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A Bioconservative Approach - Minimally invasive endodontics: A Narrative review

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ABSTRACT: The paradigm shift of dentistry is now towards more of conservative approach. The same comes in the field of endodontics i.e. Minimally invasive endodontics. It aims to primarily save the precious pulp through Endolight concept. Further root canal treatment is done by following the tooth anatomy and taking care of remaining dentin. Modified access opening, cleaning and shaping, obturation and re-restoring the treated tooth are achieved by the adjuvant of advanced technologies. But this concept can't be applied in all the clinical scenarios and still has to be studied futher. This article gives an insight about the minimally intervention in endodontic procedures.

KEYWORDS: Minimally invasive endodontics, Pericervical dentin, Minimally invasive dentistry.

I. INTRODUCTION

The "less is more" concept is a philosophy of living. Modern era is all about getting things done in the most convenient, easiest, fastest and least intrusive way. The terms "minimally invasive" were probably pronounced for the very first time with a realistic implication in late 80's. Over the last few years, minimally invasive treatments have been embraced in all fields of medicine as a consequence of technological advances in microsystem engineering, nanotechnology, laser therapy, robotics and high-resolution imaging tools for diagnostics and guidance of surgical instruments. These innovations are dramatically improving the mortality and morbidity by the outcomes associated with many surgical procedures.

[1]The world congress of MID defines minimally invasive dentistry as those techniques, which respect health, function and esthetics of oral tissue by preventing disease from occurring, or intercepting its progress with minimal tissue loss. It indeed is a systematic respect for the original tissue."[1] Minimally invasive endodontics (MIE) is a concept of maximum preservation of the healthy coronal, cervical and radicular tooth structure during the endodontic treatment.

[2]According to Gianluca Plotino, everything in dentistry and especially in endodontics, must be based on and guided by the anatomy. Thus, the term minimally must be seen as a synonymous of anatomically, so that it can be always called as: "Anatomically Invasive Endodontics.

II. NEED FOR MINIMALLY INVASIVE ENDODONTICS

[3]The remaining structural integrity is important factor that determines prognosis as it relates to the post endodontic survival rate of the tooth. When endodontically treated teeth fail under function, that outcome is determined primarily by two etiologies: (1) Degree of stress experienced by the tooth under load and (2) Inherent biomechanical properties of the remaining structure responsible for resisting fracture. This makes the concept of minimal intervention highly significant in the field of endodontics.

[4,5]According to Helfer et al, Reeh et al endodontic treatment poses major etiologic factor for tooth fracture, due to brittleness of teeth caused by the loss of moisture.

[6] The Endodontic-Endo-Restorative-Prosthodontic (EERP) continuum is a restoratively guided concept in which endodontics is simply a starting step to the restoration and preservation of the tooth. Biomimetics and minimally invasive dentistry form the basis of this principle. This concept seems to be a logical concept to follow clinically for successful outcome of any restorative treatment.

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III. PRINCIPLES OF MINIMALLY INVASIVE ENDODONTICS

a) Peri Cervical Dentin (PCD):[7]Pericervical dentin as defined by Clark and Khademi in 2008 is an area roughly around 4mm coronal to crestal bone and 4mm crestal to apical bone. It acts as the neck of the tooth and transfers masticatory forces to the root and the bone. Thus, the dentin surrounding the alveolar crest is often regarded as the "Irreplaceable Critical Most Zone", as while the apex of the root can get affected, and the coronal third of the clinical crown removed and replaced restoratively, the dentin near the alveolar crest is not replaceable and is sacred.

Peri Cingulum Dentine is the term used for this critical landmark in the anterior teeth. the term Directed Dentine Conservation was coined in relation to the preservation of PCD as the survival rate increases with its preservation proportionately.

Fig. 1: Peri-cervicaldentin

b) 3D Ferrule:[7]Three-dimensional ferrule has been described as axial wall dentin in all three dimensions covered by the axial wall of the crown or bridge abutment. It is an evaluation of the available dentin that buttresses the crown. 3D refers to the components of ferrule namely:

1) Vertical component - around 1.5 to 2.5 mm
2) Dentin thickness (Girth) - Absolute minimum thickness – 1-2 mm
3) Total occlusal convergence/ Net Taper-Total draw of 2 opposing axial walls to receive a fixed crown which is 10° in 3mm of vertical ferrule, 20° in 4mm, possible in the traditional stainless-steel crowns whereas the newer porcelain crown demands 50° or more taper owing to its deep chamfer marginal zones.

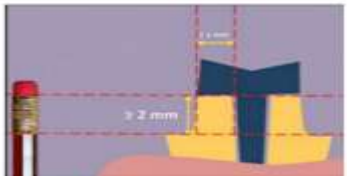

Fig. 2: 3D Ferrule dentin

c) Soffit/Banking:[7]Soffit is term used by architects for underside of a roof, at the corner of the roof and the wall. The same concept can be applied to the chamber of a molar tooth which is bounded by a roof, 4 walls, and a floor with small orifices that are arranged along the edges of the floor. Soffit, is a small piece of roof around the entire coronal portion of the pulp chamber, it gives a perfect example of banked tooth structure. The attempts to remove the soffit are far more damaging to the surrounding PCD. This approach of banking tooth structure aids in long- term retention and fracture resistance of tooth.

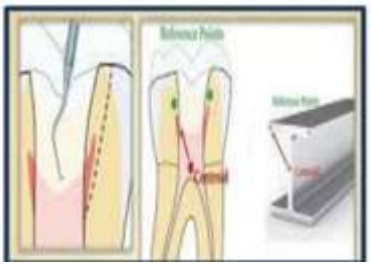

Fig. 3: Soffit

IV. ROLE OF MODERN TECHNOLOGY

In fact, in the last 20 years, endodontists faced a continuous revolution of the field, embracing new technologies, materials, instruments, device and concepts in the day-by-day practice. Embracing the concept of minimally invasive endodontics and implementing it in practice represents the perfect example how some paradigms of the field were substituted by new ones based on new phenomena. The current technological advancements that enabled the process of tissue preservation in endodontics can be summarized as follows:

- Dental operating microscopes (DOM)
- Small field of view cone-beam computed tomography (CBCT) imaging
- Ultrasonic (US) tips and devices
- Martensitic flexible and resistant files
- Evolution of irrigation techniques
- Evolution of biocompatible root canal filling materials
- 3D fixed (static) and/or dynamic guidance
- Adhesive dentistry procedures

The main aim of MIE is the preservation of dentin, thus the technologies for Dentin preservation are divided into following phases:

Phase 1-Planning: to access the clinical scenarios.CBCT scans contain valuable data for less invasive root canal treatments. A detailed evaluation of the preoperatory volume offers the

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following information, not clinically presented by other radiographic methods such as determination of the point of entry, assessing anatomical details (size and position of the pulp chamber, number of roots and canals configuration, curvatures, canal splitting, horizontal root bulk and canal dimension at peri-cervical region)

Phase 2-Treatment: these are thetechnologies for dentin preservation like image-guided endodontic access (static-guided access preparation, dynamic guided access preparation), magnification aids, etc.

V. MINIMALLY INVASIVE ACCESS

[8]New minimally invasive endodontic cavities have been described and proposed to preserve dentin and enamel through strategic access. According to Boveda and Kishen, conservative endodontic access shapes are geometrical shapes that prioritize the removal of:

- Restorative material ahead of tooth structure
- Enamel ahead of dentin and
- Occlusal tooth structure ahead of cervical dentin.

The difference between Traditional access cavity and Conservative access cavity are:

	Traditional access cavity	**Conservative access cavity**
Principle	Extension for Prevention	Prevention of extension
Cavity preparation design	The centre of the pulp chamber should be the target of the initial penetration	Only the tooth structure required to be removed is prepared
Pericervical dentin	No preservation of	Preservation
Soffit	Less probable	Prepared
	All the teeth	Endodontic Treatment Cannot be attempted for all teeth
Pulp tissue remnants	No possibility	Possibility of endodontic failure if shaping and cleaning protocol is not followed

Newer access designs include:

1. **Conservative Endodontic Cavity (CEC):**[9]"It aims to perform a partial unroofing of the pulp chamber with preservation of the pulp horns, with slightly convergent walls occlusally beveled, to visualize the pulp chamber floor and all the root canal orifices from different visual angulations", following the principles given by Clark and Khademi.
2. **Conservative Access Cavity with Divergent Walls (ConsAC.DW):** [10]It is the variant of conservative access cavity with a modification of little more divergent walls for proper view demonstrated by Roperto R, Sousa YT, Dias T et al. in 2019.
3. **The Ultra-Conservative Endodontic Cavity or Ninja Endodontic Cavity (NEC) or PEAC (point endodontic access cavity):** [11]"It aims to perform an ultra-conservative cavity by just locating the orifices, with an extreme unroofing of the pulp chamber and preservation of all the pulp horns, extremely convergent walls and preservation of the occlusal enamel."
4. **The Orifice-Directed Endodontic Cavity or Truss Endodontic Cavity (TREC):** [11]"It is an orifice-directed access, in which separate cavities are prepared to negotiate the different roots of molars avoiding removal of the central part of the pulp chamber‟s roof."
5. **Opportunistic Endodontic Cavity or Caries-Driven Endodontic Cavity (CDEC):** [2]It is "a strategic interproximal or buccal access aiming to remove all the carious tissue and the entire old fillings, taking advantage of the loss of tooth structure to enter the root canal system from the pre-existing cavity without enlarging it with a predefined shape."
6. **Incisal access:** To minimize cuspal deformation and cuspal bending on flexure maintaining the dentin bulk and restorative needs, cavities are prepared on incisal edges rather than in cingulum areas in this conservative preparation. Blind tunneling and inverse funneling are consequences of traditional endo access which can be avoided by a proper incisal access.
7. **Calla-Lilly preparation:** It is based on the principle of ICE:[9]

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I-Infinity edge
C-Compression based
E-Enamel driven (engage 70% enamel and 30% dentin)
It is based on the principle of ICE: I-Infinity edge C-Compression based E-Enamel driven (engage 70% enamel and 30% dentin)

8. **Dynamic Access Cavity Design:** [9]A dynamic access cavity design is different from the traditional predesigned shapes dictated by the most common anatomical variations of root canal anatomy. The dynamic access always prioritizes the removal of carious and damaged tissues ahead of the negotiation to the pulp space.
9. **Image guided endodontic access preparations:**

a) **CT Dynamic access/ X entry access:** It was popularized by Charles M Buchanan. The technique was traditionally used in implantology. [12] The procedure utilizes CBCT volume plan to prepare access by 3D assessment of jaw position and bur position with overhead cameras and software like 3-three dimensional camera system (X-NAV System), NAVIJET.

b) **CT/ CBCT guided static 3D templates:**[13]This utilises CBCT images and 3D surface scanners to create virtual images of burs and guide sleeves. A virtual template is designed and printed using 3D printers. Templates are attached to models and access prepared with specially designed burs.In general, small-sized tip and long-shank burs like Batt‟s bur type (non-cutting serrated spiral carbide bur) Clark‟s EG3 micro-access bur, CK burs (SS white) and the round-end lowspeed Munce discovery burs could be used to enhance visibility and preservation of tooth structure. Handle Files MC K-files and H-files Micro-Openers K-files, Micro-Debriders H-files.

VI. MINIMALLY INVASIVE CANAL PREPARATION

Maintaining the original canal anatomy and preservation of dentine thickness of a root canal system is critical to the successful shaping of a root canal. The main challenge for minimally invasive endodontic procedures is improving the debridement of the root canal space while decreasing the size of the access and the size of the preparation to promote healing in periapical region. New minimally invasive 3D preparation and disinfection technologies have recently come to market that do not require canal preparation as traditionally advocated.

1. Nickel titanium instruments: Modifications in the metallurgy of the NiTi alloy (M wire, Controlled Memory, ECM) resulting in more flexible rotary and reciprocating instruments are shown to preserve the root canal curvatures better.

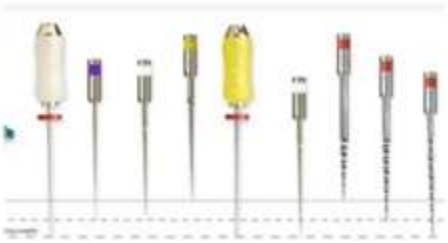

Fig. 4: Endo EZE TiLOS

Fig. 5: Trunatomy files

a. Endo EZE TiLOS Anatomic Endodontic Technology and XP endo files
b. Trunatomy
c. SAF system 3D cleaning

2. **EndoActivator system:**[14]This technology utilizes sonic energy to drive a preselected tip, which in turn, activates various intracanal reagents, producing a vigorous hydrodynamic phenomenon at the frequency level of 2-3 kHz in well-shaped canals.54

This technology utilizes sonic energy to drive a preselected tip, which in turn, activates various intracanal reagents, producing a vigorous hydrodynamic phenomenon at the frequency level of 2-3 kHz in well-shaped canals.

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3. **Ultra-sonic:**Two types of ultrasonic irrigation have been described. The first one is active and has been almost discarded in the clinical practice. The second type is passive ultrasonic irrigation (PUI) first used by Weller et al.in 1980. [15]During PUI, energy is transmitted from a file or smooth oscillating wire to the irrigant by means of ultrasonic waves that induces two physical phenomena: acoustic streaming and cavitation of the irrigant solution.

4. **Multisonic Gentle wave system:**[16]The GentleWave system (Sonendo, Orange, CA, USA) is a novel irrigation system to clean the root canal system after a minimal instrumentation. [17]The GWS is able to generate negative pressure in part due to the "closed-loop" system created with a resin platform built by the clinician that serves as a gasket between the tooth and the handpiece.

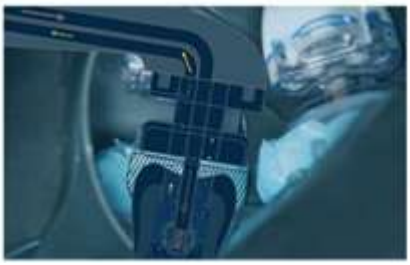

Fig. 7: Gentle wave system

5. **Photon induced photoacoustic streaming:**[18]This method was ingeniously developed proposed by. Dr. Enrico DiVito and his team at the Arizona Center for Laser Dentistry.(The PIPS technique is based on the power of Erbium:YAG laser and creates a turbulent 3-dimensional flow of irrigants in the canals.

6. **Photodynamic therapy in endodontics (PDT):**[19]This technique is based on the principle that the photosensitizing molecules (photosensitizer - PS) are able to bind to the membrane of the bacteria. [20]An endodontic system called LightActivated Disinfection (LAD) was developed. It is based on a combination of a Photosensitizer and a special light source.

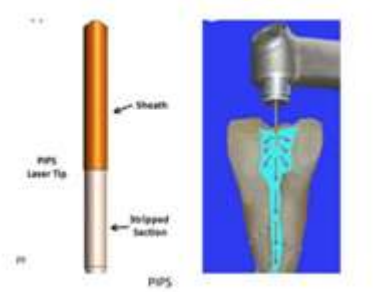

Fig. 8: Photon induced photoacoustic streaming

7. **EndoVac system:** A new apical negative-pressure irrigation system called EndoVac (Discus Dental, Culver city, CA) is designed by Dr G.John Schoeffel in 2007. [21]It uses apical negative pressure to promote the flow of the irrigant solution placed into the pulp chamber to the apical third of the root canal where the tip of a microcannula is placed.

Fig. 9: EndoVac system

VII. OBTURATION IN MINIMALLY INVASIVE PREPARATION

[7]Bio-minimalism in canal space preparation requires a filling material that replicates the internal anatomy of the root canal space, adheres to interfacial dentin and creates an impervious, irreversible seal at all portals of exit. And this can be achieved by the hydraulic cementation techniques. Bioceramics or Bioactive Endodontic Cements (BECs) materials which are for endodontic use are defined as "hydraulic cements".

[22]Hydraulic endodontic procedures advocated in minimally invasive procedures due tohighly hydrophilic and thus the natural moisture in the canal and tubules is an advantage:

1. These sealers do not shrink but expand slightly and are insoluble in tissue fluids further causing a tight impervious seal.
2. The surface is impregnated with a nanoparticle layer of bioceramic, which may reduce the gap between the sealer and the core and has shown to improve the seal of the filling.

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3. high and deep condensation forces and high temperatures are not needed for these new filling materials.

Hydraulic endodontic cements for root canal filling are:

1. BioRoot RCS (root canal sealer)- Septodont, SaintMaur-desFosses Cedex, France
2. Endosequence BC (bioceramic) sealer- Brasseler, Savannah, GA, USA
3. TotallFill (bioceramic sealer)- FKG Dentaire, La-Chaux-De-Fonds, Switzerland
4. iRoot SP (sealer)- Innovative BioCeramix Inc., Vancouver, Canada
5. Tech biosealer Endo-Isasan, Como, Italy
6. EndoSeal MTA-Maruchi, Wonju, Korea
7. MTA Fillapex-Angelus Industria de Produtos Odontologicos S/A, Londrina, Brazil
8. TheraCal LC (light cured)- Bisco Inc., Schaumburg, IL, USA

VIII. RESTORATIVE STRATEGIES

[23]The success of endodontic treatment depends on the post-operative final restoration which prevents the re-entry of microbes by seepage through restorative margins.Thus [24]Endocrown is another conservative restorative option for endodontically treated teeth with short clinical crowns and/or slender or calcified root canals first proposed in 1995 by Pissis, who advocated for use of the pulp chamber as a monoblock of heat-pressed ceramic to improve macromechanical retention. Onlays and composite restorations are other biomimetic conservative approaches for restoration of minimally invasive endodontically treated teeth.

IX. OTHER MINIMALLY INVASIVE PROCEDURES

Microsurgery in Endodontics is a minimally invasive technique that results in less postoperative pain and edema and faster wound healing. It offers a significantly higher success rate than traditional apical surgery technique. The use of light and magnification through the surgical microscope offer the greatest advantage to achieve a minimally invasive approach.

Main differences between the traditional surgical technique and modern microsurgery:

	Traditional Surgery	**Microsurgery**
Osteotomy size	8–10 mm	3–4 mm
Bevel angle degree	45–65	0–10
Inspection of resected surface	None	Always
Isthmus identification and treatment	Impossible	Always
Root-end preparation	seldom inside canal	Always within canal
Root-end preparation instrument	Bur	Ultrasonic tips
Root-end filling material	Amalgam	Mineral trioxide triacetate
Sutures	4 ×0 silk	5×0, 6 × 0 monofilament
Suture removal	7 d postoperative	2–3 d postoperative
Healing success, 1-y follow-up	40%–90%	85%–97%

[25]**Modified from Kim S, et al

The advanced technology in 3-dimensional model reconstruction based on computed tomography The use of guide template has become an emerging gold standard for it allows patient-specific treatment, which is still being developed by advancement

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Fig. 10, 11: 3D model reconstruction

Apexum (a non-surgical approach): [26]This new technology (Apexum Ablator; Apexum Ltd, Or- Yehuda, Israel) allows the removal or debulking of periapical tissues without using scalpels, periosteal elevators or sutures thus also marking a minimally invasive technique.The Apexum kit consists of two devices, the Apexum NiTi Ablator and Apexum PGA Ablator, designed to be used sequentially.

Fig. 11: Apexum

X. CONCLUSION

The "golden rule" is now to preserve as much tooth structure as possible in all the procedures: from the access cavity preparation to the choice of the type of coronal restoration. As the trend goes by around the minimally invasive Endodontics and its advancements, newer and better techniques have been evolved for an improved root canal treatment procedures and its outcomes. Coming into the insight of the minimally endodontic procedures compared to the traditionally well-established procedures, the former holds more of cons comparatively and hence is still to be studied and improvised. The Minimally invasive endodontic procedure requires few additional and sophisticated equipment and techniques other than the normalised protocols required in traditional endodontic practise. Yet of all the cons mentioned above, MIE and minimally invasive biomimetic dentistry have been booming in the recent years to come.

REFRENCES

[1]. Clark D, Khademi J, Herbranson E. Fracture resistant endodontic and restorative preparations. Dent Today. 2013 Feb;32(2):118-23.
[2]. Plotino G, editor. Minimally invasive approaches in endodontic practice. Springer Nature; 2020 Oct 5, 1st edition.
[3]. Lang H, Korkmaz Y, Schneider K, Raab WM. Impact of endodontic treatments on the rigidity of the root. J Dent Res. 2006 Apr;85(4):364-8.
[4]. Reeh ES, Messer HH, Douglas WH. Reduction in tooth stiffness as a result of endodontic and restorative procedures. J Endod. 1989 Nov 1;15(11):512-6.
[5]. Helfer AR, Melnick S, Schilder H. Determination of the moisture content of vital and pulpless teeth. Oral Surg Oral Med Oral Pathol Oral Radiol. 1972 Oct 1;34(4):661-70.
[6]. Clark D, Khademi J. Modern molar endodontic access and directed dentin conservation. Dent Clin North Am. 2010 Apr;54(2):249-73.
[7]. Clark D, Khademi J, Herbranson E. The new science of strong endo teeth. Dent Today. 2013 Apr;32(4):112-7.
[8]. Boveda C, Kishen A. Contracted endodontic cavities: the foundation for less invasive alternatives in the management of apical periodontitis. Endod Topics. 2015 Nov;33(1):169-86.
[9]. Clark D, Khademi J. Modern molar endodontic access and directed dentin conservation. Dent Clin North Am. 2010 Apr;54(2):249-73.
[10]. Roperto R, Sousa YT, Dias T, Machado R, Perreira RD, Leoni GB, PalmaDibb RG, Rodrigues MP, Soares CJ, Teich S, Sousa-Neto MD. Biomechanical behavior of maxillary premolars with conservative and traditional endodontic cavities. Quintessence Int. 2019 May 1;50(5):350-56.
[11]. Clark D, Khademi J. Modern endodontic access and dentin conservation, part I. Dent today. 2009 Oct;28(10):86-99.
[12]. Jain SD, Saunders MW, Carrico CK, Jadhav A, Deeb JG, Myers GL.

Dynamically Navigated versus Freehand Access Cavity Preparation: A Comparative Study on Substance Loss Using Simulated Calcified Canals. J Endod. 2020 Nov;46(11):1745-51.

[13]. Connert T, Zehnder MS, Amato M, Weiger R, Kühl S, Krastl G. Microguided Endodontics: a method to achieve minimally invasive access cavity preparation and root canal location in mandibular incisors using a novel computer- guided technique. Int Endod J. 2018 Feb;51(2):247-55.

[14]. Ruddle CJ: Endodontic disinfection: tsunami irrigation, Endodontic Practice. Saudi Endod J. 2008;11(1):7-15

[15]. Van der Sluis LW, Versluis M, Wu MK, Wesselink PR. Passive ultrasonic irrigation of the root canal: a review of the literature. Int Endod J. 2007 Jun;40(12):415-26.

[16]. Sigurdsson A, Garland RW, Le KT, Woo SM. 12-month healing rates after endodontic therapy using the novel GentleWave system: a prospective multicenter clinical study. J Endod. 2016 Jul 1;42(7):1040-8.

[17]. Haapasalo M, Wang Z, Shen Y, Curtis A, Patel P, Khakpour M. Tissue dissolution by a novel multisonic ultracleaning system and sodium hypochlorite. J Endod. 2014 Aug 1;40(8):1178-81.

[18]. DiVito E, Peters OA, Olivi G. Effectiveness of the erbium: YAG laser and new design radial and stripped tips in removing the smear layer after root canal instrumentation. Lasers Medical Sci. 2012 Mar;27(2):273-80

[19]. Plotino G, Grande NM, Mercade M. Photodynamic therapy in endodontics. Int Endod J. 2019 Jun;52(6):760-74

[20]. Konopka KR, Goslinski TO. Photodynamic therapy in dentistry. J Dent Res. 2007 Aug;86(8):694-707.

[21]. (Ordinola-Zapata R, Bramante CM, Aprecio RM, Handysides R, Jaramillo DE. Bioflm removal by 6% sodium hypochlorite activated by different irrigation techniques. Int Endod J. 2014;47(9):659–66.

[22]. Gandolfi MG, Iacono F, Agee K, Siboni F, Tay F, Pashley DH, Prati C. Setting time and expansion in different soaking media of experimental accelerated calcium-silicate cements and ProRoot MTA. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009 Dec 1;108(6):39-45

[23]. Torabinejad M, Ung B, Kettering JD. In vitro bacterial penetration of coronally unsealed endodontically treated teeth. J Endod. 1990 Dec 1;16(12):566-9.

[24]. Pissis P. Fabrication of a metal-free ceramic restoration utilizing the monobloc technique. Pract Periodontics aesthet Dent. 1995 Jun 1;7(5):83-94.

[25]. Kim S, Kratchman S. Modern endodontic surgery concepts and practice: a review. J Endod. 2006 Jul 1;32(7):601-23.

[26]. Raisingani D. Apexum: A minimum invasive procedure. Int J Clin Pediatr Dent. 2011 Sep;4(3):224-27.