:(IN YEARS)		
	18-25	67	35.26%
	25-35	46	24.21%
	35-45	35	18.42%
	45-55	23	12.10%
>55	19	10%	
3.	MARITAL STATUS		
	MARRIED	75	39.47%
	SINGLE	56	39.47%
	SEPARATED	18	29.47%
DIVORCED	41	21.57%	
4.	ACADEMIC STATUS		
	ILLITERATE	21	11.05%
	READ & WRITE BUT NO	35	18.42%
	FORMAL EDUCATION	16	8.42%
	PRIMARY & SECONDARY	46	24.21%
EDUCATION			

S.NO	DEMOGRAPHIC DETAILS	NUMBER	PERCENTAGE
	HIGHER EDUCATION	72	37.89%
5.	MONTHLY INCOME		
	<1500	41	21.57%
	1500-3000	85	44.73%
	>3000	64	33.89%
6.	HAVE INSURANCE		
	YES	65	34.21%
	NO	125	65.78%
7.	NUMBER OF CHILDREN		
	0	45	23.68%
	1	67	35.26%
	2	48	25.26%
	>2	30	15.78%
8.	PLACE OF RESIDENCE		
	RURAL	102	53.68%
	URBAN	88	46.31%



**Fig.1: Complaints of Self-medication**



**Fig.2: Reasons for self- medications**

**Table 2: Every Practiced Self-Medication**

Yes	160	84.21%
No	30	15.78%

**Table 3: Class of Medicines Used In Self-medications**

List of medicine used in self-medication	frequency	percentage
Analgesics	48	25.26%
Antipyretics	37	19.47%
Antibacterial	26	13.68%
Vitamins & minerals	19	10%
Antiemetic	16	8.42%
Antacids & Antiulcer	14	7.36%
Antifungal	8	4.21%
Anti-allergy & medicine used in anaphylaxis	8	4.21%
Anti-malarial	5	2.63%
Ophthalmic medicines	4	2.10%
Laxatives	3	1.57%
Cathartic	2	1.05%

**DISCUSSION**

The purpose of our research was to consider the risk factors of self-medication practices among older adults. Various studies revealed that self-medication practices are standard throughout the world. The prevalence of self-medication practices in our study was 84.21%. Similar incidence has been reported from Serbia students 79.9% <sup>[9]</sup> Nepal 81.9% <sup>[10]</sup> South-western Nigeria 91.4%. In the present study, self-medication practices among elderly is about 10%. But, other study reports the self-medication practices among the elderly are about 16.9%. This study shows that the significant objection related to self-medication practices was fever and headache (40%), Followed by cough (22.63%), pain, and chills (14.73%). A study in southwestern Nigeria reported UTI, Sore throat, and diarrhea as the significant complaints, which correlates with our analysis. Classes of medicines that are used recurrently for self-medication in this study were analgesics (25.26%), antipyretics (19.47%), and antibacterial (13.68%). Our

study correlates with the results observed in another survey from Nepal in which antipyretic, analgesics, and antibacterial were the drug commonly used for self-medication. But in our research it was originate to be the least reported medicine (2.63%) [10]. The reason behind the selection of these medicines could be due to mild disease, previous experience of good findings. The common basis for self-medication practices reported by our study respondents are previous experience, sufficient knowledge about drugs, and availability of drugs readily, to save time, to save money and health facility.

## **CONCLUSION**

The study concluded that a significant part of the study participants had self-medication (84.21%). The study states that more than 10% of the elderly practiced self-medication. The study showed females practiced self-medication more than males. Their common reason was for practice was found to be previous occurrence, knowledge about the drug. The study found that fever, headache, and infections were the main diseases for the participants for self-medication. The most recurrently used class of drugs was analgesics (25.26%), antipyretics (19.47%), and antibacterial (13.68%). The monthly income & knowledge about self-medication drugs were associated with SMP (self-medication practice).

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**CONFLICT OF INTEREST-None**

**AUTHORS CONTRIBUTION AND AUTHORS FUNDING- Nil**

**ETHICAL APPROVAL-** The study was accepted and approved by the Institutional Ethics Committee

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## Chapter-05

### **ANTIOXIDANT ACTIVITIES OF VARIOUS SEED EXTRACTS FROM FOUR VARIETIES OF RAMBUTAN (*Nephelium lappaceum*) USING DPPH AND ABTS ASSAYS**

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**ABSTRACT:** The objectives of this research were to study antioxidant activities from various seed extracts of four varieties of rambutan using DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2'-azinobis (3-ethyl-benzothiazoline-6-sulfonic acid) methods and correlation of total flavonoid, phenolic, and carotenoid content with IC<sub>50</sub> of DPPH and IC<sub>50</sub> of ABTS. Antioxidant activities, total flavonoid, phenolic and carotenoid content of various seed extracts were performed by UV-visible spectrophotometry and their correlation with IC<sub>50</sub> of DPPH and IC<sub>50</sub> of ABTS antioxidant activities were analyzed by Pearson's method. Ethanolic seed extract of lebak bulus variety had the lowest IC<sub>50</sub> of DPPH scavenging activity, while ethyl acetate seed extract of rajah variety had the lowest IC<sub>50</sub> of ABTS scavenging activity. The highest total flavonoid, total phenolic and total carotenoid content were given by ethyl acetate extract of binjai variety, ethanolic extract of raphia variety and ethanolic extract of rajah variety, respectively. There was negatively high correlation between total flavonoid, phenolic, carotenoid content in seed extracts of raphia variety with their IC<sub>50</sub> of DPPH and IC<sub>50</sub> of ABTS scavenging activity. All of ethyl acetate and ethanolic seed extracts of four varieties of rambutan were very strong antioxidant by DPPH and ABTS methods. Flavonoid, phenolic and carotenoid compounds in seed extracts of raphia variety were great contributor in their antioxidant activities by DPPH and ABTS methods. The IC<sub>50</sub> of DPPH and IC<sub>50</sub> of ABTS scavenging activity in seed extracts of lebak bulus, rajah and raphia varieties gave linear result..

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## INTRODUCTION

The oxidative stress could be correlated with many degenerative diseases. Antioxidant has potency to protect oxidative stress. Phenolic compounds are commonly found in plants, which have multiple biological effects, including antioxidant activity [1-3]. Many studies had reported that phenolic content in plants could be related with their antioxidant activities. Plants contained phenolic and polyphenol compounds can act as antioxidant [4-6]. Some of antioxidant methods such as DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2'-azinobis (3-ethyl-benzothiazoline-6-sulfonic acid), FRAP (Ferric Reducing Antioxidant Power) and CUPRAC (Cupric ion Reducing Antioxidant Capacity) were widely used to predict antioxidant capacity of fresh fruits, beverages, and food [6-9]. Previous studies [4,6, 9-10] exposed that DPPH and ABTS methods could be used to measure antioxidant activity in many plants extracts. The previous research [4,11-12] exhibited antioxidant activities of some plants including rambutan (*Nephelium lappaceum*).

The objectives of this research were to study antioxidant activities of various polarities extracts (n-hexane, ethyl acetate and ethanol) from four varieties of rambutan (*Nephelium lappaceum*) seeds using DPPH and ABTS assays; and correlation of their antioxidant activities with total phenolic, flavonoid and carotenoid content in each extract.

## MATERIALS AND METHODS

### Materials

DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2'-azinobis (3-ethyl-benzothiazoline-6-sulfonic acid), gallic acid, quercetin, beta carotene was purchased from Sigma-Aldrich (MO, USA), seed from four varieties of rambutan. All of other reagents were analytical grades.

### Preparation of sample

Seed from four varieties of rambutan (*Nephelium lappaceum*) were collected from Subang- West Java that were: lebak bulus variety namely as sample LE, rajah variety as RJ, raphia variety as RP and binjai variety as BI were thoroughly washed with tap water, sorted while wet, cut, dried, and grinded into powder.

### Extraction

Three hundred grams of powdered samples were extracted by reflux apparatus using increasing polarity of solvents. The extraction using n-hexane was repeated three times. The remaining residue was then extracted three times using ethyl acetate. Finally, the remaining residue was extracted three times using ethanol. So, totally there were twelve extracts: four of n-hexane extracts (LE1, RJ1, RP1 and BI1), four of ethyl acetate extracts

(LE2, RJ2, RP2 and BI2) and four of ethanolic extracts (LE3, RJ3, RP3 and BI3).

#### **IC<sub>50</sub> of DPPH scavenging activity**

Preparation of DPPH solution was adopted from Blois [13] with minor modification. Various concentration of each extract was piped into DPPH solution 50 µg/ml (1:1) to initiate the reaction for obtaining a calibration curve. After 30 minutes incubation, the absorbance was read at wavelength 515 nm by using spectrophotometer UV-Vis Hewlett Packard 8435. Methanol was used as a blank. DPPH solution 50 µg/ml was used as control. Ascorbic acid was used as standard. Analysis was done in triplicate for standard and each extract. Antioxidant activity of each extract was determined based on the reduction of DPPH absorbance by calculating percentage of antioxidant activity [14]. IC<sub>50</sub> of DPPH scavenging activity of each extract can be calculated using its calibration curve.

#### **IC<sub>50</sub> of ABTS scavenging activity**

Preparation of ABTS radical solution were adopted from Li *et al.* [15] method with minor modification. ABTS diammonium salt solution 7.6 mM in distilled water and potassium persulfate solution 2.5 mM in distilled water were prepared. Each solution allowing to stand in the dark room for 12 hours. The two solutions were mixed with 30 minutes incubation, allowing to stand in refrigerator for 24 hours, then diluted in ethanol. Various concentration of each extract was piped into ABTS solution 50 µg/ml (1:1) to initiate the reaction for obtaining a calibration curve. The absorbance was read at wavelength 734 nm using spectrophotometer UV-Vis Hewlett Packard 8435. Ethanol (95%) was used as a blank. ABTS solution 50 µg/ml was used as control. Ascorbic acid was used as standard. Analysis was done in triplicate for standard and each extract. Antioxidant capacity of each extract was determined based on the reduction of ABTS absorbance by calculating percentage of antioxidant activity [14]. IC<sub>50</sub> of ABTS scavenging activity of each extract can be calculated using its calibration curve.

#### **Total flavonoid content (TFC)**

Total flavonoid content was measured using adapted method from Chang *et al.* [16]. The absorbance was read at wavelength 415 nm. Analysis was done in triplicate for each extract. Standard solution of quercetin 20-120 µg/ml were used to obtain a standard curve. The total flavonoid content was reported as percentage of total quercetin equivalent per 100 g extract (g QE/100 g).

#### **Total phenolic content (TPC)**

Total phenolic content was measured using Folin-Ciocalteu reagent adapted from Pourmorad [3]. The absorbance was read at wavelength 765 nm. Analysis was done in triplicate for each extract. Standard solution of gallic acid 30-180 µg/ml were used to obtain a standard curve. The total

phenolic content was reported as percentage of total gallic acid equivalent per 100 g extract (g GAE/100 g).

**Total carotenoid content (TCC)**

Total carotenoid content was measured using the modified carotene method adapted from Thaipong *et al* [6]. Each extract was diluted in n-hexane. The absorbance was read at wavelength 470 nm. Analysis was done in triplicate for each extract. Standard solution of beta carotene 5-70 µg/ml were used to obtain a standard curve. The total carotenoid content was reported as percentage of total beta carotene equivalent per 100 g extract (g BE/100 g).

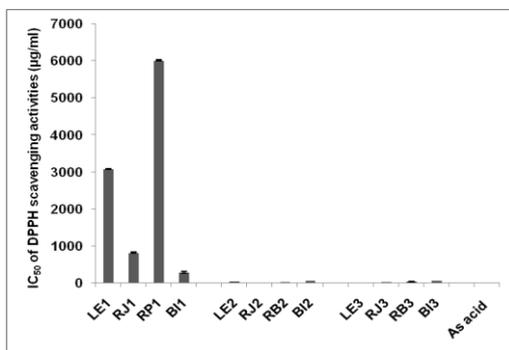
**Statistical Analysis**

Analysis of each sample was performed in triplicate. All results presented were the means (± SD) of at least three independent experiments. Statistical analysis (ANOVA with a statistical significance level set at p < 0.05 and post-hoc Tukey procedure) was carried out with SPSS 16.0 for Windows. Correlations between the total flavonoid, phenolic, carotenoid content and antioxidant activities were done using the Pearson’s method (p < 0.01).

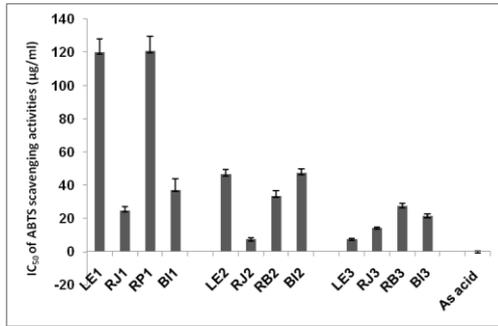
**RESULTS**

**IC<sub>50</sub> of DPPH scavenging activities and IC<sub>50</sub> of ABTS scavenging activities**

The IC<sub>50</sub> of DPPH scavenging activities and IC<sub>50</sub> of ABTS scavenging activities in various seed extracts from four varieties of rambutan using DPPH and ABTS assays were shown in Fig 1 and Fig 2. The IC<sub>50</sub> of DPPH scavenging activities and IC<sub>50</sub> of ABTS scavenging activities in various seed extracts compared to IC<sub>50</sub> of ascorbic acid standard. The lowest IC<sub>50</sub> means had the highest antioxidant activity.



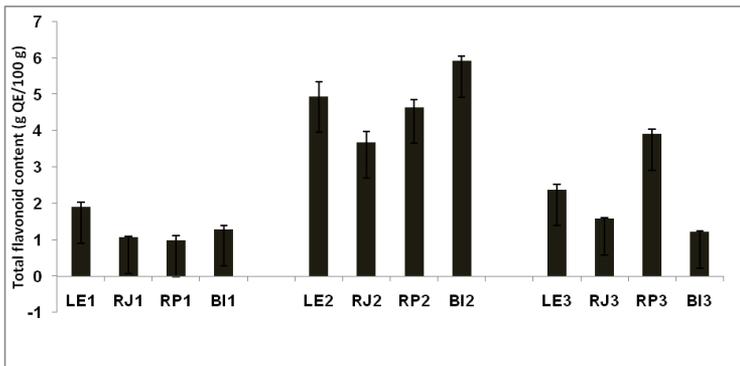
**Fig 1: IC<sub>50</sub> of DPPH scavenging activities in various seed extracts from four varieties of rambutan, n=3**



**Fig 2:** IC<sub>50</sub> of ABTS scavenging activities in various seed extracts from four varieties of rambutan, n = 3

**TFC in various seed extracts from four varieties of rambutan**

TFC in various extracts were demonstrated in term of quercetin equivalent using the standard curve equation  $y = 0.007 x - 0.027$ ,  $R^2 = 0.995$ . TFC in various rambutan seed extracts showed different result ranged from 0.99 to 5.93 g QE/100 g (Fig 3). N-hexane rambutan seed extract of rapih variety (RP1) had the lowest total flavonoid content (0.99 g QE/100 g) and the highest (5.93 g QE/100 g) was given by ethyl acetate rambutan seed extract of binjai variety (BI2).

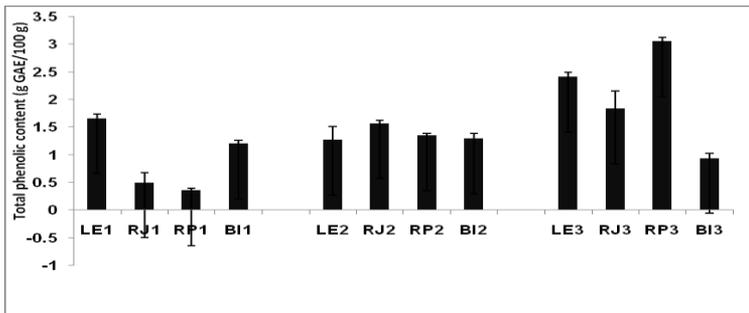


**Fig 3:** Total flavonoid content in various seed extracts from four varieties of rambutan, n=3

**TPC in various seed extracts from four varieties of rambutan**

TPC in various extracts were expressed in term of gallic acid equivalent using the standard curve equation  $y = 0.006 x - 0.055$ ,  $R^2 = 0.998$ . TPC in

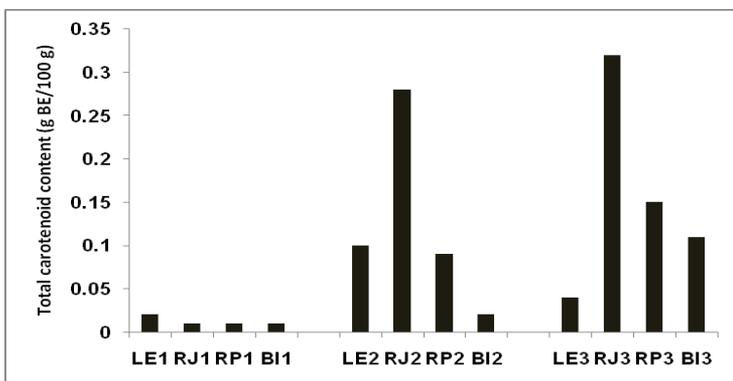
various rambutan seed extracts showed different result ranged from 0.36 to 3.05 g GAE/100 g. Ethanolic rambutan seed extract of rapijah variety (RP3) had the highest phenolic content (3.05 g GAE/100 g) (Fig 4).



**Fig 4: Total phenolic content in various seed extracts from four varieties of rambutan, n=3**

**TCC in various seed extracts from four varieties of rambutan**

TCC in various extracts were exposed in term of beta carotene equivalent using the standard curve equation  $y = 0.012 x - 0.008$ ,  $R^2 = 0.998$ . TCC in various rambutan seed extracts showed different result in the range of 0.1 – 0.32 g BE/100 g (Fig 5). The highest carotenoid content (0.32 g BE/100 g) for ethanolic rambutan seed extract of rajah variety (RJ3), while the lowest carotenoid (0.1 g BE/100 g) were given by n-hexane rambutan seed extracts of rajah, rapijah and binjai varieties (RJ1, RP1 and BI1).



**Fig 5: Total carotenoid content in various seed extracts from four varieties of rambutan, n=3**

**Table 1: Pearson’s correlation coefficient of IC<sub>50</sub> of DPPH scavenging activities, IC<sub>50</sub> of ABTS scavenging activities and TFC, TPC, TCC in various seed extracts from four varieties of rambutan**

	Pearson’s correlation coefficient (r)						
	TFC	TPC	TCC	IC <sub>50</sub> ABTS LE	IC <sub>50</sub> ABTS RJ	IC <sub>50</sub> ABTS RP	IC <sub>50</sub> ABTS BI
IC <sub>50</sub> DPPH LE	- 0.607*	- 0.184 <sup>ns</sup>	- 0.641*	0.940**			
IC <sub>50</sub> DPPH RJ	- 0.646*	- 0.940**	- 0.991**		0.907**		
IC <sub>50</sub> DPPH RP	- 0.978**	- 0.780**	- 0.916**			0.994**	
IC <sub>50</sub> DPPH BI	- 0.487 <sup>ns</sup>	0.246 <sup>ns</sup>	- 0.586 <sup>ns</sup>				0.081 <sup>ns</sup>
IC <sub>50</sub> ABTS LE	- 0.320 <sup>ns</sup>	- 0.488 <sup>ns</sup>	- 0.378 <sup>ns</sup>				
IC <sub>50</sub> ABTS RJ	- 0.889**	0.769**	- 0.850**				
IC <sub>50</sub> ABTS RP	- 0.959**	- 0.802**	- 0.926**				
IC <sub>50</sub> ABTS BI	0.755**	0.889**	- 0.826**				

DPPH = DPPH scavenging activity, ABTS = ABTS scavenging activity, TPC = total phenolic content, TFC = total phenolic content, TCC = total carotenoid content, LE = sample LE, RJ = sample RJ, RP = sample RP, BI = sample BI, ns = not significant, \* = significant at p < 0.05, \*\* = significant at p < 0.01

**Correlations between IC<sub>50</sub> of DPPH scavenging activities, IC<sub>50</sub> of ABTS scavenging activities and TFC, TPC and TCC in various seed extracts from four varieties of rambutan**

Pearson’s correlation coefficient between TFC in various seed extracts from four varieties of rambutan and their antioxidant activities demonstrated that

TFC in seed extract of rapih variety had negatively high correlation with  $IC_{50}$  of DPPH ( $r = -0.978$ ,  $p < 0.01$ ) and  $IC_{50}$  of ABTS ( $r = -0.959$ ,  $p < 0.01$ ). TPC in sample RJ and RP had negative and high correlation with their  $IC_{50}$  of DPPH scavenging activities ( $r = -0.940$ ;  $r = -0.780$ ,  $p < 0.01$ , respectively), and only TPC in seed extract of rapih variety had negative and high correlation with  $IC_{50}$  of ABTS scavenging activities ( $r = -0.802$ ,  $p < 0.01$ ). TCC in sample RJ and RP had negatively high correlation with their  $IC_{50}$  of DPPH scavenging activities ( $r = -0.991$ ,  $r = -0.916$ ,  $p < 0.01$ , respectively) and  $IC_{50}$  of ABTS scavenging activities ( $r = -0.850$ ,  $r = -0.926$ ,  $p < 0.01$ , respectively).

## DISCUSSION

Previous study [4,8,11-12,17] reported that rambutan (*N. lappaceum*) had antioxidant capacity. There was no study regarding antioxidant activity of three different polarities extracts (which were n-hexane, ethyl acetate and ethanol) of seed from four varieties (lebak bulus, rajah, rapih and binjai) of rambutan using DPPH and ABTS assays.

Both of DPPH and ABTS are stable free radicals which dissolve in methanol or ethanol, and their colors show characteristic absorption at wavelength 516 nm or 734 nm, respectively. Colors DPPH and ABTS would be changed when the free radicals were scavenged by antioxidant [18].

$IC_{50}$  of DPPH scavenging activity is the concentration of sample or standard that can inhibit 50% of DPPH scavenging activity.  $IC_{50}$  of ABTS scavenging activity is the concentration of sample or standard that can inhibit 50% of ABTS scavenging activity. The lowest  $IC_{50}$  means had the highest antioxidant capacity. The  $IC_{50}$  were used to categorize antioxidant activity of a sample that compared to standard. Sample that has  $IC_{50} < 50$   $\mu\text{g/ml}$  is very strong antioxidant, 50-100  $\mu\text{g/ml}$  is strong antioxidant, 101-150  $\mu\text{g/ml}$  is medium antioxidant, while  $IC_{50} > 150$   $\mu\text{g/ml}$  is weak antioxidant [13].

The  $IC_{50}$  of DPPH scavenging activities of various seed extract from four varieties of rambutan in the range of 7-6000  $\mu\text{g/ml}$ . Ethanolic rambutan seed extract of lebak bulus variety (LE3) had the lowest  $IC_{50}$  of DPPH radical scavenging capacity 7  $\mu\text{g/ml}$ , while ascorbic acid standard gave  $IC_{50}$  of DPPH scavenging capacity 2  $\mu\text{g/ml}$ . Based on value of  $IC_{50}$  of DPPH scavenging capacity it can be concluded that the ethyl acetate and ethanolic seed extracts of four varieties of rambutan can be categorized as very strong antioxidant. It was similar with the previous research [17] which was revealed that all of ethyl acetate and ethanolic peel extracts from four varieties of rambutan was classified as very strong antioxidant, and only

ethanolic leaves extracts of five varieties of rambutan were categorized as very strong antioxidant [4]. In the previous research [11] exposed that  $IC_{50}$  of DPPH scavenging activity of methanol peels extract of rambutan was 4.94  $\mu\text{g/ml}$  which was lower than ascorbic acid as standard, while Samuagam et al. [8] reported that 80 % ethanol peels extract which was extracted in 120 minutes at 50°C had  $IC_{50}$  of DPPH scavenging activity 8.87  $\mu\text{g/ml}$ .

In the present study exposed that  $IC_{50}$  of ABTS scavenging activities of various seed extracts from four varieties of rambutan ranged from 7.34 to 120.8  $\mu\text{g/ml}$ . Ethyl acetate seed extract of rajah variety had the lowest  $IC_{50}$  of ABTS (7.34  $\mu\text{g/ml}$ ). Based on the  $IC_{50}$  value it can be concluded that all of seed extracts from four varieties of rambutan (except n-hexane seed extract of lebak bulus and rapih varieties) were categorized as very strong antioxidant by ABTS method. It was different with the previous study [4] which exhibited that  $IC_{50}$  of ABTS scavenging activity of various leaves extracts from five varieties of rambutan in the range of 12.83- 259.66  $\mu\text{g/ml}$ . Ethanolic leaves extract of rapih variety (RPH3) had the lowest  $IC_{50}$  of ABTS scavenging activity (12.83  $\mu\text{g/ml}$ ) while ascorbic acid standard gave  $IC_{50}$  of ABTS scavenging capacity 2.69  $\mu\text{g/ml}$ . The previous research [19] revealed that ethanol extract of fruit peels of rambutan (*N. lappaceum*) had TEAC (Trolox Equivalent Antioxidant Capacity) values was 3.07 mM/mg. TEAC assays is the same with ABTS assays. Fruit peels of rambutan can be classified as extremely high antioxidant activity because of its TEAC values above 3.0 mM/mg. Ethyl acetate rambutan peel extract of binjai variety (BJ2) had the lowest  $EC_{50}$  of FRAP capacity (77.1  $\mu\text{g/ml}$ ) compared to other extracts in various peel extracts from four varieties of rambutan [17].

The presence of total phenolic might contributed on antioxidant capacity [12]. The present research reported that the highest TPC was given by ethanolic seed extract of rapih variety (3.05 g GAE/100 g), while in the previous study exposed that the highest TPC was given by ethyl acetate peel extract of lebak bulus variety (40.9 g GAE/100 g) [17] and ethanolic leaves extract of rapih variety had the highest TPC (29.46  $\mu\text{g/ml}$ ) [4]. Previous research by Thitilertdecha et al. [11] demonstrated that total phenolic of methanolic peel extract of rambutan (542.2 mg catechin/g) was higher than water peel extract, ether peel extract, methanol seed extract, ether seed extract and water seed extract. The previous research [4] exposed total phenolic in methanol peel extract of rambutan was 542 mg/g extract. It was contrast with Samuagam et al. [8] which reported that 80 % ethanolic peel extract had total phenolic content 53.94 mg GAE/g extract.

Study by Fidrianny [4] showed that the highest TFC was given by n-hexane leaves extract of binjai variety (3.5 g QE/100 g). It was different with the present study which revealed that the highest TFC was given by ethyl acetate seed extract of binjai variety, but it was similar with the previous research which demonstrated that n-hexane peel extract of binjai variety had the highest TFC [17].

The present study reported that TCC in ethanolic seed extract of rajah variety (0.32 g BE/100 g) was the highest, it was contrast with the previous study which exhibited that n-hexane extract of peel and leaves of rapih variety rambutan gave the highest TCC 0.61 g BE/100 g and 6.41 g BE/100 g, respectively [4,17].

Pearson's correlation coefficient was positively high if  $0.61 \leq r \leq 0.97$  [6] and negatively high if  $-0.61 \leq r \leq -0.97$ . Sample which had the lowest  $IC_{50}$  of DPPH scavenging activity or  $IC_{50}$  of ABTS scavenging activity gave the highest antioxidant activity. So, the good correlation between TPC, TFC and TCC with  $IC_{50}$  DPPH and or  $IC_{50}$  ABTS will be given in negatively and high correlation [20]. It means increasing in TFC, TPC and TCC caused increasing in antioxidant activities, which was expressed by lower  $IC_{50}$  of DPPH scavenging activity and or  $IC_{50}$  of ABTS scavenging activity [20].

The data in Table 1 demonstrated that there were negatively and high correlation between TFC, TPC, TCC content in various seed extracts of rapih variety with  $IC_{50}$  of DPPH ( $r = -0.979$ ,  $r = -0.779$ ,  $r = -0.915$ ,  $p < 0.01$ , respectively) and with  $IC_{50}$  of ABTS ( $r = -0.959$ ,  $r = -0.802$ ,  $r = -0.926$ ,  $p < 0.01$ , respectively). Based on this data it can be concluded that flavonoid, phenolic and carotenoid compounds in various seed extracts of rapih variety were contributor in antioxidant activities by DPPH and ABTS methods. In the previous research exposed that TPC in various peel extracts of four varieties of rambutan (rajah, rapih, lebak bulus and binjai) had positively and high correlation with percentage of DPPH scavenging activities and percentage of FRAP capacities [17]. The same result which exposed that TPC in various leaves extracts of five varieties of rambutan (lebak bulus, binjai, rajah, rapih and non consumption) had positive and high correlation with percentage of DPPH and ABTS scavenging activities [4].

Flavonoid, phenolic acid, tannins were included in phenolic compounds. Flavonoid which have -OH in A ring and/or B ring will be included in phenolic groups. Flavonoid had higher antioxidant capacity than phenolic acid [21]. The higher antioxidant capacity of flavonoid was depended on position of -OH in C-3'-C-4', -OH in C-3, oxo function in C-4, double bond in C-2 and C-3. Ortho position of hydroxyl group in C-3'-C-4' had the highest influence in antioxidant capacity of flavonoid. The flavonoid aglycones would give higher antioxidant activity than flavonoid glycosides [21].

In Figure 3 revealed that TFC in ethanolic rambutan seed extract of binjai variety (BI3) 1.22 g QE/100 g was similar with TFC in n-hexane rambutan seed extract of binjai variety (BI1) 1.28 g QE/100 g, but  $IC_{50}$  of DPPH scavenging activity of BI3 46.5  $\mu\text{g/ml}$  (very strong antioxidant) was lower than  $IC_{50}$  of DPPH scavenging activity of BI1 270  $\mu\text{g/ml}$ , which was categorized as weak antioxidant. Based on this data it can be predicted that many flavonoid compounds in BI3 had -OH in C-3'-C-4', -OH in C-3, oxo function in C-4, double bond at C-2 and C-3 which had high influence in antioxidant activity, while almost all of flavonoid compounds in BI1 had -OH in other position which had low antioxidant activity.

It could be seen in Figure 4, TPC in ethyl acetate rambutan seed extract of rajah variety (RJ2) 1.57 g GAE/100 g was similar with TPC in n-hexane rambutan seed extract of lebak bulus variety (LE1) 1.66 g GAE/100 g, but RJ2 had  $IC_{50}$  DPPH scavenging activity 7.8  $\mu\text{g/ml}$  and  $IC_{50}$  of ABTS scavenging activity 7.34  $\mu\text{g/ml}$  (very strong antioxidant) were lower than  $IC_{50}$  of DPPH and  $IC_{50}$  of ABTS of LE1 (3071  $\mu\text{g/ml}$  and 120  $\mu\text{g/ml}$ , respectively). Based on data above it can be supposed that many phenolic compounds in n-hexane rambutan seed extract of lebak bulus variety had lower antioxidant activity. It was contrast in ethyl acetate rambutan seed extract of rajah variety that contained many phenolic compounds which had high antioxidant activity.

Carotenoid had antioxidant capacity by scavenging free radical. More double bonds in carotenoid would give higher free radical scavenging capacity [22]. Carotenoid that contained above 7 double bonds gave higher free radical scavenging activity than 7 double bonds [23]. Decreasing in lipophilicity of carotenoid would decrease free radical scavenging capacity [24]. Beta carotene was used as standard because it had conjugation double bonds due to its ability to scavenge free radicals [25-26]. In Figure 5 it could be seen TCC in ethyl acetate seed extract of binjai variety (BI2) 0.02 g BE/100 g was similar with TCC in n-hexane seed extract of lebak bulus variety (LE1) 0.02 g BE/100 g. BI2 had  $IC_{50}$  of DPPH scavenging activities (44.4  $\mu\text{g/ml}$ ) and  $IC_{50}$  of ABTS scavenging activity (47.25  $\mu\text{g/ml}$ ) (very strong antioxidant) which were lower than  $IC_{50}$  of DPPH (3071  $\mu\text{g/ml}$ ) and  $IC_{50}$  of ABTS (120  $\mu\text{g/ml}$ ) for LE1. Based on the data it can be predicted that almost all of carotenoid in BI2 had more than 7 double bonds which have high antioxidant activity and only a little of carotenoid in LE1 had more than 7 double bonds.

The DPPH and ABTS methods had the same mechanism reaction. Mechanism of DPPH and ABTS that was electron transfer assays [27], but the results of the two methods not always linear, because of not all of compound which can react with free radical of DPPH also react with free radical of ABTS. The Pearson's correlation coefficient indicated that  $IC_{50}$  of

DPPH scavenging activities in seed extracts of three varieties of rambutan (lebak bulus, rajah and rapih) had positively high correlation with their IC<sub>50</sub> of ABTS scavenging activities. DPPH and ABTS assays gave linear result for antioxidant activities in seed extracts of lebak bulus, rajah and rapih varieties.

## CONCLUSION

Different results could be given by different methods. Variety of methods must be used in parallel to assess the antioxidant capacity of sample. All of ethyl acetate and ethanolic seed extracts of four varieties of rambutan had IC<sub>50</sub> of DPPH and IC<sub>50</sub> of ABTS scavenging activities < 50 µg/ml that means were very strong antioxidant. There was negatively high correlation between TFC, TPC and TCC in seed extracts of rapih variety with their IC<sub>50</sub> of DPPH and IC<sub>50</sub> of ABTS scavenging activities. Flavonoid, phenolic and carotenoid compounds in seed extracts of rapih variety were contributor in antioxidant activity using DPPH and ABTS assays. Antioxidant activities of various seed extracts from three varieties of rambutan (lebak bulus, rajah and rapih) gave linear result using DPPH and ABTS assays. Seed extracts of four varieties (lebak bulus, rajah, rapih and binjai) of rambutan (*N. lappaceum*) may be exploited as natural antioxidant sources.

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## Chapter-06

### STUDIES ON PHARMACOLOGICAL ACTIVITY OF *WITHANIA SOMNIFERA* (ASHWAGANDHA)

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**ABSTRACT:** *Withania somnifera*, popularly known as Ashwagandha, is an important medicinal plant that has been around for over 3,000 years in Ayurveda and indigenous medicine. It is one of the most significant herbs in Ayurveda (India's traditional medical system), and it has been utilized as a Rasayana for millennia for its wide-ranging health effects. The main metabolites responsible for the plant's therapeutic qualities are withanolides. It has a wide range of pharmacological qualities for application in biological methods, including antibacterial, antiinflammatory, antistress, anticancer, neuroprotective, cardioprotective, and many more. Ashwagandha has a vast range of chemical components, including alkaloids, ergostane steroids, amino acids, and neurotransmitters, which explains its extensive range of therapeutic characteristics, which can prevent and treat a variety of diseases directly or indirectly. Various parts of the Ashwagandha plant, such as the roots and, less frequently, the leaves and fruits, have been utilised as plant-derived remedies. For generations, the extract prepared from the roots of *Withania somnifera* has been considered to have potent properties like promoting energy and vitality.

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## INTRODUCTION

*Withania somnifera*, is commonly known as winter cherry or ashwagandha, it belongs to Solanaceae family and annual evergreen shrub [1,2]. It's

cultivated in Asian countries as dietary supplements (Nutraceutical). *Withania somnifera*, popularly known as Ashwagandha, is an important medicinal plant that has been around for over 3,000 years in Ayurveda and indigenous medicine. The dried powder, crude extract, and purified phytochemicals of this medicinal plant have shown promising therapeutic qualities [3]. The main metabolites responsible for the plant's therapeutic qualities are withanolides. Because of the high concentration and variety of forms of withanolide, *Withania*'s medicinal value has been identified. It was frequently utilised to cure a variety of biological disorders in people, either alone or in conjunction with other plants [4,5]. It has a wide range of pharmacological qualities for application in biological methods, including antibacterial, antiinflammatory, antistress, anticancer, neuroprotective, cardioprotective, and many more. Ashwagandha has antioxidant [6], anxiolytic, adaptogen, memory-enhancing, antiparkinsonian [7], antivenom, antiinflammatory, and anticancer effects [8,9], according to studies. Immunomodulation, hypolipidemia, antimicrobial activity [10], cardiovascular protection, sexual behaviour, tolerance, and dependence are among the additional effects investigated. The species name *somnifera* means 'sleep-inducing' in Latin, indicating that to it are attributed sedating properties, however it's been conjointly used for sexual vitality and as an adaptogen. *Withania somnifera* (ashwagandha) is an upright, bittersweet, convergent evergreen shrub [11]. It mainly acts Ashwagandha is prescribed for fatigue or fatigue, reported adaptogens in nature (Adaptogens that boost the immune system and protect against mental and physical fatigue fight stress and tension and regulate all physical functions). fatigue, asthma, cancer, tuberculosis, tumor, rheumatism, psoriasis, old age, smallpox [12], wounds, syphilis, scabies, scabies, psoriasis anti-inflammatory, antitumor [13], anti-stress, antioxidant, immunomodulatory, hematopoietic and rejuvenating properties. In India, this plant species usually grows at high altitude, especially in the Himalayan and western parts including the Bikaner and Pilani regions of Rajasthan, Rajputana, Punjab, Gujrat and Manasa (MP). Ashwagandha is one of the most significant herbs in Ayurveda (India's traditional medical system), and it has been utilized as a Rasayana for millennia for its wide-ranging health effects. Rasayana is an herbal or metallic concoction that promotes a youthful physical and mental state of health as well as happiness [14]. It is used in a variety of formulations for musculoskeletal problems (e.g., arthritis, rheumatism) and as a general tonic in athletes, the elderly, and pregnant women to boost energy, promote overall health and longevity, and prevent disease [15]. Many pharmacological investigations have been undertaken to validate ashwagandha's use as a multi-purpose therapeutic drug. Anti-inflammatory qualities, for example, have been studied in order to confirm its usage in

inflammatory arthritis, and animal stress experiments have been conducted in order to study its potential as an antistress drug [16]. Ashwagandha has a vast range of chemical components, including alkaloids, ergostane steroids, amino acids, and neurotransmitters, which explains its extensive range of therapeutic characteristics, which can prevent and treat a variety of diseases directly or indirectly [17]. Traditional Indian medicine has employed the plant, particularly its root powder, for centuries. Anahygrine, Isopelletierine, Anaferine, Cuscohygrine, Vinblastine, Steroidal Lactones, Withaferin A, and other phytochemicals are found in its root [18]. The biologically active chemicals generated from this include sitoindoside and withanolide, which contain glucose molecules at carbon 27. *Withania somnifera* is a tomentose, tall shrub with evergreen branches [19]. The leaves are simple, glassy and elliptical in shape. Greenish or pale-yellow flowers appear in axillary, umbellate cymes. Fruits are globose berries that turn orange red when mature and are enclosed in a prolonged membranous calyx. The seeds are reniform and yellow. It has been discovered to be useful in the treatment of Alzheimer's and Parkinson's disease [20]. Various parts of the Ashwagandha plant, such as the roots and, less frequently, the leaves and fruits, have been utilised as plant-derived remedies. For generations, the roots of *Withania somnifera* have been used as a general tonic to promote energy and longevity. Several inflammatory markers, such as cytokines (Interleukin-6, Tumor necrosis factor-), reactive oxygen species (ROS), and nitric oxide, have been demonstrated to be inhibited by the roots of *Withania somnifera*. Furthermore, stem extract has anticancer properties, while berry extract has anti-disease Alzheimer's properties.

**Table.1: Phytochemicals of various parts of *Withania somnifera***

S.No	Part of plant	Phytochemicals
1	Root	Ashwagandhanolide, Withasomnine, visamine, anahygrine, withanine, mesoanaferine,
2	Stem	Somniwithanolide and Withasomnilide
3	leaves	Withanolides, tropine, anaferine and choline
4	Aerial parts	27-acetoxy-4 $\beta$ and diepoxy withanolide
5	Fruits	Palmitic acid, oleic acid and inoleic acid,

### Phytochemicals

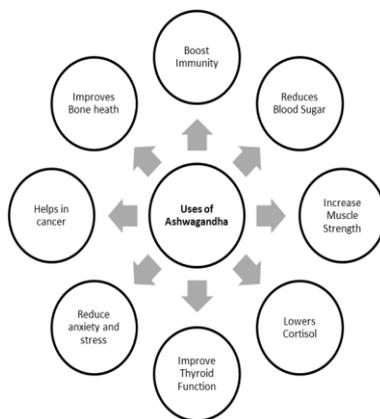
Phytochemicals are plant-derived compounds. Plants create phytochemicals (from the Greek phyto, which means "plant") through primary or secondary metabolism [21]. They usually have biological activity in the plant host and

help the plant grow or defend itself against predators, pathogens, or rivals. The principal ingredients of Ashwagandha extract, according to phytochemical screening, include phenolic compound, glycosides, alkaloid, and flavonoid. Among these phenolic chemicals are some that may be responsible for anti-oxidant activity.

### **Medicinal uses**

In India ,traditional medicine known as Ayurveda which has been present since 6000 BC as cited by Charak Samhita. For almost 6000 years, Ashwagandha has hold a crucial place in Indian Medicine [22]. The word Ashwa - Horse, Gandha - Smell which signifies Horse like smell which later was interpreted as Horse like Power who ever consumes it. It is considered as the most essential Rasayana in Ayurveda. The whole plant is considered important for various uses of ailment and therapeutic treatment since ancient times [23]. Several Studies and Research is been done on its uses and effect on human body. Its root or Mula is collected in both summer and winter season for the formulation of therapeutic medicine. Its root is considered aphrodisiac, diuretic, narcotic, astringent, tonic, anthelmintic as well as stimulant [24]. There are five basic forms which is been used in Pharmaceuticals formulations like Paste (Kalka), Liquid (Svarasa), Decoction (Srita ), Cold decoction (sita) and Hot infusion (Phanta ). Its paste is consumed by children as well as old age group with Milk to relive debility ,constipation, Rheumatism, insomnia, Goiter, Leucoderma, neurotic related issues. Its paste can also relive inflammation of joint pains ,Ulcer, Carbuncles and painfull swelling. It has also been used as Anti-Venom when combined with other medicine taken for snake bite. Its root has been taken as Juice for the treatment of Stomach deworming, Piles, Boils, Heat Pimples, Leucorrhoea and gas flatulence [25]. Several species of Ashwagandha is found in nature but the most significant is Nagori Ashwagandha. It is always suggested to use fresh juice or freshly prepared paste for high Potency and efficacy. Apart from roots its leaves, flower and seed is also found to be used for Medicinal purpose. It is has been proven effective in improving human Libido and other in fertility problems in both male n female. In male it has been extremely effective in the treatment like Oligosperms (low sperm count), hypospermia and teratospermia [26]. Its powder form is taken for improvement in production of males hormones like testosterone, Luteinizing hormonal disbalance.In female it is used as a Powerful tonic for uterine endometriosis. It increases Virility and stamina in men. Aswagandha arishtam is used as anti-depression and anxiety It also helps to regulate the Vata nad pitta doshas in human body which controls the serotonin level in turn keeps check in anxiety symptoms like uneasiness, restlessness, sweating of hand and feet. It also regulates sleep pattern and treat insomnia by improving mental health [27]. According to a Study conducted in 2017 in Tsukuba University in Japan. Its intake may be

extremely beneficial to increase bone density improvement as well as muscle mass density and treats health problems like fibromyalgia, osteoporosis etc. Diabetes Mellitus is result due to decrease or lack of insulin production by pancreatic cells can be improved by intake of *Ashwagandha lehyam* [28]. It blocks the breakdown of starch to glucose inturn reduces glucose level in blood. It is extremely efficient in treating heart related ailment as it is a very powerful anti-oxidant. Not only in therapeutic but also used in cosmetic industries being natural antioxidant. It helps in anti-aging process and skin improvement as it reduces free radical damage caused due to over exposure of sun. A significant reduction of wrinkles, dark circles, pigmentation of skin is seen after topical application of *Ashwagandha lapam* [29]. Few studies showed it does help in hair quality improvement and reduction of hair fall by nourishing the scalp, increases blood circulation which resulted in stronger hair roots. Few studies shows that Ashwagandha is very effective in the treatment of Hunting disease as it contains neuro protective properties which is leads to improvement in biochemical, behavioral dysfunction. Clinical studies and research have demonstrated that root extract from ashwagandha plant helps prevent seizures. The study was carried out in mice, but the same results can be realized in humans [30].



### **Pharmacological activities of *Withania somnifera* (Ashwagandha):**

**Anti-inflammatory:** In a study conducted by Uthirapathy S, the methanolic extract of *Withania somnifera* root was found to have substantial action in lowering paw edoema caused by carrageenan and reducing paw volume in Freund's adjuvant induced arthritis. In comparison to the common medicine indomethacin, the methanolic extract of *Withania somnifera* has a lower harmful effect [31].

**Anti-oxidant:** Wafaa et al. reported that the water extract of Ashwagandha (*Withania somnifera*) leaf exhibits potent antioxidant activity as well as anticancer characteristics when tested against the HepG2 cell line of hepatocellular carcinoma. Ashwagandha has been shown to be a potent antioxidant and a prospective anticancer drug in the treatment of HCC.

**Antimicrobial:** Bisht and Rawat looked into whether a methanolic extract of *Withania somnifera* leaf has an inhibitory effect on the growth of multidrug resistant pathogens such as Gram-positive cocci isolated from pus samples of patients with soft tissue infections. Nisha et al. investigated the antibacterial and antifungal properties of extracts and purified components from various Ashwagandha (*Withania somnifera*) plant sections in a variety of test microorganisms [32]. They came to the conclusion that Ashwagandha extract has the capacity to inhibit a variety of bacteria species.

**Anti-cancerous:** Renu et al. investigated the anticancer properties of *Withania somnifera*. In vitro and in vivo studies revealed anticancer efficacy in the water extract of Ashwagandha leaves (ASH-WEX). The active anticancer component was identified using bioactivity-based size fractionation and NMR analysis (s). Biochemical experiments were used to explore the mechanism of anticancer action in the extract and its purified component. Triethylene glycol was discovered as the active anticancer component (TEG). Withanamides, withanolides, withanosides, withanolide glycosides [33], steroidal saponins, and lignanamides are among the phytochemicals found in ashwagandha. The steroidal alkaloids and lactones known as withanolides are the main ingredients of alcoholic preparations of Ashwagandha. Withaferin A and withaferin B are two of them.

**Anti-diabetic:** Shah et al. observed that Ashwagandha (*Withania somnifera*) has a synergistic effect on glucose absorption in 3T3 fibroblasts in the presence of insulin. Jonathan et al. found that a plant extract of *Withania somnifera* exhibits anti-diabetic properties in two cellular diabetes models.

**Antiarthritic:** Khan et al. found that *Withania somnifera* root extract reduced oxidative stress and the development of autoantibodies in collagen-induced arthritic rats. The findings demonstrated that *Withania somnifera* extract has antioxidant and antiarthritic action as well as reduced inflammation in CIA rats, implying that this plant could be used to treat arthritis [34].

**Hepatoprotection:** Sabina et al. investigated Ashwagandha's hepatoprotective effects in the treatment of paracetamol-induced liver damage in rats. Treatment with *Withania somnifera* prevented changes in the levels of the activities of aspartate aminotransferase (AST), Alanine aminotransferase (ALT), and Alkaline Phosphatase (ALP) in serum, which

clearly indicated hepatic cell injury. The levels of serum bilirubin were also substantially higher in the *Withania somnifera* -treated rats than in the control rats, which were restored back to normal after treatment [35,36]. The total protein level of acetaminophen-treated rats was similarly considerably lower than that of normal rats. Treatment with , on the other hand, reversed the effects of Acetaminophen poisoning, restoring protein levels to those of control rats.

**Immunomodulatory:** The immunomodulatory properties of *Withania somnifera* were explored by Ajit et al. (Ashwagandha). They demonstrated in a clinical research that extracts from the plant's roots and leaves, which were standardised with withanolide glycosides, have significant immune stimulatory activities. Th2 up-regulating activity was established, as shown by increased IL4 production and increased Th1 (IFN-), strongly confirming the involvement of *Withania somnifera* in circumstances where Th1/Th2 modulation is essential. boosted CD4+/CD8+ cell proliferation without changing the ratio, as well as NK cell proliferation, CD3+/CD19+/CD45+ cell expression, and circulating antibody and antibody-forming cells [38,39]. The findings of their study show that *Withania somnifera* with a defined chemical signature and immune-stimulatory properties is a desirable addition to immunity-boosting herbal formulas.

**Antiparkinsonian:** S. Rajasankar et al. looked at whether the root extract of *Withania somnifera* could help with catecholamines, oxidative damage, and physiological abnormalities associated with Parkinson's disease. The PD mouse model was given a 7-day or 28-day therapy with *Withania somnifera* root extract, which resulted in enhanced neural function and enhanced levels of GSH and GPx in the striatum. Thus, showing that *Withania somnifera* has potent Antiparkinsonian activity [40].

**Table.2: Pharmacological activities**

S No.	Pharmacological Activity	Type of Extract	Reference
1.	Anti-inflammatory	Methanolic	Uthirapathy and Subasini 2021.
2.	Immunomodulatory effect	Extract prepared by Green Chemistry based process (devoid of any alcohol)	Priyanka G et al., 2020.

S No.	Pharmacological Activity	Type of Extract	Reference
3.	Antimicrobial activity	Methanolic Ethanolic, methanolic, acetone and several other extracts were used	Bisht P and Rawat V 2014. Khanchandani et al., 2019.
4.	Antistress	Alcoholic Root extract	Amit Ashok G and MB S 2015
5.	Antiaging	Alcoholic Root extract	Kelgane SB et al., 2020
6.	Anticonvulsant	Alcoholic extract	Kumar S et al., 2016
7.	Antioxidant	Acqueous extract	Ahmed W et al., 2018.
8.	Anti-arthritis effect	Alcoholic root extract	Khan, M et al., 2015
9.	Anti-carcinogenic	Acqueous extract	Wadhwa R et al., 2013
10.	Antidiabetic	Alcoholic leaf and root extract	Gorelick J et al., 2015
11.	Hepatoprotection	Alcoholic extract	Sabina EP et al., 2013
12.	Anti-ulcerogenic effect	Alcoholic extract of defatted seeds	Singh N et al., 1982
13.	Cardiovascular protection	Aqueous extract	Sandhu JS et al., 2010
14.	Antiparkinsonian	Alcoholic extract	RajaSankar S et al., 2009
15.	Anxiolytic effect	Aqueous root extract	Salve J et al., 2019

**Antistress:** In a research performed on animals and humans, Alex B Speers et al. discovered that the root and leaf extracts of *Withania somnifera* demonstrated remarkable anti-stress and anti-anxiety action. Though fewer

research looked into these uses, WS decreased depression and sleeplessness symptoms [41]. The hypothalamic-pituitary-adrenal and sympathetic-adrenal medullary axis, as well as GABAergic and serotonergic pathways, may be modulated by WS to ameliorate these symptoms.

## CONCLUSION

*Withania somnifera*, popularly known as Ashwagandha, is an important medicinal plant that has been around for over 3,000 years in Ayurveda and indigenous medicine. It is one of the most significant herbs in Ayurveda (India's traditional medical system), and it has been utilized as a Rasayana for millennia for its wide-ranging health effects. The main metabolites responsible for the plant's therapeutic qualities are withanolides. It has a wide range of pharmacological qualities for application in biological methods, including antibacterial, antiinflammatory, antistress, anticancer, neuroprotective, cardioprotective, and many more. Ashwagandha has a vast range of chemical components, including alkaloids, ergostane steroids, amino acids, and neurotransmitters, which explains its extensive range of therapeutic characteristics, which can prevent and treat a variety of diseases directly or indirectly. Various parts of the Ashwagandha plant, such as the roots and, less frequently, the leaves and fruits, have been utilised as plant-derived remedies. For generations, the roots of *Withania somnifera* have been used as a general tonic to promote energy and longevity.

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## **Chapter-07**

### **DIFFERENT ASPECTS OF QUALITY CONTROL IN THE STANDARDIZATION OF AYURVEDIC FORMULATION**

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**Abstract:** Herbal medicine has great therapeutic value and has the potential to meet global health needs. However, standardization, quality control, and quality assurance is a herculean task due to the variability of the components present in single or Polyherbal formulations, so it is a toilsome task to be characterized by a single method. Nowadays, various sophisticated analytical steps and techniques have been implemented for the qualitative and quantitative identification of herbal or Ayurvedic formulations. Multiple and sequential analysis required for the characterization of the herbal drug which includes organoleptic studies, pharmacognostic studies, extraction of phytoconstituents in different solvents. Further, the respective solvent fractions were processed for isolation of Phytoconstituents. The characterization and structure elucidation of the isolated phytoconstituents can be performed by sophisticated analytical techniques such as UV, IR, NMR, MASS spectrometry, etc. The identified phytoconstituent can be used as a single drug in clinical application and also used in the standardization as well as stability studies of polyherbal or ayurvedic formulation as a marker compound. This review, converse Quality control parameters; Identification, Isolation, Characterization and Stability studies of Herbal and Ayurvedic formulations.

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### **INTRODUCTION**

In the current scenario with increasing awareness, the usability and acceptability of herbal drugs have been continuously expanding in medical practices. Although with the various therapeutic activities, its application is non-orthodox, it is a fact that more than 80% of the population is associated with herbal medicines and their derived product for their well-being. With the rising demand for herbal medicines, numerous variety of adulteration and abuses are observed in the global market [1]. Adulteration influences

the quality, safety, and efficacy of the ayurvedic and herbal formulation. The challenges associated with the quality, safety, and efficacy of the herbal drug establishment can be overcome by significant quality control parameters [2]. Quality improvement of herbal formulations lies in various stages such as procurement of drugs, handling, processing, and storage [3]. The quality standard is the paramount concern for any herbal medicine used in clinical application and has also been a prominent concern of the World Health Organization since its inception [4]. Gradually, more emphasis has been taken on the quality assurance of herbal or ayurvedic products by the implementation of modern analytical techniques used for the extraction, isolation, standardization, and stability testing of drug products [5]. The validation of developed analytical method is based on accuracy, precision, reproducibility, The limit of detection, and limit of quantification, etc. The validated method can be described as a monograph in Ayurvedic Pharmacopoeia of India to investigate further and characterize herbal preparations [6].

Earlier, the Standardization of multi-component ayurvedic formulations was an arduous task. However various analytical methods like UV, HPLC, HPTLC, Gas chromatography etc., have evolved for the simultaneous estimation of the active components present in ayurvedic formulation. The Radiotracer, isotope and Phytomarker identification- based approaches are significantly used to standardize herbal formulations [7,8].

Stability study of the herbal drug and formulation is an important parameter during development and storage [9]. Various drug regulatory agencies like ICH, USP etc., recommended many guidelines for the stability study [10]. Stability study must include physical, chemical, biological, and clinical stability of the drug [11]. The various analytical method was developed to check the stability of products in variable conditions like environmental factors, temperature, light intensity, moisture, air, drug excipient interaction, microbial growth, leaching from packaging, and therapeutic variability[12]. To ensure the quality of herbal medicine various aspect of quality testing has been incorporated in the processing of raw drugs and their formulation. The important aspects for quality standard are microscopic examination, physicochemical test for preliminary identification, extraction, isolation, identification and quantification of the drug to check the purity and stability of the active compound in ayurvedic formulations.

## **MAIN TEXT**

### **Quality control parameters**

#### ***Pharmacognostic Character***

Various macro and microscopic pharmacognostic character used for the identification of herbal drugs. The macroscopic character used is presence

or absence of petiole, different kinds of apex, venation and margin pattern for leaves, texture analysis for the stem, and root identified based on shape, size, and fracture[13]. A detailed pharmacognostic study of the herbal drug was performed to determine qualitative and quantitative analysis[14,15]. This analysis comprises of following kind examination are:

- Qualitative microscopy: Powder microscopy, leaf, root, and stem microscopy
- Quantitative analysis: Stomatal number, Determination of vein, palisade ratio

Pharmacognostic characteristics of the few medicinal plants are given in table1.

**Table 1: Microscopic character of some selective plants used for their identification**

	Character	Plant/Family Name	References
Types of Trichomes	Stellate	<i>Solanummelongena</i> var. <i>insane</i>	[16]
	Uniseriate filiform	Papilionoideae	[17]
	Uniseriate cylindrical	Papilionoideae	
	Glandular	<i>Cannabis sativa</i> , <i>Cistus cretica</i> , <i>Salviniarepens</i> , <i>Cocciniagrandis</i>	[18,19,20,21]
	Non-glandular	<i>Arabidopsis thaliana</i> , <i>Salviniarepens</i>	[34, 35]
	Procumbent	<i>Medicagotruncatula</i>	[22]
	Peltate glandular	<i>Humuluslupulus</i>	[23]
Types of Stomata	Anomocytic	Ranunculaceae	[24]
	Anisocytic	Diacritic	
	Diacytic	Caryophyllaceae	
	Paracytic	Rubiaceae	
	Actinocytic	<i>Lansea</i> sp.	[25]
	Cyclocytic	<i>Synopsis</i> sp.	
	Tetracytic	Many monocots and some dicots like <i>Tilia</i> sp.	[26]
	Hemi paracytic	<i>Trianthemalancastrum</i>	[27]
Calcium oxalate crystals		<i>Tragia ramose</i>	[28]
Silica deposition		Grasses	[29]

***The physiochemical test used in the characterization of Ayurvedic drug***

Physiochemical tests most commonly used for the characterization of herbal drugs are loss on drying, total ash, acid insoluble ash, water-soluble extractive, alcohol soluble extractive. The other tests used for the characterization of tail and ghrita are saponification number, acid value, iodine value, peroxide value, pH and refractive index etc. Physiochemical parameter of few medicinal plants and formulation are given in table 2.

The physiochemical parameters of any herbal drugs gives the authentication and helps to identified presence spurious, adulterate and misbrand drug in given sample [30,31,32].

**Table 2: Physiochemical test parameters of different drugs [33]**

Plant name	plant part	Loss On Drying	Total Ash value	Acid Insoluble Ash	Alcohol soluble Extract	Water-soluble extract	Foreign matter
		(NMT)	(NMT)	(NMT)	(NLT)	(NLT)	(NLT)
Goksura	Fruit	10%	15%	2%	6%	10%	1%
Aragwadha	Stem bark	10%	13%	1%	25%	18%	2%
Guduchi	Stem bark	10%	16%	3%	3%	11%	2%
Heartwood	Heart wood	10%	6%	1.50%	3%	10%	1%
Eranda	Root or stem	10%	8%	1%	3%	9%	2%

***Phytochemical Test***

Standardization of raw drug and formulation can be executed only by the confirmation of a particular phytoconstituent present in the given sample. This phytochemical test has been used for qualitative analysis of active phytoconstituents in respective raw drugs and their preparations. The most commonly used physiochemical test for the investigation of any raw drugs and herbal preparations are given in table 3.

**Extraction of Phytoconstituents**

The Ayurveda is Traditional Medicine and was developed by ancient people these medicine fought against various diseases for thousands of years. Around 49% of the world's population has tried natural medicines for the prevention and treatment of diseases [34]. Phytochemical constituents are Secondary metabolites of plants such Alkaloids, Flavonoids, Poly Phenol, Glycosides, Tannins, Saponins, and Terpenoids [35], the various methods are available to extract phytochemical constituents from Medicinal plants. Maceration, Percolation, Decoction reflux extraction, Soxhlet extraction, Supercritical fluid extraction, Ultrasound-assisted extraction, Microwave-

assisted extraction, pulsed electric field, and Enzyme assisted extraction [36]. Extraction is one of the initial steps to separate the active compounds from the raw material of the medicinal plant. In extraction methods have Distillation, Solvent extraction, sublimation, and pressing according to the extraction principle. The most widely used method is Solvent extraction and Water, Alcohol, and hydro alcohol is used as solvents [37]. The following stages in the extraction of active compounds are 1). The solvents penetrate the solid matrix, 2). The solute dissolves in the solvents, 3). The solute is diffuse out of the solid matrix, 4). The extracted solute is collected [38].

**Table 3: Different extraction techniques, solvent used, and their active compounds**

<b>Extraction technique</b>	<b>Solvent</b>	<b>Active constituents</b>	<b>References</b>
Soxhlet extraction method	Dichloromethane	Azadirachtin (1%)	[46]
Maceration method	Ethanol	Curcumin (30%)	[47]
Supercritical fluid extraction	CO <sub>2</sub>	$\alpha$ -Pinene	[48]
Microwave-assisted extraction	Chloroform	Andrographolide (0.589%)	[49]
Ultrasound-assisted extraction	Ethanol	Piperine (5.8mg/g)	[50]
Pulsed electric field extraction method	Aqueous NaCl (0.1%)	Rosmarinic acid	[51]
Enzyme assisted extraction method	Water, Endoprotease enzyme	Ferulic acid	[52]

**Table 4: Analytical techniques used for the identification of active constituents**

Analytical technique	Condition	Identification feature	Active constituents	Name of the plant	Reference
High-Performance Thin Layer Chromatography (HPTLC)	Chloroform: Methanol (7:1) used a mobile phase	R <sub>f</sub> value is 0.31	Andrographolide	<i>Andrographis paniculata</i>	[53]
	Toluene: Ethyl acetate: Diethyl ether (6:3:1) as mobile phase	R <sub>f</sub> value is 0.40	Piperine	Fruits of Piper Species	[54]
High-Performance Liquid Chromatography (HPLC)	Flow rate is 1ml min <sup>-1</sup> Methanol: Acetonitrile (6:4) v/v	R <sub>t</sub> is 3.3 min	Reserpine	<i>R. Serpentina</i>	[55]
UV-visible spectroscopy	n-butanol:Water:Acetic acid (8:1:1)	Observed λ max at 256nm	Quercetin	<i>Cocculushirsutus</i>	[56]
Mass-Spectrometer	75% Ethanol fraction	m/z: 447.09336	Orientin	<i>Cecropiaspecies</i>	[57]
NMR-Spectroscopy	Chloroform extract	Methylene	Andrographolide	<i>Andrographis paniculata</i>	[58]
		The group at H-11 (δ2.35, 2H), and H-15 (δ4.191, 2H).			

Analytical technique	Condition	Identification feature	Active constituents	Name of the plant	Reference
		Methyl groups at H-18 ( $\delta$ 1.28, 3H), H-20 ( $\delta$ 0.80, 3H)			
		The presence of			
		two double bonds were encountered at H-12 ( $\delta$ 6.89, 1H) and H-17			
		( $\delta$ 4.598, 2H).			

**Isolation and Identification of phytoconstituents**

The obtained Phytoconstituent from different extracts must be isolated before going into structure elucidation and identification as well as bioactivity screening in Ayurvedamedicinal plants. In present days’ new technologies, methods of extractions are available for analysis of phytoconstituent. The process of isolation is one of the techniques to get the desired phytoconstituents to the utmost extent and remove the unwanted constituents from the extraction [39]. The isolation of the phytoconstituents of medicinal plants extracts or effective parts with purifying of their constituents by Physical and chemical methods [40]. The following methods used in isolation of active phytoconstituents are precipitation, Crystallization, Fractional distillation, and dialysis are commonly used at present are Classical methods some of the examples are given in table 4. Various modern techniques are also available.

such as separation techniques such as Thin-layer chromatography(TLC), Column Chromatography (CC) and High-performance Thin-layer

chromatography(HPTLC), Gas Chromatography(GC), Ultrafiltration and Flash chromatography(FC) is playing a vital role in the separation of Phytoconstituent [41]. The Phytoconstituents of Ayurveda medicinal plants extracts are should be identified and elucidated their Chemical structures which gives the basic idea of functional groups are present and their chemical properties. Further, the Structural studies are somewhat difficult to get by the Classical Chemical method hence the Spectral analysis methods are majorly involved. In general, the following Spectral methods are used in Chemical Structure determination of Phytoconstituents are UV-Visible Spectroscopy gives the electronic transitions of Compounds, Infrared (IR)-Spectroscopy provides finger print out of Chemical compounds such as Organic Compounds, NMR-Spectroscopy identifies the type of nuclei present in Phytoconstituents Such as Type of Hydrogen and Carbon and Skeleton of Structure and most of the Phytochemicals are Organic compounds. Finally, Mass Spectrometry is provided a mass of Chemical compounds and Molecular formula [42], some of the examples of analytical techniques are given in table 5.

**Table 5: According USP types of stability study and their condition**

Types of stability	Conditions
Chemical	Chemical integrity, labeling potency
Physical	Appearance, Uniformity
Microbiological	Sterility
Therapeutic	Drug action remain unchanged
Toxicological	No increase in toxicity

**Table 6: Different climate zone, conditions, and geographical area**

Climate Zone	Condition		Geographical area
	Temperature	% RH	
Zone I (Temperate climate)	21±2°C	45±5%	Canada, Russia, UK, Germany
Zone II (Subtropical Mediterranean)	25±2°C	60±5%	USA, Japan, Australia, China, Iran
Zone III (Hot & Dry) – HD	30±2°C	35±5%	Iraq, Jordan
Zone IV (Zone IVb) (Hot & Humid)—HH	30±2°C	70±5%	India, Srilanka, Bangladesh UAE, UMAN, Brazil
Zone IV (Zone IVb) (Hot & High Humid)- HHH			

**Table 7: Types of stability study, condition, sampling, and duration of the study**

Stability study condition	Temperature and Humidity				Sampling interval	Duration
	Zone I	Zone I	Zone II	Zone V		
Long term/ Ambient/ Room temp	21±2° C	25±2° C	30±2° C	30±2° C	Months and years	Many years
	45±5 %	60±5 %	35±5 %	70±5 %		Up to expiration date
Intermediate	30±2°C				Months to one year	1 year
	60±5%					
Short term	40±2°C				6 month	6 months
	70±5%					

**Stability study of Ayurveda Formulations**

Stability is the characteristics of the formulation that can be expressed in terms of the duration at which formulation maintain their integrity in terms of safety, efficacy, and quality. Different formulations that have different duration to maintain their integrity can be called the shelf life of the drug [43, 44]. Stability study comprises of a different kind of stability testing given in table 6. According to USP stability, Drug product retains their quality/character in a specific container and closure. With the respect following concern [45]. As per ICH guideline stability study condition based on types of study and climate zone. As per different climatic conditions, the geographical area is divided into the four zones given in table 7. In various zone stability studies can be conducted by various methods with certain specifications given in table 8. Stability study testing can be performed under stress conditions along with specific temperature and humidity called stress testing. Condition for stress testing are (temperature >40±2°C, humidity >75% RH) stress: oxidation, photolysis, and hydrolysis.

**CONCLUSIONS**

For the identification and characterization of plants products, all the quality control parameters play a significant role to ensure their quality which is directly related to the safety and efficacy of the respective plant during

clinical uses. At the stage of identification to stability testing and storage quality control parameter assure their characteristics feature. Identification of correct plant parts and species is the most desirable parameter for the preparation of Ayurvedic formulation. To ensure their identity various macro and microscopic were used after identification another important parameter is to check their quality which can be confirmed by qualitative and quantitative analysis. Quality of product can be maintained by performing various quality tests on In-process and finished products. The quality control parameter is the parallel process associated with every unit operation of Ayurvedic preparation. Quality control is an emerging field to the establishment of quality standard products.

### List of Abbreviations

TLC: Thin-layer chromatography; HPTLC: High-performance thin-layer chromatography; HPLC: High-performance liquid chromatography; FC: Ultrafiltration and flash chromatography; GC: Gas chromatography; CC: Column chromatography; IR: Infrared; UV: Ultraviolet; NMR: Nuclear magnetic resonance; ICH: International Council for Harmonisation; NMT: Not more than; NLT: Not less than.

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## **Chapter-08**

### **CARDIOVASCULAR RISK PREDICTION USING STANDARD AND NOVEL TOOLS AMONG ADULTS VISITING A TERTIARY CARE HOSPITAL IN CHENGALPET DISTRICT – A CROSS-SECTIONAL STUDY**

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**ABSTRACT:** Background: Cardiovascular disease (CVD) is one of the leading causes of death worldwide. Several factors are known to increase the risk of CVD. Strong, effective and early interventions to identify and target these risk factors may help reduce the increasing risk of CVD.

Aim and objective: Aim of the present study was to quantify the degree of cardiovascular disease risk among adult patients visiting a tertiary care hospital in Chengalpattu district. The objectives of the study are i) to measure CVD risk using the FRS, IHRs and q-risk 2 among the patients, and ii) to identify novel risk factors for predicting high CVD risk among the patients.

Methods: Patients visiting Hindu Mission Hospital were screened and enrolled in this cross-sectional study, based on the inclusion and exclusion criteria. Case reporting forms were used to collect patient information including sociodemographic characteristics, anthropometric measurements, blood pressure, medical records, lifestyle and diet habits. Risk scores were estimated for all the subjects using the Framingham, Interheart and Q-risk 2 scoring systems and were classified into low, moderate and high-risk groups. In addition, the overall data was classified into low risk and high risk groups, depending on the risk levels across the 3 scoring systems. All the data were recorded and assessed for identifying novel risk factors which may be useful for development of a modified/novel scoring system.

Results: A total of 510 participants were recruited in the study. Assessment using Framingham risk score revealed 14.5%, 4.2% and 81.2% of participants had low, moderate and high risk of CVD, respectively.

Meanwhile, around 15.7%, 55.9% and 28.3% of participants had low, moderate and high risk of CVD respectively, as observed using the Interheart risk score. A proportion of 36% had low, 28.8% had moderate and 35.8% had high-risk of CVD according to Q risk 2 scoring system. On combining the 3 scoring systems, 38% of the subjects were categorized as low-risk and 62% as high-risk. Dietary intake analysis showed that increased consumption of non-vegetarian food (meat and fish) was observed in the high-risk group. In addition, subjects who drank green tea regularly were found to be significantly higher in the low-risk group. 67% of female subjects who attained menopause were identified among high-risk category. Conclusion: This is a hospital-based study and the findings of this study have helped to generate variables for a scoring system for CVD risk using some novel risk factors (green tea, periodontal disease, menopause status) that were not included in any other scoring systems, indicating that a modified CVD risk scoring system may be ideal for use at Hindu Mission Hospital, but could also be extended to the general public.

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## INTRODUCTION

Cardiovascular disease (CVD) arises due to a change in the anatomy and physiology of the heart and blood vessels [1]. They can be broadly classified into 2 types depending on the site of occurrence; 1) CVD involving the blood vessels (coronary artery disease, peripheral arterial disease, cerebrovascular disease, renal artery stenosis and aortic aneurysm) and 2) CVD involving the heart (cardiomyopathy, hypertensive heart disease, heart failure, pulmonary heart disease, cardiac dysrhythmias, inflammatory heart disease/endocarditis/myocarditis, valvular heart disease, congenital heart disease and rheumatic heart disease [2]. Signs and symptoms of the disease include angina, radiating chest pain, chest tightness, numbness, weakness or coldness in limbs, feeling lightheaded or dizzy, sweating, dyspnea, nausea, vomiting, palpitation, weakness and irregular heartbeat [3].

CVD remains the leading cause of mortality and morbidity in developing countries throughout the world. Additionally, the annual global mortality due to CVD is projected to increase from 17.5 million in 2012 to 22.2 million by 2030 [4]. In India, the annual number of deaths from CVD was estimated as 4.77 million, as of 2020 [5]. Myocardial infarction and stroke, the two major types of CVD, are caused due to blockage in the arterial wall by fatty materials. Most types of CVD do not have a direct cause but instead, are triggered by certain risk factors [7]. These risk factors can be classified into 2 types namely, modifiable (treated or controlled through

medications or lifestyle changes like total high cholesterol, high blood pressure, diabetes mellitus, smoking or tobacco, periodontal disease, obesity or overweight and sedentary lifestyle) and non-modifiable risk factors (aging, gender and hereditary).[8].

### **Impact of risk factors on CVD**

American society for preventive cardiology has summarized the top 10 risk factors for CVD including unhealthy nutrition, physical activity, dyslipidemia, hyperglycemia, high blood pressure, obesity, thrombosis, smoking, kidney dysfunction and genetics / familial hypercholesterolemia. Better understanding of these cardiovascular risk factors will help reduce the burden of CVD in the near future [9]. Unhealthy nutrition includes diet rich in sugars, high saturated trans-fat and low fiber foods. Primary component of healthy nutritional diet is based on quality, quantity, and timing. Calories should be limited to 1,600 to 3,000 per day based on age, sex, BMI and level of physical activity, with major focus on nutrient dense and whole foods.

Intestinal microbiome plays a vital role in modulating risk of several chronic diseases particularly CVDs. Food consumption is said to greatly impact the gut microbiome. Lower microbiota diversity is associated with increased CVD. Mediterranean diet (MedDiet) and the dietary approaches to stop hypertension (DASH) diet are the predominantly followed diet plan for prevention of CVD. Several epidemiological and clinical trials have assessed the effect of MedDiet on recognized CVD risk factors, some of which reported beneficial effects on blood pressure, triglycerides, low-density lipoprotein cholesterol (LDL-C) and body weight. DASH diet emphasizes on fruit, vegetables, fat-free/low-fat dairy, whole grains, nuts and legumes, and limits saturated fat, cholesterol, red and processed meats, sweets, added sugars, salt and sugar- sweetened beverages as widely recommended by international diabetes and heart association guidelines. In addition to reducing blood pressure, the DASH dietary pattern has since been shown to have a decreasing effect on LDL-C. In addition, time restricted eating (with 14 hours fasting interval) has reported benefits for weight loss and potential CVD prevention. Patients may be referred to cardiac rehab, dietitians, or shared medical appointments for education and support [10].

Lipids including fats, steroids, phospholipids, triglycerides, and cholesterol are important cellular components of tissues and organs of the body. They are carried by lipoproteins in the blood. Atherogenic lipoproteins (cholesterol carrying lipoproteins) may become entrapped within the sub-endothelial space, where they may undergo oxidation and scavenging by arterial macrophages, resulting in foam cells, fatty streaks, and eventually

atherosclerotic plaque formation. Progressive enlargement of the atherosclerotic plaque may produce chronic hemodynamically significant narrowing of the artery resulting in angina or claudication; acute plaque rupture may cause myocardial infarction and/or stroke [11]. High blood pressure leads to thickening of the blood vessel walls. When combined with cholesterol deposits in the blood vessels, the risk of myocardial infarction and stroke increases [12].

Diabetes mellitus contributes to both microvascular disease (e.g., retinopathy, nephropathy, and neuropathy) and macrovascular disease. Hyperglycemia may contribute to atherosclerosis via direct and indirect mechanisms. Direct adverse effects of elevated circulating glucose levels include endothelial dysfunction, oxidative stress, heightened systemic inflammation, activation of receptors of advanced glycosylated end products, increased LDL oxidation, and endothelial nitric oxide synthase (eNOS) dysfunction. Indirect adverse effects of elevated glucose levels include platelet hyperactivity [13].

Body Mass Index (BMI) is a measurement of body fat based on the height and weight of an individual, applicable to both males and females. It is calculated using the formula  $BMI = \frac{kg}{m^2}$ , where kg denotes weight in kilograms and m<sup>2</sup> denotes height in meter square. The value thus obtained is used to categorize whether a person is underweight (<18.5kg/m<sup>2</sup>), normal weight (18.5-24.9kg/m<sup>2</sup>), overweight (25-29.9kg/m<sup>2</sup>), or obese ( $\geq 30$ kg/m<sup>2</sup>). Obesity is associated with an increase in coronary artery calcium, carotid intimal medial thickness, left ventricular thickness, and increased lifetime CVD risk, substantially mediated by obesity-promoted CVD risk factors. The adverse biomechanical aspects of obesity (–fat mass disease) often compromise cardiac function via pericardial mechanical restraint, impaired left ventricular expansion, impaired left ventricular filling, and diastolic heart failure. Obesity can also lead to adipocyte and adipose tissue dysfunction [14].

CKD is an independent risk factor for CVD, due to endothelial dysfunction, accelerated atherosclerosis, increased inflammation, vascular calcification and other vasculopathies. Other non-traditional CVD risk factors often found in patients with CKD include left ventricular hypertrophy, anemia, abnormal calcium phosphate metabolism, and elevated urate levels [15].

Genetics is also one of the major risk factors for heart diseases. Some of the common inherited cardiac disorders include arrhythmias, congenital heart disease and cardiomyopathy [11].

CVD can be prevented by modifying the lifestyle such as following a strict healthy diet, exercise, quit smoking and alcohol consumption, maintain blood sugar level and reduce stress. Modest change in risk can lead to a

significant change in disease burden [16].

#### **CVD risk scoring systems:**

Risk factors greatly increase the incidence of CVD. Evaluating the risk scores is important for the prevention and management of CVD[17]. There are several types of CVD risk scoring systems available among which the three widely used scoring systems employed in the present study are Framingham risk score, Inter heart risk score and Q-risk 2 score.

The Framingham risk score (FRS) is one of the conventional techniques used for evaluating CVD risk. The risk score is estimated by assessing factors such as age, gender, TC, HDL, systolic blood pressure, diabetes mellitus, previous medical history (especially for hypertension), medication, smoking status, and past history of vascular disease or stroke[18].

The Inter heart risk score (IHRS) is considered as a prognostic tool for CVD risk. The factors assessed to evaluate risk score include age, gender, waist and hip circumferences, total cholesterol (TC), high density lipoproteins (HDL), systolic blood pressure (SBP)/diastolic blood pressure (DBP), diabetes mellitus, past medical history (with medication details), family history of heart disease, smoking status, physical activity, psychosocial factors and dietary intake.[19].

Q-risk 2 score is a validated tool which predicts a one in ten chance of developing CVD and stroke based on parameters such as age (25-84), gender, ethnicity, systolic blood pressure, diabetic status, chronic kidney disease (stage 4 or 5), arterial fibrillation, past medical history on hypertension, rheumatoid arthritis, total cholesterol/ HDL ratio, height(cm) and weight(kg)[20].

In all the 3 scoring systems, the risk score (%) is used to classify into low, moderate and high risk groups.

#### **Diagnosis and treatment:**

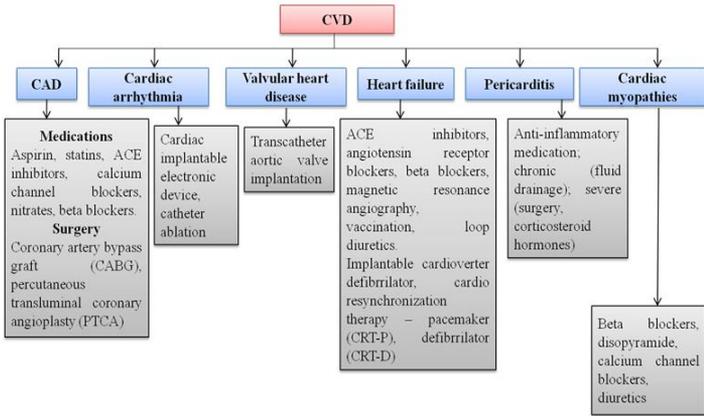
CVDs can be diagnosed by history taking, physical examination, echocardiography, transesophageal, cardiac catheterization (angiogram), radionuclide scans, magnetic resonance imaging (MRI) [16]. Figure 1 illustrates the treatment strategies employed for the different types of CVDs.

### **LITERATURE REVIEW**

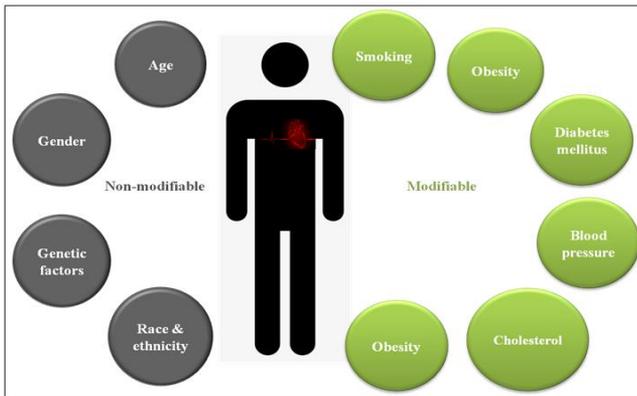
#### **Association of major risk factors with CVD:**

A standardized case control study by Salim Yusuf et al investigated the effect of potentially modifiable risk factors associated with acute myocardial infarction in 52 countries. The study recruited a total of 15152 cases and 14820 controls to determine the population attributable risk (PAR). Smoking, raised ApoB/ApoA1 ratio, history of hypertension, diabetes, abdominal obesity, physical inactivity, alcohol consumption, and

psychosocial factors were all found to have significantly high PAR for all age groups and gender. Therefore, modifying these risk factors will help prevent premature cases of myocardial infarction (MI)[21]. Figure 2 describes the various modifiable and non-modifiable risk factors in CVD.



**Fig.1: Treatment approaches for different types of CVD**



**Fig. 2: Modifiable and non-modifiable risk factors involved in CVD**

Steven Bell et al., reported a correlation between level of alcohol consumption and initial presentation of CVD by performing a population

based cohort study of linked electronic health records (CALIBER) comprising 19,37,360 adults, aged  $\geq 30$  with no history of CVD at baseline, during the period 1997-2010 with a median follow-up of 6 years. During the follow up period, 1,14,859 subjects developed incident CVD. Heavy drinkers had increased risk of unheralded coronary death, heart failure, cardiac arrest, transient ischemic attack, ischemic stroke, intracerebral hemorrhage, and peripheral arterial disease but a lower risk of myocardial infarction[22].

Whanhee lee et al., estimated the risk of smoking and passive smoking on cardiovascular morbidity at the national and regional levels. This study calculated sex standardized and age standardized prevalence of CVD and smoking indices in 253 community healthcare centers in Korea using the 2008-2013 Korea community health survey data. The study revealed that at the national level, smoking was significantly associated with stroke and hypertension prevalence, whilst passive smoking at home and work were also significantly associated with prevalence of stroke, angina and hypertension. Furthermore, the effects of smoking and passive smoking were greater in urban-industrial areas than in rural areas[23]. In the meantime, another study (Alirezajafari et al) conducted a systematic review and meta-analysis of studies published on the prevalence of ever and current cigarette smoking in women from January 2010 to April 2020. The pooled prevalence of ever and current cigarette smoking in women was 28% and 17%, respectively. The prevalence among women was very high, which was significant in all subgroups of adolescents, adults, and pregnant women[24]. Tatiana Warren et al., examined the relationship between two sedentary behaviors, namely riding in a car and watching television and CVD mortality in men. This prospective study was initiated in 1982 which comprised 7,744 male participants aged 20-89 years, with no history of CVD. During the 21 year follow-up, 377 participants died due to CVD. Men who reported  $>10$  hrs/wk riding in a car or  $>23$  hr/wk of combined sedentary behavior had 82% and 64% greater risk of dying from CVD. Thus suggesting that in men, riding in a car and combined time spent in these two sedentary behaviors was significant CVD mortality predictors. Additionally, high levels of physical activity were related to notably lower rates of CVD death even in the presence of high levels of sedentary behavior[25].

Louise Hartley et al., conducted a randomized controlled trials with objective to establish the effects of green tea and black tea on the primary prevention of CVD. It is observed that there were very few long-term studies. Thus, the restricted proof indicates that tea has beneficial outcomes on CVD risk elements [26].

Charles f. emery et al., evaluated sex differences in heart rate variability

response to speechstress among men and women (age 30-49 years) with and without a documented family history of CVD. Subjects were 77 adults with positive family history and negative family history of CVD. This study was recorded via ECG. Outcomes included time domain and frequency domain. Indicators HRV and heart rate at rest and during stress. The result of this study is women exhibited higher HR than men, greater HR reactivity in response to the speech stress [27]

Ashley s. felixphd et al., estimate stress and CVD risk among african-american women. They examined association of stressful life events and social stress with incident CVD. This study includes 10,785 African American women enrolled in the women's health initiative observational study and clinical trial cohort. Multi-variable COX regression was used to estimate hazard ratio and 95% confidence intervals for association between stress related exposure and incident CVD. The conclusion of this study cohort of older women, recent reports of stressful life events were related to incident CVD [28].

#### **Co-morbidities as risk factors for CVD:**

Association between type 2 diabetes and 12 initial manifestations of CVD was determined by Anoop Dinesh Shah et.al., in the cohort study which comprised data of 1,921,260 individuals obtained from the CALIBER programme during the period Jan 1, 1998, to March 25, 2010. The study revealed 113, 638 first presentations of CVD during a median follow-up of 5.5 years, among which 6,137 had type 2 diabetes. Moreover, type 2 diabetes was positively associated with peripheral arterial disease, ischaemic stroke, stable angina, heart failure and non- fatal myocardial infarction[29]. Another most common co-morbidity which increases the risk of CVD is obesity. Tim Adair et al., investigated the role of overweight and obesity in their recent CVD mortality trends using the multiple cause of death (MCOD) data-direct individual-level evidence from death certificates-and linking the findings to cohort lifetime obesity prevalence. The study identified overweight- and obesity-related mortality as any CVD reported on the death certificate (CVD MCO) with one or more of diabetes, chronic kidney disease, obesity, lipidemias or hypertensive heart disease (DKOLH-CVD), causes strongly associated with overweight and obesity. DKOLH-CVD mortality rate rose by 3% per annum in the most recent year. There were larger increases in DKOLH-CVD mortality rates at successively younger ages, strongly related with higher relative lifetime obesity prevalence in younger cohorts [30].

Another study by Leila Jahangiry et al., investigated risk of CVD among 160 patients with metabolic syndrome, aged 20 years and above, using FRS. The resulting CVD risk percentage was classified as low (<10%),

intermediate (10-20%), and high (>20%). The results showed that 77.5%, 16.3% and 6.3% of the patients with metabolic syndrome were classified as low, intermediate and high risk, respectively. Moreover, patients with high systolic blood pressure and fasting blood glucose levels showed 3 to 5 times higher susceptibility to have intermediate and high CVD risk [31].

Michael C Honigberg et al., conducted a cohort study with 144,260 postmenopausal women of aged 40 years and above. The primary outcome of the study was a composite of incident coronary artery disease, heart failure, aortic stenosis, mitral regurgitation, atrial fibrillation, ischemic stroke, peripheral artery disease, and venous thromboembolism. Participants were followed up for a median of 7 years, during which 5415 women (3.9%) with no premature menopause, 292 women (6.0%) with natural premature menopause and 49 women (7.6%) with surgical premature menopause reported of primary outcome [32].

Oral health problems such as periodontal disease, dental caries, and tooth loss have been suggested to have associations with CVD. Periodontal disease causes transient bacteraemia, systemic inflammation, and endothelial dysfunction, which are possible mechanisms underlying atherogenesis. Several studies have reported a positive link between periodontal disease and CVD, mainly due to the fact that both diseases share common risk factors such as smoking and diabetes. Shin-Young Park et al., investigated the correlation between oral hygiene and CVD in a nationwide cohort study (National Health Insurance System-National Health Screening Cohort) consisting 247,696 healthy individuals aged >40 years, with no history of CVD and followed up for 9.5 years. During the follow up period, 14,893 major adverse cardiovascular events (MACE) such as cardiac death, myocardial infarction, stroke, and heart failure were reported. The risk MACE occurrence was higher when a subject was diagnosed as having periodontal disease, had a higher number of dental caries, and had lost a higher number of teeth. In addition, better oral hygiene care such as frequent tooth brushing and regular dental visits for professional cleaning procedures were associated with a lower cardiovascular risk [33].

#### **Risk assessment using CVD risk scores**

Naveen Garg et al., evaluated the performance of various CVD risk calculators including FRS-CVD (FRS-CVD), ACC/ AHA Atherosclerotic CVD (ASCVD) risk score, QRISK2, Joint British Society calculator-3 (JBS3), Framingham Coronary Heart-Disease Risk Score (FRS- CHD) and WHO/ISH CV risk in Indian population. About 1,110 newly diagnosed myocardial infarction patients were recruited in the study and the findings revealed that FRS-CVD identified maximum number of myocardial

infarction (MI) patients as high risk. Whereas, WHO and ASCVD identified the least number of MI patients as high risk. The QRISK2, JBS3 and FRS- CHD showed moderate performance. Therefore the study concluded that FRS-CHD as the useful risk calculator to identify patients at high cardiovascular risk [34].

The study conducted by Julia Hippisley-Cox et al., derived and validated the QRISK2 and compared its performance with modified FRS. This prospective open cohort study was conducted from January 1993 to March 2008 and a total of 2.3 million patients were recruited. The inclusion criterion for this study is patient aged 35-74 at the date of entry into study with no history of CVD. Prevalence of cardiovascular risk factors and incidence of CVD over 10 years were noted. Among the 1,12,156 subjects identified as high risk using FRS, 46,094 were regrouped as low risk in QRISK2. Similarly, among 78,024 subjects identified as high risk in QRISK2, 11,962 were regrouped as low risk in FRS. From the 10-year examination it was observed that the high risk individuals in QRISK2 exhibited increased incidence of CV events than high risk individuals in FRS, thereby indicating QRISK2 as the most validated tool compared to the modified FRS[20].

On the contrary, Therese Tillin et al., conducted a prospective study to validate the performance of QRISK2 and FRS-CVD risk scores in a tri-ethnic UK population. A total of 4,539 participants aged 40-69, with no history of CVD at baseline were recruited and categorized as high and low risk according to QRISK2 and FRS-CVD risk scores. The participants were followed-up till the incidence of CVD. However, both scores performed poorly in identifying high risk African Caribbeans; QRISK2 and Framingham identified as high risk only 10% and 24% of those who experienced events[35].

Meanwhile, Jobert Richie Nansseu et al., performed a cross sectional study from May 2017 to July 2017 in the University of Yaoundé I, Cameroon. The inclusion criteria for the study were students aged 18 and above with no history of CVD. INTERHEART modifiable risk score was used to evaluate the prevalence of CVD risk in young adults which included 11 risk factors. Based on the presence of risk factors scores were allotted and divided into three groups, low (0 to 9), moderate (10 to 15) and high (16 to 48). This study was carried out in 949 healthy students which showed that 50% of the participants had moderate to high risk of CVD. Awareness, patient education and management are essential to reduce the burden of CVD in the future [36].

### **Aim**

The aim of the study is to quantify the degree of CVD risk among adult

patients visiting tertiary care hospital in Chengalpet district.

### **Objectives**

To measure CVD risk using the FRS, IHRS and q-risk 2 among the patients. To identify novel risk factors for predicting high CVD risk among the patients

## **MATERIALS AND METHODS**

### **Methodology**

#### **Study subjects' recruitment:**

This was a cross-sectional study conducted in a Hindu Mission Hospital, Tambaram with a study population of 510 were recruited for the study after obtaining informed consent from all the subjects. The inclusion criteria for the study were adult patients'  $\geq 18$  years of age and willing to undergo the study procedures. Both male and female subjects were included in the study. Patients with established/suspected CVD, stroke, peripheral vascular disease and nephropathy, pregnant/lactating women, COVID-19 infected patients and HIV positive patients were excluded from the study.

#### **Data collection**

Case reporting form were used for data collection. It comprised of sociodemographic characteristics, anthropometric measurement (waist and hip circumference, height and weight), blood pressure, medical records (past history of any illnesses, information of previous surgery or medications, family history and blood investigations), lifestyle and diet habits were recorded from subjects.

#### **Risk estimation**

Assessing the risk of predisposition to CVD was performed using tools such as FRS, IHRS and q risk 2, which will measure the risk factors for CVD. These scoring systems employ assessment of risk factors such as diabetes, smoking status, age, hypertension and other factors such as stress, diet and physical activity and determine risk levels for a period of 10 years. And other information such as elevated leukocytes, periodontal disease, menopause, duration of metformin consumption, coffee consumption and green tea consumption were examined from subjects to identify novel risk factors. Risk scores were estimated for all the subjects using Framingham, interheart and Q-risk 2 scoring systems and were classified into low, moderate and high-risk groups. In addition, the overall data was classified into 2 groups, namely, low risk and high risk depending on the risk levels among the 3 scoring systems. For example, if the subjects showed high risk in at least one of the 3 scoring systems, they were categorized as high-risk group and the others were considered as low risk.

All the data were recorded and assessed for identifying novel risk factors which was used in the development of scoring system.

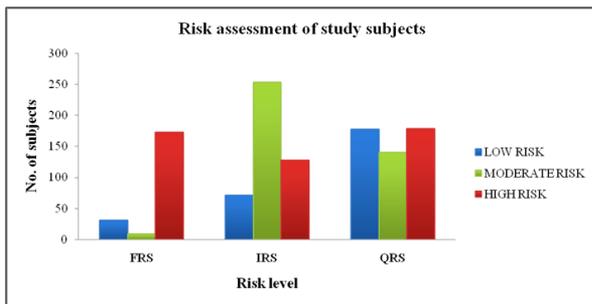
**Statistical analysis**

Continuous and categorical data were expressed as mean±SD or median and frequencies and percentages, respectively. P-value less than 0.05 will be considered as statistically significant. All statistical measures will be performed using SPSS v16.0.

**RESULTS**

**Baseline characteristics of the study population and risk assessment:**

A total of 1200 subjects were screened from June to October 2021, among which 510 subjects who fit the study inclusion criteria were recruited. A questionnaire was used for data collection, comprising questions such as lifestyle, diet, medical history, vitals and lab investigations. Mean age of the study population was found to be 55.02±14.02 year. The distribution of males and females in the study population was not statistically significant (p=0.288) suggesting that there was no gender bias in our study. Risk scores were estimated for all the subjects using Framingham, inter and Q-risk 2 scoring systems and were classified into low, moderate and high-risk groups.



**Fig. 3: Distribution of study participants into low, moderate and high risk levels based on FRS, IRS and QRS scores**

Table 1 describes the baseline characteristics of the study population and the risk categories based on the scoring systems. Each of the 3 scoring systems evaluate different parameters based on which the risk levels are calculated and classified as low, moderate and high risk(Figure 3). Of the

510 subjects enrolled in the study, risk scores were estimated for 211 subjects using all the 3 scoring systems, whereas only 2 scoring systems were employed for 280 subjects. Moreover, for 19 subjects only one of the scoring systems was able to be utilized. Comparison of risk levels/categories among the scoring systems for the study population is described in Table 2. In addition, the overall data was classified into 2 groups, namely, low risk and high risk depending on the risk levels among the 3 scoring systems. For example, if the subjects showed high risk in at least one of the 3 scoring systems, they were categorized as high-risk group and the others were considered as low risk.

**Table1: Baseline characteristics of the study population and their classification based on risk score.**

Parameter	Total (n=510)	Framingham risk level (FRS) (n=213)			Interheart risk level (IRS) (n=452)			Qrisk2 (QRS) (n=497)		
		Low risk (n=31)	Moderate risk (n=9)	High risk(n=17)	Low risk (n=71)	Moderate risk (n=253)	High risk (n=128)	Low risk (n=178)	Moderate risk (n=140)	High risk (n=17)
Age*	55.02±14.0	42.58±8.71	55.11±11.1	57.2±11.7	47.18±15.4	54.24±13.1	60.14±13.88	46.99±8.44	58.09±8.16	67.83±8.69
Male#	243 (47.6%)	11 (35.48)	4 (44.44)	82 (47.39)	27 (38)	107 (42.29)	79 (61.71)	70 (39.32)	56 (40)	107 (59.77)
Female#	267 (52.4%)	20 (64.42)	5 (55.56)	91 (52.61)	44 (62)	146 (57.71)	49 (38.29)	108 (60.68)	84 (60)	72 (40.23)
Height*	156.9±12.68	154.59±8.35	162.64±9.68	158.31±9.50	154.99±15.55	157.53±9.06	157.74±8.60	156.11±8.82	157.76±8.6	157.41±17.08

Parameter	Total (n=510)	Framingham risk level (FRS) (n=213)			Interheart risk level (IRS) (n=452)			Qrisk2 (QRS) (n=497)		
Weight*	67.1 7±12 .39	66.5 4±9. 31	76.9 0±1 7.84	69.1 8±1 1.28	66.99 ±12. 39	67.0 2±11 .81	67.9 2±1 2.13	67.5 3±1 1.40	69.5 5±11 .04	65. 43± 13. 39
Waist circumference*	35.5 4±5. 11	33.4 4±3. 94	37. 71± 5.2 1	36.3 9±3. 424	34.4 1±4. 33	35.5 6±5. 40	36.4 4±3. 65	35. 48± 3.4 8	36.0 0±3. 86	35. 33± 5.0 4
Hip circumference*	39.0 9±5. 16	37.8 ±4.1 1	41. 71 ±6. 6	39. 8± 3.3	39.0 5±4. 92	39.1 8±5. 21	39.3 2±3. 97	38. 94± 4.0 5	39.0 9±4. 38	38. 43± 5.1 6
SBP*	129. 8±18 .38	120 ±9.8	245 ±24 .55	131 ±19 .6	123.0 9±13. 29	128. 66±1 5.98	135. 48±2 3.29	125. 56±1 5.13	129. 29±1 6.21	138.35 19.97
DBP*	79.5 2±10 .99	77.6 ±8	84. ± 15	79.1 6±1 2.75	78.2 3±9. 45	79.2 5±9. 70	80.6 7±1 4.22	78. 48± 9.7 9	79.4 7±11 .26	81. 00± 12. 32
PR*	86.7 8±14 .65	84.5 ±11	84. ± 13 .9	85± 13. 11	81.01 ±14. 85	87.7 0±14 .36	89.8 1±1 4.78	85.9 3±1 5.19	88.5 0±13 .65	87. 47± 15. 63
Family history of heart	95 (18. 6%)	5	2	18	8	47	38	43	18	25

Parameter	Total (n=510)	Framingham risk level (FRS) (n=213)			Interheart risk level (IRS) (n=452)			Qrisk2 (QRS) (n=497)		
rt dise ase #										
Period ontal diseas e#	51 (10%)	2	1	19	3	27	21	20	30	15
Meno pause attaine d#	170 (33.3%)	10	2	59	18	95	39	57	55	50
If yes, no of years back*	45.10±91.76	28±55.8	30±55.5	42.3±87.6	34.38±78.19	50.26±93.10	52.07±109.20	30.06±68.28	55.56±82.89	62.87±118.39
Non smoke r#	447 (87.6%)	28	8	155	66	231	98	152	119	129
Forme r smoke r#	36 (7.1%)	1	1	11	4	13	15	12	8	12
Curre nt smoke r#	27 (5.3%)	2		7	1	9	15	8	7	7
if yes no.of cigs per	1±4.81	0.26±1.01	0.55±1.66	0.73±4.9	1.14±7.32	0.51±2.43	2.25±6.97	1.17±5.58	1.14±5.79	0.81±3.36

Parameter	Total (n=510)	Framingham risk level (FRS) (n=213)			Interheart risk level (IRS) (n=452)			Qrisk2 (QRS) (n=497)		
day*										
No secon dhand smoke #	489 (95. 9%)	30	9	169	69	244	118	163	130	144
Secon d hand smoki ng#	21 (4.1 %)	1	0	4	2	9	10	9	4	4
If yes hours per week*	1.38 ±18. 24	0.03 ±0.1 7	0	0.0 5± 0.3 5	0.8 7±7 .17	2.44 ±25. 57	0.17 ±0.7 1	2.21 ±27. 52	1.14 ±15. 55	0.0 5±0 .36
Non alcohol #	459( 90.0 %)	27	7	159	63	232	110	153	119	140
Alcohol #	51 (10 %)	4	2	14	8	21	18	19	15	8
If yes no of pegs	0.28 ±1.0 6	0.29 ±0.9 3	0.77 ±1.5 6	0.1 6± 0.7 9	0.3 5±1 .12	0.23 ±0.9 5	0.39 ±1.2 8	0.28 ±1.0 1	0.35 ±1.1 9	0.1 2±0 .58
Veget arian#	202 (39. 6%)	11	5	92	32	104	38	56	46	78

Parameter	Total (n=510)	Framingham risk level (FRS) (n=213)			Interheart risk level (IRS) (n=452)			Qrisk2 (QRS) (n=497)		
Non-vegetarian#	308 (60.4%)	20	4	81	39	149	90	116	88	70
Salty food or snacks#	204 (40.0%)	16	2	63	16	116	65	76	54	50
Deep fried foods or fast foods#	238 (46.7%)	21	2	82	27	134	65	96	63	50
Fruit#	369 (72.4%)	19	5	145	43	191	81	125	99	109
Vegetables#	486 (95.3%)	31	7	170	70	241	118	161	131	141
Meat or fish#	264 (51.8%)	19	3	84	31	132	80	96	78	63
Coffee#	267 (52.4%)	18	6	102	33	118	69	89	71	80
If yes, no of cups per	1.00 ±1.10	1.03 ±0.94	1.22 ±0.97	1.0 1±0.98	0.8 3±0.95	0.93 ±1.12	1.12 ±1.22	1.04 ±1.21	1.01 ±1.05	0.9 9±1.03

Parameter	Total (n=510)	Framingham risk level (FRS) (n=213)			Interheart risk level (IRS) (n=452)			Qrisk2 (QRS) (n=497)		
day*										
Tea#	287 (56.3%)	16	4	88	40	160	77	98	73	84
If yes,no of cups per day*	1.21 ±1.2 9	1.22 ±1.4 7	1.55 ±2.3 5	1.0 ±1. 14	1.2 2±1 .45			1.29 ±1.3 6	1.19 ±1.2 7	1.1 3±1 .16
Green tea#	46 (9.0 %)	1	1	10	6	30	9	16	13	8
Sedent ary#	208 (40.8 %)	13	4	89	18	94	58	64	55	70
Mild#	201 (39.4 %)	15	4	58	31	106	49	66	52	56
Moder ate#	96 (18.8 %)	3	1	23	22	49	20	42	25	19
Strenu ous exerci se#	5 (1.0 %)	0	0	3	0	4	1	0	2	3
Never stresse d#	193 (37.	9	2	75	31	114	36	64	60	51

Parameter	Total (n=510)	Framingham risk level (FRS) (n=213)			Interheart risk level (IRS) (n=452)			Qrisk2 (QRS) (n=497)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
	8%)									
Mild stress#	264 (51.8%)	22	7	90	38	118	63	87	65	80
Moderate stress#	45 (8.8%)	0	0	6	2	17	25	19	6	16
Severe stress#	8 (1.6%)	0	0	2	0	4	4	2	1	1
Depressed for two weeks or more in a row#	128 (25.1%)	0	0	21	11	63	42	32	37	48

\* Values expressed as mean ± standard deviation

# Values expressed as frequency (%)

**Table 2: Comparison of risk levels among FRS, IRS and QRScoring systems.**

Parameter	Total(n=510)	FRS			IRS			QRS		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
<b>FRS</b>										
Low	31 (14.5%)				15	10	0	21	8	1
Moderate	9 (4.2%)				2	4	1	3	6	0

Parameter	Total(n=510)	FRS			IRS			QRS		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
<b>FRS</b>										
High	173 (81.2%)				11	83	38	36	57	79
<b>IRS</b>										
Low	71 (15.7%)	15	2	11				48	14	8
Moderate	253 (55.9%)	10	4	83				93	81	74
High	128 (28.3%)	0	1	38				22	34	66
<b>QRS</b>										
Low	178(35.8%)	21	3	36	48	93	22			
Moderate	140(28.1%)	8	6	57	14	81	34			
High	179(36%)	1	0	79	8	74	66			

Age stratification analysis based on CVD risk levels was performed. All subjects were classified into three groups, namely – group A comprising of subjects between 20-40 years of age; group B comprising 41-60 years of age and group C comprising subjects ≥61 years. The total number of subjects was found to be 80, 248 and 182 for groups A, B and C, respectively. Classification based on risk levels revealed that 71.2% of group A belonged to low risk and 12.6% belonged to high risk, suggesting that young subjects were predominant in the high-risk category due to their sedentary lifestyle and dietary intake. 87.3% of group C subjects belonging to the elderly population were seen in high-risk due to the presence of systemic illnesses like diabetes and hypertension (Table 3).

**Table 3: Age stratification analysis of subjects based on CVD risk**

Risk category	Age category			P-value
	A (n=80)	B (n=248)	C (n=182)	
Low	57 (71.2%)	113 (45.5%)	23 (12.6%)	0.0001
High	23 (28.7%)	135 (54.4%)	159 (87.3%)	

Among 510 subjects, 364 had diabetic mellitus, 205 had hypertension, 45 had hypothyroidism and 51 had periodontal disease. Table 4 explains the frequency distribution of the comorbidities and duration of the disease based on risk levels. Table 5 shows that the prevalence of DM was 272 (85.8%) in high risk and 92 (47.7%) in low risk, both high and low risk subjects had predominantly 50% of uncontrolled DM. Meanwhile, the prevalence of HTN was found to be 47 (24.3%) in low risk and 158 (49.8%) in high risk, both high and low risk subjects had predominantly 70% of uncontrolled HTN. The prevalence of both co-morbidities was statistically significant. Hypothyroidism was observed in 19 (9.8%) subjects in the low-risk category compared to 26 (8.2%) subjects in the high-risk category. Periodontal disease has been associated with the onset of cardio vascular disease. The prevalence of periodontal disease was found to be 8.8% and 10.7% in low risk and high-risk groups, respectively.

**Table 4: Association of co-morbidities with CVD risk levels.**

Study code	Total	FRS			IRS			QRS		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
DM	364 (71.4%)	4	1	157	16	191	109	119	101	126
DM duration	59.68 ±81.34	4.9 ±18.5	13.3 ±40	74 ±89	5.41 ±19.10	2.95 ±85.13	0.73 ±80.03	7.86 ±50.22	64.44 ±78.75	97.42 ±106.99
HTN	205 (40.2%)	5	6	74	14	74	89	45	59	92
Duration	29.24 ±57.52	7.4 ±24	23.6 ±40	34.2 ±65.2	17.25 ±55.37	20.02 ±48.80	51.64 ±62.16	12.55 ±31.49	30.69 ±55.79	57.18 ±78.25
HTN on medication	173 (33.9%)	4	5	62	13	61	73	36	48	81

DM- diabetes mellitus; HTN - hypertension

**Table 5: Risk assessment based on co-morbid conditions**

Parameter	Low(n=193) Frequency (%)	High(n=317) Frequency (%)	P-value
Diabetic	92(47.7)	272(85.8)	0.0001
Hypertension	47(24.3)	158(49.8)	0.0001
Hypothyroidism	19(9.8)	26(8.2)	0.52
Periodontal	17(8.8)	34(10.7)	0.484

Medical records containing information on hematology, glucose profile, lipid profile and other biochemical markers were collected. Mean ± standard deviation was estimated for all the biochemical parameters for the study population, as shown in Table 6. Correlation of biochemical parameters with risk levels revealed that elevated levels of LDL and HbA1c was significantly higher in the high-risk group (Table 7).

**Table 6: Comparison of biochemical parameters with risk categories among FRS, IRS and QRS scores**

Parameter	Total	FRS			IRS			QRS		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
Hb Male :14- 17g/dl Femal e:12 - 16g/dl	11.97 ±2.91	13.0 5±2. 36	12.4 ±1.5 4	12.3 ±2.1	12.6 6±4. 06	11.7 0±2. 48	12.08 ±2.87	12.4± 3.36	11.4 ±2.8 6	11.8 7±2. 47
RBC Male :4.5- 5.9x1 0 <sup>6</sup> cells/ mm <sup>3</sup> Femal e:4.1										

Parameter	Total	FRS			IRS			QRS		
		Low	Mod erate	High	Low	Mode rate	High	Low	Mod erate	High
- 5.1x1 0 <sup>6</sup>  cells/ mm <sup>3</sup>	4.64± 3.16	4.9± 2.2	4.4± 0.4	4.3± 0.87	4.77 ±1.8 6	4.35 ±1.1 7	5.22± 5.91	4.65± 1.19	4.22 ±0.7 6	4.94 ±5.9 2
WBC 4.5- 11x1 0 <sup>3</sup>  cells/ mm <sup>3</sup>	8378. 8± 4138	6633 .2± 3805 .84	5774 .7± 4416 .27	7592 .2± 4089 .88	7723 .9± 3447 .16	7830 .6± 4002 .45	9375. 1± 4775. 41	8284. 3± 3637. 45	8047 .2± 4424 .98	8782 .4± 4463
MCV 80- 100 fl/cel ls	87.47 ±58.9 0	84.4 ±7.7	84.7 ±1.7	98.8 ±10 5	82.8 0±8. 47	82.5 8±10 .80	101.1 3±11 2.32	93.60 ±102. 57	84.3 3±8. 06	84.3 6±5. 84
MCH 26- 34 pg/ce ll	29.44 ±19.5 2	28.7 ±3.0 5	29.3 4±1. 97	28.3 ±3.2 4	27.7 9±4. 37	30.4 8±27 .50	28.77 ±2.71	31.5± 33.98	28.1 7±3. 06	28.7 2±2. 39
MCH C 33- 37g/d l	33.41 ±1.96	34.1 3±1. 87	34.4 ±1.5 4	33.4 ±1.7	33.5 9±2. 53	33.1 6±1. 99	33.66 ±1.36	33.19 ±2.32	33.8 ±1.7 0	33.8 ±1.4 5
ESR Male :0- 15m m/hr Fema le:0- 20m m/hr	24.55 ±33.9 5	10.8 ±8.7	19.3 3±1 9.08	39.1 3±5 9.49	22.4 4±19 .04	21.6 9±21 .50	35.55 ±62.2	19.33 ±33.8 8	28.3 2±4 0.86	26.7 6±26 .53
Neutr ophil s (40- 80%)	65.59 ±12.6 6	61.3 ±11. 09	62.2 ±12. 2	62.2 ±11. 66	62.9 4±10 .24	66.0 9±13 .25	67.85 ±12.4 9	66.06 ±11.0 1	66.1 9±1 2.8	64.9 3±15 .27

Parameter	Total	FRS			IRS			QRS		
		Low	Mod erate	High	Low	Mode rate	High	Low	Mod erate	High
Lym phoc ytes (20- 40%)	26.96 ±21.0 4	29.4 ±9.4 7	30.1 ±10. 1	31.3 ±29. 3	30.2 0±16 .69	24.6 9±12 .60	27.69 ±34.3 5	27.55 ±15.8 6	25.0 6±1 3.81	28.7 4±34 .1
Eosin ophil s (1- 6%)	5.21± 24.92	3.8± 1.8	2.5± 1.76	8.73 ±42. 14	3.77 ±1.9 6	4.14 ±10. 49	8.86± 47.08	2.95± 1.84	4.78 ±13. 44	9.39 ±47. 48
Mon ocyte s (2- 10%)	7.31± 23.94	4.71 ±1.8 2	4.78 ±2.3	10.5 ±42. 2	5.50 ±2.6 8	5.96 ±3.2 2	12.01 ±46.6 9	4.97± 3.04	6.24 ±2.9	12.4 3±47 .13
Baso phil s (<1% )	0.53± 4.99	0.26 ±0.5	0.26 ±0.6	1.36 ±8.7 4	0.29 ±0.5 3	0.17 ±0.3 7	1.49± 9.74	0.14± 0.34	0.17 ±0.4 1	1.48 ±9.6 4
Platel et (1.5- 4lakh s/cu mm)	741.5 8± 10964 .3	2.78 ±0.4 4	2.49 ±0.5 54	2270 ±19 209	3.01 ±0.7 8	1572 .4± 1598 2.97	3.19± 2.68	3.31± 2.75	2723 .3± 2104 2.36	2.8± 0.99
CRP (3.0 mg/l)	41.96 ±71.9 1		8.1	29.0 9±6 4.41	0	64.7 8±86 .32	4.60± 4.40	5.78± 8.68	88.8 ±10 9.96	40.0 2±60 .71
Urea (7- 20mg /l)	28.84 ±32.5 0	22.6 8±7. 27	23.8 ±6.4 5	33.8 ±49. 9	24.8 0±17 .76	26.6 5±14 .32	36.19 ±58.4 8	23.7± 11.83	31.9 1±2 5.89	34.6 1±52 .63
Creat inine (0.6- 1.3m g/dl)	1.00± 2.20	0.91 ±0.4 3	0.88 ±0.1 7	1.14 ±3.2 8	0.86 ±0.3 0	1.09 ±3.1 1	0.90± 0.43	0.8±0 .28	1.35 ±4.1 2	0.93 ±0.2 4
Chol ester ol (<20 0mg/ dl)	189.8 3±45. 69	199. 68± 39.5 2	209. 33± 50.6	187. 03± 46.6	212. 97± 58.2 4	189. 40±4 4.58	184.4 6±36. 57	1093. 35± 40.79	190. 52± 48.9 6	183. 75±4 5.5
HDL	42.40	41.9	42.7	42.5	40.6	42.7	45.23	42.68	43.1	41.8

Parameter	Total	FRS			IRS			QRS		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
(35-60mg/dl)	±9.09	6±4.28	7±3.59	3±9.8	5±3.51	8±7.25	±16.07	±5.05	5±14.26	1±6.42
LDL (<100mg/dl)	117.2±41.82	129.8±36.2	137.56±32.48	114.31±42.46	144.25±49.73	116.79±40.37	116.44±37.86	121.53±36.04	115.83±45.46	112.26±42
Triglycerides (150mg/dl)	168.66±104.41	136.97±71.56	156.33±90.45	170.93±99.08	152.89±79.24	158.68±71.86	159.11±77.77	164.65±83.79	161.81±82.9	174.96±119
VLDL (2-30mg/dl)	35.80±44.37	28.24±13.7	25.74±3.81	37.71±48.93	30.14±13.03	39.82±62.75	31.14±15.05	32.75±16.77	35.91±34.69	41.01±68.95
TC/HDL ratio (<5)	4.73±2.71	4.81±1.16	4.92±1.61	4.68±2.95	5.33±1.67	4.45±1.06	5.31±5.60	5.11±4.42	4.53±1.1	4.43±1.34
FBS (70-110mg/dl)	164.51±73.86	129.67±80.2	153.00±111.51	158.25±65.91	156.06±86.94	168.86±68.76	174.31±83.93	172.69±76.98	160.55±67.55	154.68±65.86
PPBS (80-140mg/dl)	240.03±113.69	169.26±111.15	225.0±140.89	232.6±100.19	226.97±153.35	238.77±102.23	258.85±226.96	245.42±121.85	229.6±107.8	237.46±91.14
HbA1c (4-5.6%)	8.38±7.07	6.42±2.11	5.44±0.72	8.01±2.10	6.93±2.17	8.10±2.36	10.29±15.19	8.05±2.54	9.3±13.05	8.09±1.81
RBS (80-140mg/dl)	166.98±92.06	100.00±34.59	183.68±98.32	155.86±47	100.00±34.59	183.68±98.32	155.86±47.00	186.43±142.61	206.7±81.2	132.52±66.58
T3	4.75±	2.4±	3.8	6.4±	2.13	7.02	2.37±	6.78±	6.47	2.19

Parameter	Total	FRS			IRS			QRS		
		Low	Mod erate	High	Low	Mode rate	High	Low	Mod erate	High
(2.3-4.2pg/dl)	13.41	0.8		17.6	±0.6 1	±18. 51	0.88	17.72	±17. 8	±0.7 6
T4 (0.8-1.8ng/dl)	2.59± 2.91	2.53 ±3.1 1	1.15	2.86 ±3.1 8	2.67 ±3.4 7	2.41 ±2.8 1	2.59± 2.44	2.16± 2.64	3.4± 3.61	2.37 ±2.5 3
TSH (0.5-5.0mlu/ml)	8.42± 36.69	2.95 ±2.4 2	3.95 ±2.6 3	10.7 ±46. 6	8.95 ±28. 60	12.0 0±50 .36	3.01± 2.88	7.34± 21.9	3.4± 4.47	12.7 ±57. 87
Sodium (135-145mEq/l)	135.3 7±6.6 2	141. 33± 2.51	145	135. 86± 4.5	136. 92±9 .36	134. 86±6 .31	135.3 1±6.5 2	137.5 ±5.09	133. 57± 8.47	134. 72±5 .94
Potassium (3.5-5.0mmol/l)	4.91± 5.75	4.4± 0.52	5.6	6.06 ±7.9 7	3.82 ±0.3 3	5.40 ±6.9 1	3.90± 0.58	4.87± 5.08	4.04 ±0.4 7	5.81 ±8.4 1
Chloride (96-108mmol/l)	98.45 ±8.25	102 ±1	104	97.8 3±1 4	98.7 0±3. 74	99.0 1±4. 56	99.27 ±3.37	97.12 ±14.4 1	98.3 8±4. 29	98.9 7±4. 35
Bicarbonate (21-32mmol/l)	21.91 ±2.82	22.6 6±1. 15	24	21.7 3±4. 81	22.3 0±1. 15	21.5 3±3. 50	22.36 ±2.21	22.34 ±1.23	21.1 8±4. 12	22.2 ±2.5 4
Micr oalbu ria (<30mg)	5	5			5			5		
Calci um	1.5					1.5			1.5	

Parameter	Total	FRS			IRS			QRS		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
(8.6-10.3 mg/dl)										
Vitamin b12 (190-950pg/ml)	1041.5±135.52			2000		1041±135.5			2000	
Vitamin d (20-40ng/ml)	32.41			32.41		32.4			32.4	
Vitamin d3 (20-40ng/ml)	15					15			15	
Ferritin (20-250ng/ml)	117.65±87.04				0	83.53±66.19	220	93.8	182±53.74	

**Table 7: Association of biochemical parameters with risk levels**

Parameter	Low risk (n=193)	High risk (n=317)	P-value
	Frequency (%)	Frequency (%)	
WBC	15(7.7%)	34(10.7%)	0.308
Total cholesterol	19(9.8%)	59(18.6%)	0.112
<b>LDL</b>	<b>33(17%)</b>	<b>13(4.1%)</b>	<b>0.023</b>
Triglycerides	10(5.1%)	78(24.6%)	0.112
Fasting blood glucose	54(27.9%)	136(42.9%)	0.094

Parameter	Low risk (n=193)	High risk (n=317)	P-value
	Frequency (%)	Frequency (%)	
Post prandial blood glucose	49(25.3%)	127(40%)	0.06
<b>HbA1c</b>	<b>43(22.2%)</b>	<b>124(7.5%)</b>	<b>0.011</b>

Medication history of the study subjects was also obtained and the distribution of drugs consumed based on the risk levels are given in Table 8. Among 364 diabetic patients, the most commonly prescribed anti-diabetic drugs are Metformin and Sulphonyl urea (Table 9). Most commonly prescribed antihypertensive drugs include angiotensin receptor blockers, calcium channel blockers and beta blockers. Among which beta blockers are statistically significant for high-risk category (Table 10). Metformin was observed to be consumed by 41.3% of the subjects in the high-risk category, when compared to other anti-diabetic drugs (Table 11).

**Table 8: Comparison between medications and 3 risk scores**

Parameter	Total	FRS			IRS			QRS		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
Sulphonylureas	132 (25.9%)			52	6	60	39	43	32	51
DPP-4 inhibitor	76 (14.9%)	1		33	1	29	27	24	25	23
Metformin	175 (34.3%)	1		71	7	76	55	54	50	64
Thiazolidinediones	1 (0.2%)				0	0	1	1		
A-glucosidase inhibitor	25 (4.9%)			12	1	10	7	5	7	13
SGLT-2 inhibitor	7 (1.44%)			5			4	3	2	2

Parameter	Total	FRS			IRS			QRS		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
Rapid acting insulin	24 (4.7%)	1		12	1	12	4	5	6	12
Short acting insulin	17 (3.3%)			7	0	10	7	10	2	4
Intermediate acting insulin	12 (2.4%)			5	0	7	5	7	1	3
Long acting insulin	4 (0.8%)			1	0	1	1	1	1	2
Diuretics	16 (3.1%)	1		5	1	6	7	3	3	7
Ace inhibitors	4 (0.8%)			3	0	1	2		3	1
Angiotensin receptor blockers	75 (14.7%)	3	3	19	8	26	28	17	21	32
Calcium channel blockers	72 (14.1%)	1	3	23	7	29	27	17	21	31
Beta adrenergic blockers	26 (5.1%)		3	12		6	12	2	7	16
Hydralazine	1(0.2%)			1					1	
Hypothyroidism drugs	45 (8.8%)	2		16	8	20	9	13	14	13

Parameter	Total	FRS			IRS			QRS		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
Antibiotics	13 (2.5%)			2	1	10	2	4	3	4
Anti viral	1 (0.2%)					1				
Vitamin supplements	31 (6.1%)			9	4	16	10	14	7	7
Hypolipidemic drugs	31 (6.1%)	1		16	1	6	12	4	9	15
Anti ulcer	21 (4.1%)	1		9	4	12	5	4	5	6
Analgesic	10 (2.0%)			1		6		6	1	
Antipyretic	1 (0.2%)									
Anti inflammatory	6 (1.2%)			2		3				
Anti emetic	14 (2.7%)			5		9		5	2	4
Psychotic drugs	14 (2.7%)			6		8		3	6	4
Corticosteroids	8 (1.6%)			2		5		2	2	4
Anti tuberculosis	2 (0.4%)			1		2				1

Parameter	Total	FRS			IRS			QRS		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
Bronchodilator	4 (0.8%)			2		1		1	1	2

**Table 9: Comparison between medications and risk level**

Parameter	Low risk (n=193) Frequency (%)	High risk (n=317) Frequency (%)	P-value
Sulfonyl urea	40(20.75)	92(29.0)	<b>0.036</b>
Dpp4	18(9.35)	58(18.2)	<b>0.006</b>
Metformin	44(22.7)	131(41.3)	<b>0.0001</b>
Alpha glucosidase	4(2.0)	21(6.6)	<b>0.021</b>
Sglt2	0	7(2.2)	<b>0.038</b>
Beta blocker	3(1.5)	23(7.2)	<b>0.005</b>
Hypolipidemic	6(3.1)	30(9.4)	<b>0.007</b>

**Table 10: Most commonly used anti-diabetics among study population**

Drug	No. of participants (%)
Metformin	175 (48.1)
Sulphonyl urea	132 (36.5)
Dpp4 inhibitor	76(20.8)
Alpha glucosidase inhibitor	25(6.8)
Rapid acting insulin	24(6.5)
Short acting insulin	17(4.6)
Intermediate acting insulin	12(3.2)
Sglt2 inhibitor	7(1.9)
Long-acting insulin	4(1)

**Table 11: Most commonly used antihypertensive among study population**

Drug	No. of participants (%)
Angiotensin receptor blockers	75(36.5)
Calcium channel blockers	72(35.1)

Drug	No. of participants (%)
Beta blockers	26(12.6)
Diuretics	16(7.8)
Ace inhibitors	4(1.9)
Hydralazine	1(0.4)

Dietary habits of the study subjects were assessed. Habitual consumption of salty foods, deep fried foods, fast food/street foods and meat has been reported to increase risk of CVD (Table 12). Similarly, increased number of non-vegetarians was observed in high-risk group. In addition, significantly higher number of green tea drinkers was found in the low- risk group. Association between risk levels (Framingham and Q-risk) and dietary intake is described in Table 13 and Table 14.

**Table 12: Association between diet and CVD risk level**

Parameter	Low risk Frequency (%)	High risk Frequency (%)	P-value
Vegetarian	62 (30.7)	140 (69.3)	<b>0.00</b> 7
Non vegetarian	<b>131 (42.5)</b>	<b>177 (57.5)</b>	
Salt food intake	79 (38.73)	125 (61.27)	0.737
Deep fried food or fast fried food	99 (41.5)	139 (58.5)	0.102
Fruits	131 (35.5)	238 (64.5)	0.078
Vegetables	182 (37.5)	304 (62.5)	0.408
Meat	101 (38.3)	163 (61.7)	0.842
Coffee	94 (35.3)	173 (64.7)	0.198
Tea	106 (36.9)	181 (63.1)	0.631
<b>Green tea</b>	<b>27 (57.5)</b>	<b>19 (42.5)</b>	<b>0.002</b>

**Table 13: Association between diet and Framingham risk level**

Parameter	Low risk Frequency (%)	High risk Frequency (%)	P-value
Non vegetarian (n=105)	24 (22.85)	81 (77.15)	0.124
Salt food	18 (22.2)	63 (77.8)	0.326

Parameter	Low risk Frequency (%)	High risk Frequency (%)	P-value
intake(n=204)			
Deepfried and fast-food intake (n=105)	23 (21.9)	82(78.1)	0.236
<b>Fruits (n=169)</b>	<b>24(14.3)</b>	<b>145 (85.7)</b>	<b>0.001</b>
Vegetables (n=208)	38 (18.26)	170 (81.74)	0.222
Meat (n=106)	22 (20.74)	84 (79.24)	0.442
Coffee (n=126)	24 (19.04)	102 (80.96)	0.882
Tea (n=108)	20 (18.51)	88 (81.49)	0.895
Green tea (n=12)	2 (16.66)	10 (83.34)	0.952

**Table 14: Association between diet and Q-risk 2 level**

Parameter	Low risk Frequency (%)	High risk Frequency (%)	P-value
<b>Non vegetarian (n=300)</b>	<b>207 (69)</b>	<b>93 (31)</b>	<b>0.004</b>
Salt food intake (n=197)	133 (67.51)	64 (32.49)	0.184
<b>Deep fried and fast-food intake (n=231)</b>	<b>166 (71.86)</b>	<b>65 (28.14)</b>	<b>0.001</b>
Fruits (n=359)	227 (63.23)	132 (36.77)	0.573
Vegetables (n=474)	303 (63.93)	171 (36.07)	0.9
Meat (n=258)	172 (66.66)	86 (33.34)	0.196
Coffee (n=258)	168 (65.11)	90 (34.89)	0.585
Tea (n=271)	174 (64.26)	105 (38.74)	0.395
<b>Green tea (n=41)</b>	<b>31 (75.61)</b>	<b>10 (24.39)</b>	<b>0.005</b>

About 46% of subjects with sedentary behavior were identified as high-risk, confirming that sedentary lifestyle increases the risk of CVD. Moreover, 67% of female subjects who attained menopause were identified among high-risk category. Post-menopausal women have shown to exhibit increased risk of CVD due to their reduced estrogen levels (Table 15).

**Table 15: Association between lifestyle and CVD risk level**

Parameter	Low risk (n=193) Frequency (%)	High risk (n=317) Frequency (%)	P-value
Alcohol	24(12.4)	27(8.5)	0.153
Smoking	8(4.1)	19(5.9)	0.639
Second hand smoking	9(4.6)	12(3.7)	0.629
Stress			
Never	76(39.3)	117(36.9)	0.12
Some	105(54.4)	159(51.0)	
Several	10(5.1)	35(11)	
Permanent	2(1)	6(1.8)	
Physical activity			
<b>Sedentary</b>	<b>62(32.1)</b>	<b>146(46)</b>	<b>0.001</b>
Mild	81(41.9)	120(37.8)	
Moderate	50(25.9)	46(14.5)	
Strenuous	0	5(1.5)	
Depression	48(24.8)	80(25.2)	0.926
<b>Menopause</b>	<b>58(50)</b>	<b>103(67.7)</b>	<b>0.004</b>

## DISCUSSION

CVD is reported as the leading cause of death and disability globally, with an estimated 17.9 million deaths reported annually in 2019. Of these, 85% of the deaths were due to myocardial infarction and stroke [2]. Major CVD risk factors include age, gender, family history of CVD, diabetes mellitus, hypertension, high lipid profile, fasting blood glucose, post prandial blood glucose, smoking habits, alcohol consumption, unhealthy diet, sedentary lifestyle, stress and abdominal obesity. These risk factors have been estimated in the present study using Framingham, inter-heart and Q-risk scoring systems to predict the predisposition to CVD [37].

FRS is one of the conventional techniques for evaluating CVD risk. Information on age, gender, TC, HDL, systolic blood pressure, diabetes mellitus, previous medical history especially for hypertension medication, smoking habits, and past history of vascular disease or stroke are the

parameters used to estimate the risk levels. Based on the risk percentage, the study subjects were categorized into low, moderate and high-risk groups. The findings of our study exhibited an association between FRS and CVD, with 81.2% of the subjects in high risk, 4.2% in moderate risk and remaining (14.5%) in low risk [38].

The Inter heart risk score is considered as a prognostic tool for CVD risk. It includes age, gender, waist circumference, hip circumferences, TC, HDL, SBP/DBP, diabetes mellitus, previous medical history especially for hypertension medication, family history of heart diseases, smoking habits, and family history of heart disease, physical activity, psychosocial factor and dietary intake. Our study found that inter heart risk score demonstrate that (55.9%) lies in moderate risk, (28.3%) in high risk and (15.7%) lies in lower risk [34].

Q-risk score is a validated tool which shows one in ten chances of developing CVD and stroke based on parameters such as age (25-84), gender, ethnicity, systolic blood pressure, diabetic status, chronic kidney disease (stage 4 or 5), atrial fibrillation, past medical history on hypertension, rheumatoid arthritis, total cholesterol/ HDL ratio, height (cm) and weight (kg). A total of 497 subjects were assessed using q-risk score, among which 36% were classified as having low risk, 28.1% as moderate risk and 35.8% as high risk [39].

In the present study, a significant association between CVD risk levels and clinical parameters such as high blood pressure and diabetes mellitus was observed, indicating that elevated blood pressure and presence of diabetes mellitus increase the susceptibility of CVD. Our findings were in accordance with previous studies. Takahashi et al. [40], investigated CAD risk in general population using the Framingham scoring system. The study found that increased risk of CAD was associated with high levels of SBP, TC, and low levels of HDL, suggesting subjects having metabolic syndromes are at high risk of CAD. Similarly, Yousefzadeh et al. [41] also found higher prevalence of 10-year risk of CVD in patients with metabolic syndrome ( $P < 0.001$ ).

BMI was used to categorize the participants into underweight ( $< 18.5 \text{ kg/m}^2$ ), normal weight ( $18.5\text{-}24.9 \text{ kg/m}^2$ ), overweight ( $25\text{-}29.9 \text{ kg/m}^2$ ), and obese ( $\geq 30 \text{ kg/m}^2$ ). Obesity has been associated with an increased risk of metabolic diseases and CVD. An increase in body fat can directly contribute to heart disease through atrial enlargement, ventricular enlargement and atherosclerosis. The mean hip-waist ratio was approximately 0.91 among both high-risk and low-risk groups; hence there was no significant difference. The mean hip-waist ratio for the overall participants was found to be 0.911 which is higher than the normal

reference range (0.86), hence there was no statistical difference between low and high-risk groups.

Periodontitis is a chronic gum disease which is caused by pathogens such as *Porphyromonas gingivalis*. Gingivitis, in other words inflammation of the gums, when left untreated could progress to periodontitis, eventually resulting in tooth loss. Several studies have reported an association between periodontitis and CVD, particularly atherosclerosis. Periodontal pathogens enter the blood stream and form plaques which block the blood vessels, ultimately causing atherosclerosis [42]. Hence, periodontal disease/periodontitis was included as a novel risk factor for CVD in the present study. Our study revealed that among 510 subjects recruited, 10% were found to have periodontitis. In addition, among these 51 subjects with periodontitis, 34 belonged to high-risk and 17 belonged to low-risk groups. However, the findings were not statistically significant. Improved oral hygiene such as frequent tooth brushing and regular dental visits for professional cleaning procedure was found to be associated with a reduced risk of major cardiovascular events [33].

Ovarian hormones are considered to possess protective benefits in women before menopause. Impaired ovarian function and subsequent deficiency of endogenous estrogens is suggested to enhance CVD risk and related death after menopause. The findings of our study are in agreement with the previous studies which revealed that post-menopausal women were at higher risk of CVD. In a cross-sectional, population-based study, a longer duration of reproductive life span was associated with a lower 10-year CVD risk, as evaluated by the FRS in postmenopausal women [43].

Our study showed that sedentary behavior was significantly associated with CVD risk. Around 50% high risk subjects were physically inactive (sitting, reading, watching television). Physical inactivity is also associated with increased risk of morbidity or worsening of many chronic diseases and health conditions including CVD, congestive heart failure, stroke, certain cancers, osteoporosis, obesity, diabetes mellitus, and hypertension [44]. Previous study shows that physical inactivity and subjects who spent average 8.7/day on sedentary behavior showed significant adverse change in blood glucose (4.79 mg/dl), insulin (2.73 pmol/l), BMI (0.69kg/m<sup>2</sup>), waist circumference(1.95cm), fat mass (1.03%), total cholesterol (9.73 mg/dl), HDL (3.50 mg/dl), LDL (10.7 mg/dl), triglycerides (12.4 mg/dl). In 2008, the Physical Activity Guidelines for Americans Advisory Committee concluded that adults should accumulate 150 minutes of moderate intensity physical activity, or 75 minutes of vigorous intensity physical activity, or a combination of both, each week [45]. Research have also shown that

meeting these guidelines is associated with better CVD risk profiles [46], as well as reduced risk of mortality [47].

In the present study, 55.8% subjects in the high-risk group were non-vegetarians. Meanwhile, 67.8% subjects in the low-risk group were vegetarians. Diet plays a major role in the development and progression of CVD. Healthy dietary choices may help reduce the risk of CVD. Plant-based diets like whole grains, fruits, vegetables, and nuts, were associated with lower risk of CVD [48]. In a meta-analysis of randomized control trials, a 2–10 g/day increase in soluble fiber intake resulted in a modest but significant decrease in LDL cholesterol [-0.057 mmol.L-1. g-1 (95% CI: -0.070, -0.044)] [49]. Plant-based diets, defined in terms of varying degrees of restrictions on animal food consumption, have been associated with lower risk of CVD as well as an improved cardiovascular risk profile. In addition, plant-based foods have also reported to exert potentially cardioprotective effects [50]. Diet includes poultry, fish, and red meat. 90% of non-vegetarian had consumed fish and sea food atleast once a week. Fish is recommended as a part of a healthy diet it contains proteins, n-3fatty acids, vitamin D, iodine and selenium. Hence fish is considered to be a cardioprotective [51].

Catechins in green tea is reported to possess cardioprotective effects due to its properties such as antioxidative, antihypertensive, anti-inflammatory, anti-proliferative, anti- thrombogenic and lipid lowering effects. Yohei Micceharuet. al.,<sup>[52]</sup> conducted a comparative study among Japanese men and women free from stroke and CHD. To examine the relationship between the consumption of coffee, green tea, black tea, along tea and risk of mortality from CVD concluded that the consumption of beverages was associated with a reduced risk of mortality from CVD. Similarly, our study revealed that among 46 regular green tea drinkers, 27 and 19 subjects had low and high risk of CVD, respectively. Hence concluding that, green tea consumption was associated with lower risk of CVD.

Due to the increasing incidence of CVD and related mortality, there is an urgent need to improve public awareness on the risk of CVD. Implementing optimal CVD risk scoring systems as part of routine check-up will facilitate in the early diagnosis as well as prevention of CVD. Lifestyle modification in terms of physical activity, dietary intake and improved oral hygiene will contribute in reducing the risk of CVD.

## CONCLUSION

This is a hospital-based study and the findings of this study have helped to generate variables for a scoring system for CVD risk using some novel risk

factors (green tea, periodontal disease, menopause status) that were not included in any other scoring systems, indicating that a modified CVD risk scoring system may be ideal for use at Hindu Mission Hospital, but could also be extended to the general public.

### Limitation

COVID-19 pandemic and narrow study timeline are the two major factors restricting the number of subjects considered for the study.

Questions on tobacco and alcohol consumption may have elicited answers with a social desirability bias.

Comparison of three risk score was not possible due to the unequal distribution of subjects in each score.

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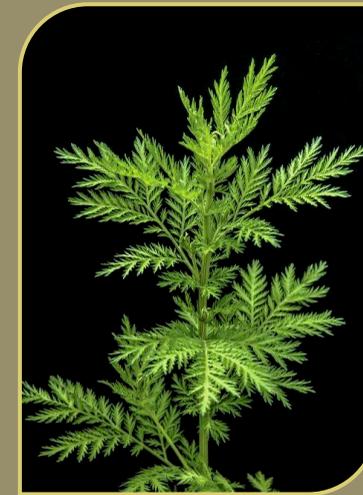
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A Textbook by

Dr. Sanatkumar B. Nyamagoud

Dr. Chandrahas S. Jadhav



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Geerwanjyoti Prakashan



COMPREHENSIVE REVIEW OF CLINICAL RESEARCH

Geerwanjyoti Prakashan



Aman B. Upaganlawar, PhD  
Vipin V. Dhote, PhD  
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NATURAL PRODUCTS AND THERAPEUTICS

Health Benefits of

# PHENOLIC ANTIOXIDANTS

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# **Health Benefits of Phenolic Antioxidants**



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## Chapter 1

# Natural and Synthetic Sources of Phenolic Antioxidants

**Agilandeswari Devarajan<sup>1,\*</sup>, Bhagya V. Rao<sup>2</sup> and Tisa Francis<sup>3</sup>**

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### Abstract

Free radicals are unstable compounds with unpaired electrons which contains oxygen and nitrogen that are termed as reactive oxygen species (ROS) and reactive nitrogen species (RNS). The antioxidants naturally present in our body challenge ROS and RNS. However, when an imbalance arises, these free radicals cause cellular damage. Hence, there was a need to search for antioxidants from other external sources. Polyphenols show an ample variety of biological effects as an outcome of their antioxidant property. The phenolic antioxidants (PA) play a significant role as radical scavengers. The formation of free radicals can be inhibited by the PAs by interrupting the propagation of auto-oxidation. The PA's are derived naturally from plant sources. They are also synthesized artificially from different sources (SPAs). The natural phenolic antioxidants are obtained from plant sources such as vegetables, spices and herbs, fruits, grains, coffee, green leaves, black tea, wine, and beer, etc. Phenolic antioxidants are also found in animal and plant tissues, especially in the fractions of phospholipids in cell membranes. SPAs are BHT (Butylated hydroxytoluene), BHA (Butylated hydroxyanisole), Propyl gallate (PG), and Tertiary butylhydroquinone (TBHQ). SPAs also include the polymeric phenol antioxidants which usually undergo a modification process due to their low aqueous solubility, poor bioavailability in vivo, and low stability under physiological conditions e.g., enzymatic modification of flavonoids. The health effects of polyphenols depend on the amount consumed and their bioavailability since bioavailability appears to differ greatly between the various polyphenol groups from different sources.

**Keywords:** polyphenols, natural, marine, synthesis, modify, flavonoid, tannins

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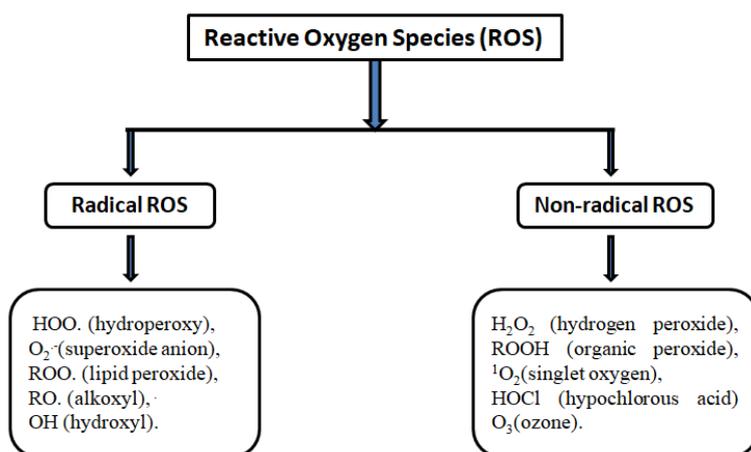
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## 1. Introduction

Antioxidants are divided as free radical terminators, metal ions chelator that has the ability to catalyze the oxidation of lipids, and/or oxygen scavengers that reacts with oxygen in an enclosed system. Some antioxidants are reacting with the energy-high lipid radicals in transforming into products that are stable whereas others retard the degree of chain initiation in the breakdown of hydroperoxides which are termed as prophylactic antioxidants. Phenolic antioxidants act as free radical terminators and/or chelators of metal ions. The basic concepts such as oxygen, oxidants, free radicals, and antioxidants would provide a better understanding of the mechanisms of antioxidants. The various sources of natural and synthetic phenolic antioxidants offer a wide range of antioxidant activity (Uddin and Upaganlawar, 2019).

### 1.1. Oxygen and Oxidants

Oxygen is a fundamental requirement for the aerobic processes of human life. Approximately 4-6% of oxygen inhaled is converted by the reduction of oxygen into Reactive Oxygen Species (ROS) which are toxic (Harman et al., 1993, Bandyipudya et al., 1999). Free radicals are species of chemicals like atoms containing unpaired electrons that are produced by the split of weak bonds. Free radicals are usually found in biological systems which are unstable atoms/molecules/ions of unpaired electrons. The unpaired electrons make the free radicals to actively react with other molecules to capture electrons for their stability. This is a chain reaction. Free radicals are derived from molecules of oxygen, nitrogen, and Sulphur consisting of two significant reactive species. The free radicals containing oxygen are called ROS and nitrogen as Reactive Nitrogen Species (RNS). ROS is further classified into radical and non-radical species (Al-Mamary et al., 2021, Li et al., 2013, Reichart et al., 2018) as shown in Figure 1.



Radical ROS: HOO. (hydroperoxy), O<sub>2</sub><sup>-</sup>(superoxide anion), ROO. (lipid peroxide), RO. (alkoxyl), OH (hydroxyl). Non-radical ROS: H<sub>2</sub>O<sub>2</sub>(hydrogen peroxide), ROOH (organic peroxide), <sup>1</sup>O<sub>2</sub>(singlet oxygen), HOCl (hypochlorous acid), and O<sub>3</sub>(ozone).

**Figure 1.** Classification of Reactive Oxygen Species (ROS).

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These ROS are challenged and balanced by the naturally occurring antioxidants of the body (enzymatic antioxidants such as SOD (superoxide dismutase), CAT (catalase), peroxidase; free-radical scavengers (FRS) – alpha-tocopherol, reduced glutathione (GSH), ascorbate) present in the body. An imbalance between reactive species and antioxidants results in oxidative stress and cellular damage (Fridovich et al., 1983, Chance et al., 1979, Meister et al., 1983).

## 1.2. Hydroperoxy Radical (HOO.)

HOO. can be named as per hydroxyl radical that is formed because of the reverse reaction of proton and superoxide anion radical. They are present in lesser concentrations in the cytoplasm. Hence it was predicted that this radical might have some part in imitating the lipid peroxidation. Comparatively, this radical is highly specific.

## 1.3. Superoxide Anion Radical ( $O_2^{\cdot-}$ )

The main source of most of the ROS biological (superoxide anion, hydrogen peroxide, and hydroxyl) is mitochondria. The free oxygen is reduced during the oxidative phosphorylation process which is the precursor for many ROS. Many parts of the brain consisting of a higher concentration of iron that is responsible for stimulating free radical reactions. Both hydrogen peroxide and superoxide anion radicals are formed in CNS (central nervous system) and in the brain.

## 1.4. Alkoxy Radical (RO.) and Lipid Peroxide Radical (ROO.)

RO. and ROO. are products of lipid peroxidation. Lipid hydroperoxide is stable, however, it forms alkoxy radicals and peroxide radicals due to the presence of iron and copper ions. The reactions of these radicals depend on the substituents in  $\alpha$ -carbon resulting in the increase of reactivity by the electron-donating group and vice-versa. Henceforth the aromatic alkoxy radicals and peroxide radicals become lesser reactive due to single-electron delocalization. By abstracting, H-atom, these radicals react with the biological molecules (Halliwell et al., 1984).

## 1.5. Hydroxyl Radical ( $\cdot OH$ )

Hydroxyl radical is formed from superoxide anion radical and hydrogen peroxide. In a biological system,  $\cdot OH$  is considered a severely reactive and destructive radical. During stressed conditions (higher superoxide anion radical), hydrogen peroxide reacts with  $Fe^{+2}$  to complex with intracellular proteins. The free ions,  $Fe^{+2}$  is released in the above reaction that again react with hydrogen peroxide to form hydroxyl radical. This hydroxyl free radical has the capability to penetrate more into the phospholipid bilayer compared to the superoxide anion radical. Henceforth this hydroxyl radical is considered extremely destructive to biological systems

since they react with biological molecules like protein, carbohydrates, DNA, and lipids causing more cell damage when compared to other ROS species (Knight et al., 1999, Haber et al., 1934, Fenton et al., 1894).

### **1.6. Hydrogen Peroxide (H<sub>2</sub>O<sub>2</sub>)**

Superoxide anion radical is swiftly converted into hydrogen peroxide by an enzymatic reaction. The antioxidant enzyme involved in the above reaction is superoxide dismutase (SOD). The hydrogen peroxide formed is less reactive. In the above reaction, the two superoxide anion radicals were involved, among which one oxidized into an anion and the other gets reduced into hydrogen peroxide. This radical is stable. They have the ability to diffuse into cells. At the same time, it can be converted to water and oxygen by GPx (glutathione peroxidase) and CAT (catalase) (Vitale et al., 2000, Fernandez et al., 1985).

### **1.7. Singlet Oxygen (<sup>1</sup>O<sub>2</sub>)**

<sup>1</sup>O<sub>2</sub> is produced in cells particularly in neutrophils and eosinophils. They can also be formed by enzymatic reactions. The molecular oxygen is activated into two excited states for the production of this radical. The oxygen molecule is activated to form 2 excited states in which 1<sup>st</sup> state contains two electrons spinning oppositely in the same π\* orbital whereas the 2<sup>nd</sup> consists of one electron in which both have 2 degenerated π\* orbitals. The 1<sup>st</sup> state is highly reactive compared to the second (Kanofsky et al., 1983, Chan et al., 1971, Hayaishi et al., 1969).

### **1.8. Hypochlorous Acid (HOCl)**

Chlorine reacts with hydrogen peroxide which is catalyzed by myeloperoxidase to produce hypochlorous acid in neutrophils. It is an oxidizing agent which is highly reactive. It affects various biological molecules by destroying phagocytized pathogens. The excess generation of hypochlorous acid results in different health issues like cancer, atherosclerosis, etc (Daugherty et al., 1994, Pullar et al., 2000, Prutz et al., 1996).

### **1.9. Ozone (O<sub>3</sub>)**

Antibodies forms ozone by the oxidation of water and hydrogen peroxide. Water is used as the source of electrons initiating its addition with singlet oxygen to form dihydrogen trioxide which is later converted into ozone. Ozone affects mainly the lungs by reacting with DNA, fatty acids, and cholesterol (Babior et al., 2003, Mustafa et al., 1990).

## 2. Antioxidants

The compounds, which are able to avoid or highly slow down the oxidation process at lower concentrations, are called antioxidants. These antioxidants are lesser in concentration compared to the oxidizable substance (Halliwell et al., 1990, Halliwell et al., 1997). Antioxidants delay the oxidative processes in the biological system and play a vital part in several physiological functions (Mandal et al., 2009). These antioxidants are from natural and synthetic sources (Gupta and Sharama, 2006), and chemically they are related to substituted phenolic molecules (Pokorny, 1991). Nature provides a significant number of phytochemicals that serve as health promoters.

### 2.1. Phenolic Antioxidants

Plants are considered as the production house of hundreds and hundreds of compounds of phenols and polyphenols. This is one of the secondary metabolites that are largely distributed in plant sources. Plants provide a maximum of phenols to animals since animals are unable to synthesize on their own. It consists of many numbers of molecules having phenol rings in their structure. Phenolic compounds belong to a group of primary antioxidants that are chiefly FRS (Chavan et al., 2018).

The phenolic complexes exist in all morphological parts of the plants, including fruits, seeds, vegetables, leaves, nuts, barks, and roots (Asif, 2015, Pratt and Hudson, 1990). The natural antioxidants include  $\alpha$ -tocopherol, flavonoids are phenolic compounds (Table 1) (Han et al., 2007). Natural plant phenolics play multiple roles; they are free radical scavengers, reducing agents, metal ion chelators and  $^1\text{O}_2$  Quenchers (Mathew and Abraham, 2006).

Phenolic antioxidants (AH) belong to the group of free radical terminators (Fereidoon et al., 1992). AH are highly efficient in prolonging the period of induction when mixed with oil that has not deteriorated for some level; yet, they are not efficient in delaying the decay of previously deteriorated lipids (Mabarouk et al., 1961). Therefore, antioxidants must be mixed with food items at an early stage possibly to attain the highest safeguard against the process of oxidation (Coopen et al., 1983). Federal regulations govern the application of antioxidants to foodstuffs. Food and Drug Administration (FDA) emphasizes that the antioxidants used must be stated on the labels of the products and also a clarification of their intended function (Dziezak et al., 1986).

**Table 1.** The present classification of polyphenol antioxidants

Flavonoids	Non-flavonoids	Tannins
Phenyl chromane (C15) is formed by 2 aromatic ring (C6-C3-C6.)	Molecules having atleast on pphenolic ring with various reaction groups.	Condensed:Flavonoid polymer type A (C7-C2) and type A (C4-C8 / C4-C6).
Flavonols, flavonones, flavones,	Hydroxyl, SH, nitrosyl.	Hydrolysable: Phenolic acid polymers bound to 5 or 6 carbon rings.

### 3. Sources of Phenolic Antioxidants

Phenolic antioxidants are obtained naturally from plants or artificially synthesized to exhibit their antioxidant property efficiently.

#### 3.1. Sources of Natural Phenolic Antioxidants

The phenolic antioxidants have been isolated from vegetables (Parashar et al., 2014), spices and herbs (Alok et al., 2014), fruits (Arshiya, 2013), grains (Karrar, 2014), coffee (Nardini et al., 2002), green leaves (Thasleema, 2013), black tea (Perron and Brumaghim, 2009), green tea (Chopade et al., 2008) wine (Ghatak et al., 2014) and beer (Sikora et al., 2008). Previous studies have shown that legumes like lentils, green peas, and different bean varieties, soybeans, fava, and beach beans also exert antioxidant action (Wang et al., 2011).

##### 3.1.1. Fruits as a Source of Antioxidants

Fruits contain various vitamins and minerals. They chiefly contain polyphenols, vitamin C and carotenoids. Particularly, berry fruits have more amount of antioxidants. Blackcurrant fruits contain a huge amount of vitamin C (around 120-210 mg/100 g) and carotenoids (Benvenuti et al., 2004; Hägg et al., 1995). Total phenolic content present in blackcurrant is 25 mg/g, the majority of which is anthocyanins (Benvenuti et al., 2004; Kähkönen et al., 2001) while, whereas strawberries contain around 20 mg/g of phenolic compounds, anthocyanins and ellagic acid (Hägg et al., 1995; Kähkönen et al., 2001; Klopotek et al., 2005). Raspberries have a sufficient amount of polyphenols like ellagic acid (Anttonen and Karjalainen, 2005).

Black chokeberry, the *Aronia malanocarpa* fruits, has abundant polyphenols, around 40-70 mg/g, majorly anthocyanins. The fruits are rarely consumed in their raw form because of their sour taste, which depends on anthocyanin derivatives chlorogenic acid, neo chlorogenic acids, and epicatechin (Oszmianski and Wojdylo, 2005; Olsson et al., 2004; Wu et al., 2004). Grapes contain high polyphenol content, and the color intensity of fruits is directly proportional to their antioxidant potential (Kaplan and Najda, 2014). The grapes are considered as rich resource of phenolic antioxidant phenolic acids, flavonoids and stilbenes (Keser et al., 2013). Red grape seed contains catechin and epicatechin, while skin possesses quercetin, rutin and resveratrol (Butkhup et al., 2010). Previous studies have showed that *Averrhoa carambola* L. (star fruit) contains main antioxidant like (-) epicatechin and proanthocyanidins (Budi Setiawan et al., 2001; Leong and Shui, 2002; Shui and Leong, 2004).

Quercetin is the major polyphenolic flavonoid with potential antioxidant activity in different fruits, including berries, apples, vegetables, and onions (David et al., 2016). It is also present in herbs like amla, tulsi, asparagus, coriander, mango, and others (Shakya, 2016). Microalgae like *Chlorella*, *Nannochloropsis*, and *Spirulina* species are the powerhouse of natural polyphenolic chemicals (Zakaria et al., 2017).

##### 3.1.2. Herbs and Spices as a Source of Phenolic Compounds

Spices and herbs are loaded with phenolic antioxidants (Srinivasan, 2014; Surh, 2002). Previous studies reported that the spices and herbs like oregano, rosemary, basil, sage, thyme, fennel, celery, cumin, clove, nutmeg, ginger, red pepper, turmeric, and parsley have a higher

number of phenolic substances that has potential antioxidant action (Ivanovic et al., 2013; Pizzale et al., 2002; Zheng and Wang, 2001).

Basil leaves are loaded with polyphenolic substances, flavonoids, caffeic acid derivatives, and phenolic acids. The phenolic compounds present are ferulic acid, cinnamic acid, and gallic acid (Ghasemzadeh et al., 2016). The polyphenols present in ginger are gingerols (Wang et al., 2020). Aqueous extract of dry ginger yielded 840 mg/g of total polyphenols and the antioxidant activity of ginger correlates with phenolic content (Shirin Adel and Prakash, 2010).

The flowers, leaves, and stems of *Salvia officinalis* (sage) contain coumarins, flavonoids, and tannins phenolic compounds. Flavonoids like rosmarinic acid, chlorogenic acid, luteolin-7-glucoside, quercetin, rutin, ellagic acid, epicatechin and epigallocatechin gallate have been found in different extracts of sage (Hernández-Saavedra et al., 2016; Mingfu et al., 1998). Hanganu et al., 2019, reported that ethanol extract of Sage consists of polyphenols quercetin, rutin, ferulic acid, caffeic acid, and p-cumaric acid. The ethanol extract of dried leaves of Sage showed high antioxidant potential due to the high amount of ferulic acid (Francik et al., 2020).

The hydroalcohol extract of Rosemary (*Rosmarinus officinalis*) contains 0.601 mg/ml total polyphenols, 0.270 mg/ml luteoline and 0.350 mg/kg rosmarinic acid total flavonoids respectively (Olah et al., 2016). Rosemary also contains carnosic acid, a diterpenoid phenol in high concentration (Mena et al., 2016).

Principal polyphenol present in turmeric (*Curcuma longa*) is curcumin, which has a beneficial effect on health (Kocaadam and Sanlier, 2017). Curcumin is a mixture of 3 lipophilic polyphenols curcuminoids curcumin, bisdemethoxycurcumin and demethoxycurcumin (Aftab and Vieira, 2010; Dosoky and Setzer, 2018). Red pepper, *Capsicum annum* has many polyphenols in both free and bound forms. The previous study showed that the extracts of red pepper have 218.2 mg/100 g of free polyphenols and 42.5 mg/100 g of bound polyphenols (Obob and Rocha, 2007), which showed antioxidant activity. Total polyphenolic content in red pepper 3670-7689 µg/g is higher in the reddish stage than in green. Total flavonoids are also high in the red stage of red pepper, which ranges from 550-960 µg/g (Hamed et al., 2019).

### **3.1.3. Nuts and Oilseeds as the Source of Polyphenols**

Walnuts contain ellagic acid and gallic acid as polyphenols (Fakuda et al., 2003). Anthocyanins are present abundantly in Pistachio nuts (Saitta et al., 2014). Almond nuts are a nutrient-rich source of different polyphenols like proanthocyanidins, tannins, flavonoids, phenolic acids, and isoflavones (Bolling, 2017). Peanuts are loaded with polyphenols and antioxidants like resveratrol, p-coumaric acid, and flavonoids (Arya et al., 2016).

### **3.1.4. Beverages as a Source of Polyphenols**

Green tea and coffee are good sources of natural polyphenolic compounds with antioxidant activity. The flavonols, phenolic acids, flavonoids are the polyphenols present in green tea (Vinson, 2000). The catechins belong to the flavonoid group, and main catechins like epicatechin, epigallocatechin, and epicatechin-3-gallate are more abundant in green tea than black tea (Khan and Mukhtar, 2007; Sano et al., 2001). Tea catechins provide many human health benefits due to its antioxidant action (Erba et al., 2005; Higdon and Frei, 2003; Mukhtar and Ahmad, 2000).

Coffee consumed by many people worldwide has a good amount of polyphenols. Coffee has the highest total polyphenols compared to any other beverage (Yamagata, 2018). The

caffeine, chlorogenic acid, diterpenes are polyphenols present in coffee (Yesil and Yilmaz, 2013) and can inhibit oxidative stress (Andriantsitohaina et al., 2012; Serafini and Testa, 2009).

### **3.1.5. Mushroom as the Source of Polyphenols**

The different mushroom species are not only nutritious, but they also have natural polyphenols that show antioxidant activities. White button mushroom, *Agaricus bisporus* contains 6.18 mg/g of total phenols. The phenolic constituents are catechin, gallic acid, ferulic acid, caffeic acid, protocatechuic acid, and myricetin (Liu et al., 2013). The water extract of *Lentinula edodes* mushroom contains 4 mg/g dry weight of the total phenolic compound in terms of gallic acid equivalent with higher radical scavenging activity (Garcia et al., 2021). Honey mushrooms are the other source of polyphenolic antioxidants. *Armillaria mellea* water extract has a good amount of total phenolic components, around 360 mg/g, and showed a stronger antioxidant effect in DPPH radical scavenging assay (Strapac et al., 2016). *Boletus edulis*, a wide variety of edible mushrooms, contains rosmarinic acid as the main component of the polyphenolic compound with an antioxidant profile (Vamanu and Nita, 2013).

## **3.2. Sources of Synthetic Phenolic Antioxidants**

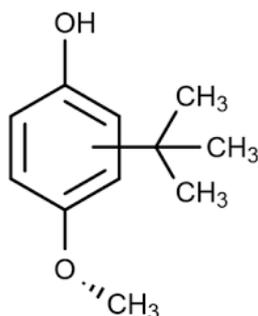
Phenolic antioxidants that are man-made is called synthetic phenolic antioxidants (SPAs), most commonly used for retarding the oxidation reactions in a huge range (Lanigan et al., 2002, Lanigan et al., 2002, Rodil et al., 2010, Rodil et al., 2012). Natural antioxidants are replaced by synthetics due to their higher chemical stability, flexibility and low cost (Rodil et al., 2012, Wang et al., 2016). The synthetic phenolic antioxidants suppress the generation of free radicals which prevents the oxidation of lipids and improvement of shelf-life. The approvals of synthetic antioxidants used as food additives are limited due to their dangerous effects on humans. The approved SPAs are (Endo et al., 1985);

1. Butylated hydroxyanisole (BHA),
2. Butylated hydroxytoluene (BHT),
3. Propyl gallate (PG), and
4. Tertiary-butylhydroquinone (TBHQ).

### **3.2.1. Butylated Hydroxyanisole (BHA)**

BHA, a monohydric phenolic antioxidant contains the mixture of isomers such as 3-tertiary-butyl-4-hydroxyanisole (90%) and 2-tertiary-butyl-4-hydroxyanisole (10%) (Figure 2). It is insoluble in water and freely soluble in fats (Stuckey et al., 1972). The melting point of BHA is 49-50°C, boiling point is 268°C and density being 1.060 g/cm (Table 2).

BHA blocks the peroxy radicals propagation (Frazier et al., 2007). The conjugated aromatic ring present in BHA is capable of stabilizing and sequestering the free radicals. This prevents further reactions of free radicals. They block the oxidative reactions by donating an atom of hydrogen radical from phenolic hydroxyl which is attached to aromatic ring. Therefore, the newly formed radicals get stabilized and further lipid oxidation is not initiated and propagated (Anderson et al., 2007, Shahidi et al., 1992, Al-Mamary et al., 2012, Said et al., 2018, Moussa et al., 2020). BHA is normally used to protect colour and flavor of essential oils.



**Figure 2.** Structure of Butylated hydroxyanisole (BHA).

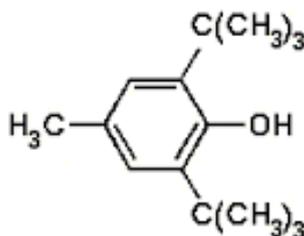
**Table 2.** Properties of synthetic phenolic antioxidants (Robards et al., 1987)

Synthetic phenolic antioxidants	Properties						
	Melting point (°C)	Boiling point (°C)	Density (g/cm <sup>3</sup> )	Synergistic with other antioxidants	Solubility		
					Water	Propylene glycol	glycerol
BHA	49-50	268	1.060	Gallate, BHT	0	50	1
BHT	69-70	265	1.048	BHA	0	0	0
PG	146-148	181	1.210	BHA	<1	6	25
TBHQ	126-128	291	1.050	Citrate, BHA, BHT	<1	30	<10

This is mainly active compared to another food-approved antioxidants. BHA is mainly successful in controlling the oxidative reactions of the short-chain fatty present in palm kernel oil and coconut that are used normally in cereals and confectionery products. BHA and BHT are basically volatile and hence these are added as important excipients mainly in packing materials since they have the ability to travel into foodstuffs. Therefore, BHA and BHT are directly added into the wax which are utilized in the preparation of innerliners and also these antioxidants are used to apply on the packing board in the form of emulsion (Porter et al., 1980).

### 3.2.2. Butylated Hydroxytoluene (BHT)

BHT is a monohydric phenolic antioxidant (Figure 3). BHT is available commercially in the form of white crystalline compound. It can also be termed as 2,6-di-tert-butyl-p-cresol or 2,6-di-tert-butyl-4-methylphenol. It is synthesized from p-cresol and isobutylene. BHA is insoluble in water and freely soluble in fats, benzene, toluene, methanol, isopropanol, and other hydrocarbon-based solvents. The melting point of BHT is 69-70°C, the boiling point is 265°C and the density being 1.048 g/cm (Table 2).



**Figure 3.** Structure of Butylated hydroxytoluene (BHT).

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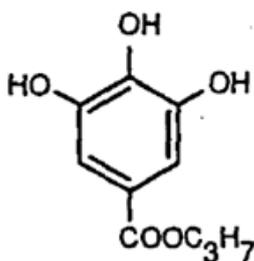
3,5-di-tert-butyl-4-hydroxybenzoic acid is the main metabolite of BHT that are derived from aldehyde and alcohol (BHT-CHO) (Yamamoto et al., 1991). BHT-Q and BHT-OOH is some of the minor metabolites of BHT which results due to oxidation. BHT acts as a free radical scavenger which prevents the rancidity via termination of chain reactions.

BHT inhibits the radical chain reactions by proceeding with alkyl peroxy rather than alkyl. One BHT molecule reacts with two peroxy radicals to form stabilized products for further reactions. Hence the two-stage reaction happens in which the first BHT reacts with peroxy to form a BHT-peroxy complex. This is a reversible reaction. This complex reacts with the second radical which is an irreversible reaction (Boozer et al., 1955, Hammond et al., 1955). BHT prevents the oxidation of animal fats and vegetable oils. However, its efficiency in the prevention of animal fat oxidation is higher hence, it is also utilized as an efficient antioxidant in food packaging. BHT, as an antioxidant damages the defensive external layers of viral cells which also prevents the multiplication of viruses (Yamamoto et al., 1991). As per Organization for Economic Co-operation and Development (OECD), BHT (up to 0.5%) is considered the most frequently used phenolic antioxidant in different commercial products (Lanigan et al., 2002).

### 3.2.3. Propyl Gallate (PG)

Chemically PG is 3,4,5-trihydroxypropylbenzoate which is synthesized by esterifying gallic acid with 1-propanol and later distilled for the removal of excess alcohol (Figure 4). This reaction is activated by hydrochloric acid, sulphuric acid, etc. It is a white crystalline powder that is sparingly soluble in water. It is an amphiphile, less volatile, and contains a lesser phenolic odor compared to BHA and BHT. The melting point of PG is 146-148°C, the boiling point is 181°C and the density is 1.210 g/cm (Table 2). Since the melting point of PG is around 148°C, it is not efficient in frying processes that involve a temperature of more than 190°C.

PG form a bluish-black complex by chelating with iron ions, thus it is used along with chelating agents like citric acid so as to remove copper catalyst and prooxidative iron. PG is highly efficient antioxidant used for dry vegetable oils. Gallates are mainly used as antioxidants to avoid spoilage and rancidity in oils and fats. PG is also used as food additives.



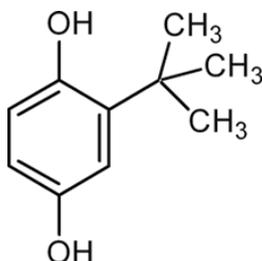
**Figure 4.** Structure of Propyl gallate (PG).

### 3.2.4. Tertiary Butylhydroquinone (TBHQ)

TBHQ is a diphenol antioxidant, commercially available as a beige-colored powder. It is synthesized by the reaction of hydroquinone with tertiary butanol or hydroquinone with isobutylene (Figure 5). It is soluble in fat. It is easy to metabolize BHA oxidation reaction into TBHQ (Rodil et al., 2012). The melting point of TBHQ is 126-128°C, the boiling point is 291°C

and the density is 1.050 g/cm (Table 2). This antioxidant does not result in the formation of the complex with copper and iron ions such as gallate.

Hydrogen free radicals are provided by TBHQ which terminates the chain reaction of free radical in unsaturated fatty acids. Tertiary-butylhydroquinone is considered as an important antioxidant for the fortification of frying oils towards oxidation or rancidity to preserve the freshness. The antioxidant protective effect of TBHQ is comparable to that of BHT and BHA (Ramis-Ramos et al., 2003). TBHQ is an antioxidant which is hydrophilic in nature which is responsible for its unique property. This property results in difficulty in its solubility of fats or oils. Due to these solubility issues, TBHQ gets concentrated at the interfaces of the fat and water/air. The oxidation of fats and oils begins at the interface and thus TBHQ efficiently acts as an antioxidant. To improve the efficiency of TBHQ, it is supplied as concentrated liquid formulations. It is highly efficient in protecting vegetable oils compared to BHA and BHT since it is stable at high temperatures (Hung et al., 2019).



**Figure 5.** Structure of Tertiary butylhydroquinone (TBHQ).

#### 4. Combined Effect of Synthetic Antioxidants

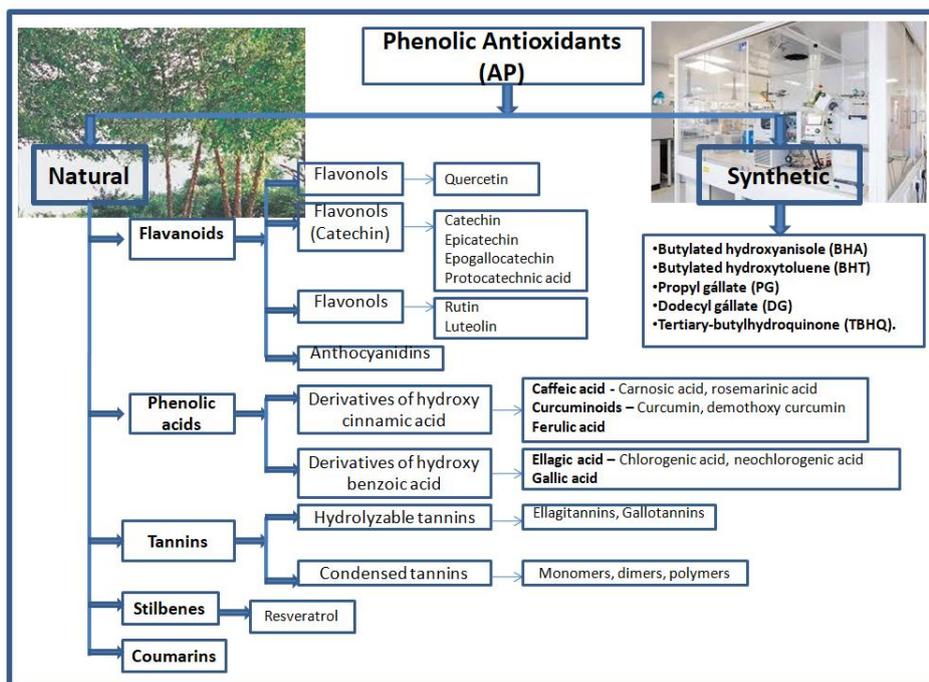
Synergistic activities are very susceptible since it depends on various substances that are combined with respective percentage. A specific combination might exert synergistic actions at single concentration ratio while antagonistic action for others. Hence, the types of various substances and these combinations require suitable homogeneity to exert highest synergism.

A synergistic effect of quercetin, rosmarinic acid, or caffeic acid was observed while antagonistic actions were observed in the combination of caffeic acid/ $\alpha$ -tocopherol; rosmarinic acid/ $\alpha$ -tocopherol; caffeic acid/(+)-catechin; and quercetin/caffeic acid (Peyrat-Maillard et al., 2013). Increased antioxidant activity was observed with the combination of polyphenols such as caffeic acid, ferulic acid, and epigallocatechin-3-gallate (Romano et al., 2009) and also between rosemary extract and butylated hydroxytoluene. The flavonols in tea extracts provide combined interactions. The tea catechins contribute to synergistic activity in green tea (Colon and Nerin et al., 2015).

A synergistic action was observed in the combination of BHT and BHA. TBHQ is used as a single or in the combined form of BHA or BHT at a higher quantity of 200 ppm / 0.02%, depending on the content of the fat present in foodstuffs which includes essential oils. TBHQ is not allowed when it combines with PG and is reported for its use as an efficient stabilizer of crude oils (25-400 mg/kg). There seemed to be an increase in the antioxidant effect of TBHQ when it combines with other antioxidants namely citrate, BHT, and BHA (Allam et al., 2002). The combined significantly effect improved when BHA was combined with TBHQ. Good stabilization factors (SF) was observed with TBHQ:PY (Guzman et al., 2009). Derivatives of

ascorbic acid, EDTA and citric acid act synergistically. Due to evaporation and decomposition, the antioxidants are lost at 185°C (in solution) and the order is BHT > PG > BHA > TBHQ (De Jesusa et al., 2020). Gallates are used as a single or with BHA / BHT at 0.02% of concentration.

## 5. Classification of Phenolic Antioxidants



**Figure 6.** Classification of Phenolic Antioxidants (AP).

From the above-mentioned sources, the phenolic antioxidants can be categorized depending on their phytochemical constituent (natural) or synthesized chemical mixture with similar activity (Figure 6). Thus, the natural phenolic antioxidants are generally classified into various types namely flavonoids, phenolic acids, tannins, stilbenes, and coumarins. The SPAs are artificially synthesized antioxidants.

## Conclusion

The phenolic antioxidants are obtained from natural as well as synthetic sources. The polyphenolic compounds are secondary metabolites which are derived from various plant sources. They are found naturally in large quantities in fruits, vegetables, cereals and beverages. Phenolic acid, flavonoids, tannins, stilbenes, coumarins, etc forms the plant phenolics. These antioxidants delay the auto-oxidation either by preventing free radicals' formation or interrupting free radical propagation via donating a hydrogen atom or an electron. They act as a ROS scavenger, chelate the metals, etc by providing multiprotection against the ROS. Due to

the scarcity of natural phenolic antioxidants, they are synthesized in larger quantities artificially to meet the demand which is termed Synthetic Phenolic Antioxidants (SPAs) namely BHA, BHT, PG, etc.

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[Declared as Deemed-to-be-University under section 3 of the UGC Act, 1956 vide Government of India Notification No. F.9-19/2000-U.3(A)]

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3.4.7 Number of books/ chapters in edited volumes and papers in National/International conference-proceedings published per teacher and indexed in Scopus/Web of Science/ PubMed UGC-CARE list during the year

Sl. No	UGC-CARE ID	Publication Type	Publication Title	Author-name	Journal-name	Year
1.	Group 1	Book Chapter	Natural and Synthetic sources of Phenolic Antioxidants	Bhagya V Rao	Nova Science Publishers, Inc. Hauppauge, NY, USA	2022



  
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