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Minimally Invasive Endodontic

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بسم الله الرحمن الرحيم

يرفع الله الذين آمنوا منكم والذين أوتوا العلم درجات

صدق الله العظيم

Certification of the supervisor

I certify that this project entitled **" Minimally Invasive Endodontic "** was prepared by the fifth-year student **Nour Sabah** under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

Supervisor's name:

Noor Hayder

Date:

Dedication

I dedicate my success to my superhero (father)

My father... who worked hard.He left before harvesting the fruits of the plant

And embracing this success, without which it would not have been..

To my mother who always motivate and support me to achieve continuous in my way, you mean the world for me.

My friends, who stand by me when things look bleak,

My supervisor, who has been a constant source of support and Encouragement

And to all people in my life who touched my heart.

Acknowledgment

I would like to thank “The Greatest Allah” for inspiring me with the strength, willingness and patience to accomplish this work and I will pray that this blessing upon me would continue throughout my life. Special peace to his messenger Mohammed (The bless and mercy up on him and his best progeny and best companions).

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This review is the result of easy and friendly collaboration with my supervisor **Dr. Noor Hayder,** for her ideas, advices, support and guidance throughout the study. So, I ask Allah to reward her best reward.

Special thanks to all members of Conservative department.

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Abbreviation	Meaning
CAC	Conservative access cavity
CEA	Contracted endodontic access
CEAC	Conservative endodontic access cavity
CEC	Conservative endodontic cavity
CECDW	CEC with walls being divergent
DDC	Orifice directed access for dentine conservation
EEC	Endodontic expanded cavity
MEC	Modified endodontic cavity
MI	Minimally invasive
MS	Modified straight line
NEC	Ninja endodontic cavity
PEAC	Point endodontic access cavity
SL	Straight line
SLF	Straight line furcation
SLR	Straight line radicular
TA	Truss access cavity
(TAC)	Traditional access cavity
(TEAC)	Traditional endodontic access cavity
(TEC)	Traditional endodontic cavity
(TREC)	Truss endodontic access cavity
(TL)	Traditional straight line
(UEC)	Ultra conservative endodontic cavity

Introduction

A successful root canal procedure increases the likelihood that the tooth will continue to function normally within the mouth for a significant amount of time **(Taneja ,2021)**

After endodontic treatment, the lifetime of a tooth is dependent on the amount of residual tissue and healing. Endodontic outcomes are also affected by factors such as the quality of the root canal filling as well as the structural integrity of the tooth after the root canal preparation. Dentine behavior and configuration throughout age and function are presently the focus of current research efforts in this field **(Shibu and Julie ,2014)**.

Although a more conservative approach is being promoted in the present day, this has been made feasible by many new technologies and processes. The significance of preservation and a cautious therapeutic strategy cannot be understated **(Chethan et al. ,2021)**.

This innovative kind of root canal therapy, known as minimally invasive endodontics (MIE), takes a different approach that focuses on minimizing structural alterations after treatment **(Shibu and Julie ,2014)**.

Treatment and prevention of pulpal diseases and apical periodontitis, as well as preserving as much good tissue as possible, are all part of the MIE method, which is safe, accurate, and time-saving **(Gluskin et al. ,2014)**.

Endodontic procedures are becoming less invasive because of the development of new materials and technology, such as cone beam computed tomography (CBCT) scans, advanced microscopes, unique access designs, and inventive access cavities **(celikten et al.,2021)**.

Aim of the study

The aim of this review is to discusses various procedures that can be incorporated at each step of endodontics to a chieve minimal intervention , which is the goal of the new-age endodontics.

Chapter one

Review of literature

1.1 preserving structural integrity :-

Some of the ideas in the way dentistry has been practiced over the past century have recently undergone a paradigm shift. The tooth's residual structural integrity is a critical component in determining prognosis interms of future function after restoration. The purpose of all restorative therapies, notably in endodontics, is to maintain strength and stiffness that resists structural deformation. For example, extension for prevention is no longer found to be widely accepted, as it requires removal of the sound and intact tooth structure for only a potential chance of a future benefit. Understanding the biomechanical behavior of dentin as the weakest link in any restorative system is essential if we are to avoid causing more harm to it **(Gluskin et al., 2014 ; Celikten et al., 2021)**

According to the in-depth research by Silva et al., there have been cases when endodontically treated teethwere extracted because of inadequate repair of the dental structure **(Silva et al. ,2021)**

Therefore, to boost the prognosis of endodontically treated teeth, healthy dental material must be retained.Six multiple studies demonstrate that a tooth with extensive enamel and dentin loss performs much worse than an undamaged tooth when it comes to the capacity to bear occlusal and functional forces. Reduced access preparation diameter by half resulted in the operator removing four times less tooth structure in MIE compared to a standard preparation.A higher density of dentin boosted the tooth's tensile and fracture strength, making it more resistant to breakage.Based on logical reasoning, the preservation of maximal dentine mass during access cavity preparation and root canal shaping is of utmost importance; to date, no manufactured substance can effectively compensate for the lost dentinal tissue because of its unique features and traits **(Silva et al. ,2021)**

Eedodontic therapy is a common dental technique used to repair teeth whose pulp tissues have become permanently irritated or decaying as a result of caries or dental trauma. This treatment, which comprises mechanical and chemical root canal preparation, may affect numerous mechanical and physical aspects of the tooth structure **(Soares et al., 2018)**

Endodontic therapy can also affect the lifespan of endodontic treatment, tooth rehabilitation, and biomechanics during oral function. Several factors and clinical judgments must be followed while recovering endodontically treated teeth. The choice of fiberglass posts and restorative materials is influenced by several criteria, including the availability and value of surviving dental structure,the existence of a ferrule, the duration of the post cementation, and the ultimate coronal restoration.Biomechanics refers to the study of biological structure, as well as its function, using the principles of engineering mechanics. Endodontically treated teeth (ETT) are effective for structural management of biomechanics, which play a vital role to increase nutritive tissues in dental health. Furthermore, it focuses on the development of the dental tissues and restorative tooth structure. Endodontic therapy focuses on the good health of the dental areas, and biomechanics focuses on the natural dental system of chewing and assisting the human body with digestion. In this concern, biomechanics plays a vital role in resisting fracture, and also lessens the pressure on weakened, as well as decaying, teeth. In other words, ETT promotes better handling of dental tissues so that an ideal prognosis can be achieved. The biomechanics of dentin and its behavior are altered at three levels because of endodontic treatment, which are dentin macro and micro-structure, the composition of tissues, and an all-over structure of tooth **(Gaikwad and Pandit, 2016)**.

Biomechanics and biomechanical preparation, in particular for root canal treatment, are useful for the development of cavity-related disorders. Root canal therapy is a treatment sequence for a damaged tooth's pulp that concludes in the eradication of infection and the protection of the remediated tooth against additional microbial invasion. The term "root canal therapy" refers to this treatment sequence.

One of the most significant parts is access cavity preparation, with the main goal of identifying root canal openings for further biomechanics preparedness and complete removal of the "root canal system" **(Mahalaxmi, 2019)**.

As a result, great access cavity design is critical for high-quality endodontic treatment. The notion of "extension for prevention" simplifies treatment operations, however, this also eliminates crucial dentin at the cervical area, leaving natural teeth biomechanically impaired following endodontic therapy. MIE fosters an iatrogenic root dentin removal system, which influences radicular stress distribution on teeth.This also experimented with the root dental system to analyze the root volume, on radicular bending structure. A load of fracture and stress distribution is necessary for the management of the dental diagnosis and analysis of the root health of teeth. In other words, this focuses on the management of mechanical integrity of ETT or endodontically treated teeth **(Makati et al., 2018)**.

1.2. Biomechanics of dentine

A vital cellular component, the dentine houses the cellular processes of the pulp-dwelling cells known as odontoblasts **(Ossareh et al., 2018)**.

Biomechanics is the branch of engineering mechanics that deals with the study of biological structures and their functions in terms of mechanical principles. Natural collagen provides strength, whereas the inorganic component of dentin can withstand the hardness and high compressive properties of dentin because of its water-based nature. Tensile stress in compression is greater than tensile stress in tension. The small pulpal environment and fluid in dentinal tubules all work together to prevent cracks in the dentin from occurring **(Wolters et al., 2017)**.

Endodontic therapy may cause a decrease in dentin water content, which might lead to dentin tissue contraction and the formation of cracks and fractures that could lead to tooth breaking **(Soares et al., 2007)**.

During endodontic treatment, tissue composition, dentin macrostructure, and total tooth structure are all altered. With age, our dentin becomes more brittle and less elastic due to physiological and pathological processes. This leads to a decline in the mechanical properties of our teeth. There must be an appropriate equilibrium between the rigidity of dentin (mineralization) and the toughness (elasticity) of the tissue(collagen and hydration water) **(Wolters et al., 2017).**

When evaluating the long-term efficacy of endodontic treatment, the decreased fracture resistance of root canal-treated teeth remains a serious concern. According to Reeh et al., the structural integrity of teeth treated with endodontics is a critical factor in their long-term survival (1989). Also, as per Mauger et al. (1993), and Willershausen et al. (2008), important for long-term root canal treatment success is knowledge of root canal morphology, chemomechanical preparation processes, and cavity designs. As per Tang et al.(2010), pericervical dentine and structural integrity of treated teeth are important considerations in determining the long-term outlook of an individual tooth's root canal treatment. Endodontically treated teeth with preserved hard tissue are more resistant to breaking and have lower stress concentrations,especially in the cervical region **(Chan et al., 2022)**.

A minimally invasive method and various preparatory equipment should be used to properly preserve dentine during endodontic treatment, even if the loss of tooth structure is not the primary cause of reduced fracture resistance in endodontically treated teeth **(Van der Vyver et al., 2019)**.

With this objective in mind, pericervical dentin preservation has been advocated for in endodontics using the MIE method maintaining dentin, which acts as a stress-transmitting conduit, may increase the strength of the tooth. Removal of dental hard tissues such as the oblique ridges, peri-cervical dentin, and the thinning of marginal surfaces for clinical convenience may increase the risk of tooth breakage, they developed this procedure **(Shabbir et al,.2021)**.

1.3. Traditional Access Cavity (TradAC)

has been defined as a cavity that “aims to per- form a complete unroofing of the pulp chamber, exposure of all the pulp horns and a straight- line access to the root canals with coronally divergent walls without undercuts, to visualize the pulp chamber floor and all the root canal orifices from the same visual angulation” **(Plotino et al., 2017).**

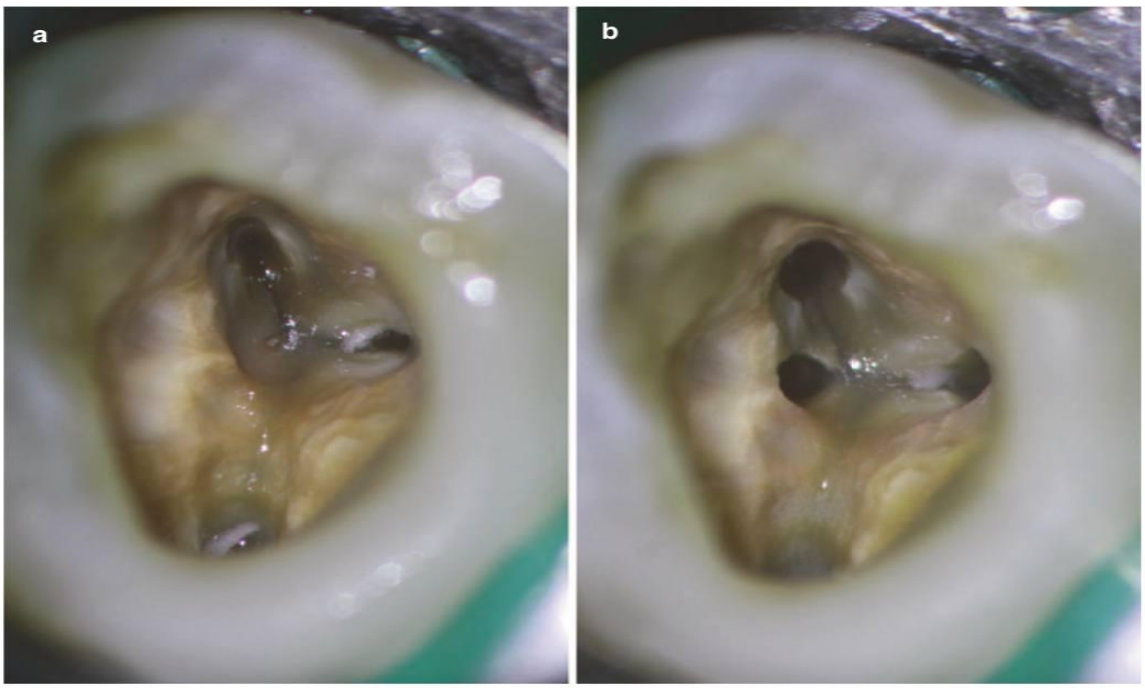

Fig.(1.1) (a) Typical traditional extended access cavity design in a maxillary first molar before the negotiation of the MB2 canal and (b) after finding and shaping the MB2 canal

The traditional endodontic access cavities principles include (Ingle et al., 2002 ; Boveda et al., 2015) :-

•The removal of all carious dentin and defective restorations.

• The outline form that is dictated by the occlusal extent of the prepared cavity with diver- gent axial walls.

• The convenience form that is dictated by the degree of dentin to be removed at specific locations so as to achieve a straight-line access to root canal orifices.

• The "toilet" cleaning of the cavity.

• The extension for prevention that is dictated by the removal of dentin obstructions to extend the straight line access to the apical foramen or the primary curvature of the root canal.

1.4. Procedures used in Minimally Invasive Endodontics (MIE)

MIE can be incorporated into various phases of endodontics, i.e., access opening, biomechanical preparation of root canals as well as surgical endodontics. All these will be further discussed, keeping in mind, the concept of MIE.

1.4.1. Minimally Invasive Access Cavity Preparation

A minimally invasive access cavity can be prepared only if the following considerations can be entirely realized **(Iandolo and Abdel Latif, 2018) :**-

(1) direct visualisation of the entire floor of the pulp chamber and ability to fully explore the anatomy of the pulp chamber

(2) ability to localise all of the anticipated canal orifices

(3) complete removal of any present calcifications on the floor of the pulp chamber

(4) ability to prepare the isthmuses in premolars with two root canals

(5) likewise, ability to prepare the mesial isthmuses in mandibular molars

(6) access allows exploration and cleaning of the pulp chamber without removing the pulp horns and with minimal removal of the roof.

According to these points, we consequently discuss in which clinical situations preparing a conservative access cavity is recommended.

Teeth with irreversible pulpitis or necrosis due to Class V cavities. After removal of the caries, a sound occlusal surface can be obtained. Therefore, in this case, it is advised to prepare a conservative access cavity in order to preserve the tooth structure. This applies likewise to teeth with irreversible pulpitis or necrosis due to proximal caries that does not extend to the occlusal surface. In these cases, after eliminating the entire carious lesion, it is possible to extend the preparation a little bit occlusally to perform the endodontic treatment through a mesial or distal cavity.Teeth with irreversible necrosis or necrosis caused by preparation below crowns and bridges In such cases, if the pulpal pathology is due to the preparation of the teeth and provided that no carious lesion exists and the crown or a bridge has definitive margins, it is ideal to prepare a conservative access cavity for structural and aesthetic reasons **(Iandolo and Abdel Latif, 2018).**

Teeth with irreversible pulpitis or necrosis caused by periodontic-endodontic lesions with no or minimal occlusal caries Severe periodontal disease can lead to pulpal pathology, while the tooth structure can be intact and sound. In such cases, a small conservative access cavity can aid in maintaining the integrity of the affected teeth. This applies similarly to cases of teeth with irreversible pulpitis or necrosis due to trauma or hazardous occlusal stresses **(Iandolo and Abdel Latif, 2018).**

The following minimally invasive access cavity designs can be incorporated, namely **(Reeh et al., 1989).**

I. Conservative endodontic access cavity

II. Ninja endodontic access cavity

III. Truss access cavity

IV. Caries-driven access cavity

V. Restorative-driven access cavity

VI. Straight-line furcation and straight-line radicular

1.4.1.a. Conservative endodontic access cavity (CEAC)

Such access cavity designs were proposed by Clark and Khademi in 2010 .in posterior teeth ;preparation normally starts at the central fossa of the occlusal surface and extends with smoothly convergent axial walls only to the degree required to expose the canal orifices ;retaining part of the roof of the pulp chamber **(Clark and Khademi, 2010)**. This form of access can also be done with divergent walls (ConsAC.DW) **(Roperto, et al., 2019).**

In anterior teeth ;this strategy involves transferring the entry point on the lingual or palatal surface from the cingulum to the incisal edge by forming a narrow triangular or ovale shaped cavity retaining the pulp hornes and the full pericervical dentin **(Vieira et al., 2020)**.

1.4.1.b. Ultra-Conservative Access Cavity (Ultra AC)

It is also known as 'ninja' access, such cavities start as described in the Cons AC, but with no further extensions, maintaining as great of the pulp chamber roof as possible**.** In anterior teeth, when there is attrition or a deep concavity in the lingual aspect of the crown, the access can be done in the middle of the incisal edge, parallel to the long axis of the tooth **(Plotino et al., 2017).**

1.4.1.c. Truss Access Cavity (Truss AC)

This type of access cavity design aims to maintain the dentinal bridge between two or more tiny cavities prepared to access the canal orifice(s) in each root of multi-rooted teeth. In mandibular molars, for example, two or three individual cavities can be formed to access the mesial and distal canals **(Neelakantan,et al. 2018).**

1.4.1.d. Caries-Driven Access Cavity (Caries AC)

In this type the access to the pulp chamber is done by removing caries and preserving all remaining tooth structures, including the soft structure, described as the underside of an architectural feature such as the ceiling, the corner of the ceiling and the wall **(Clark et al., 2013)**

1.4.1.e. Restorative-Driven Access Cavity (RestoAC)

In restored teeth with no caries, access to the pulp chamber is done by totally or partially removing existing restorations and by preserving all possible remaining tooth structures **(Silva et al., 2020).**

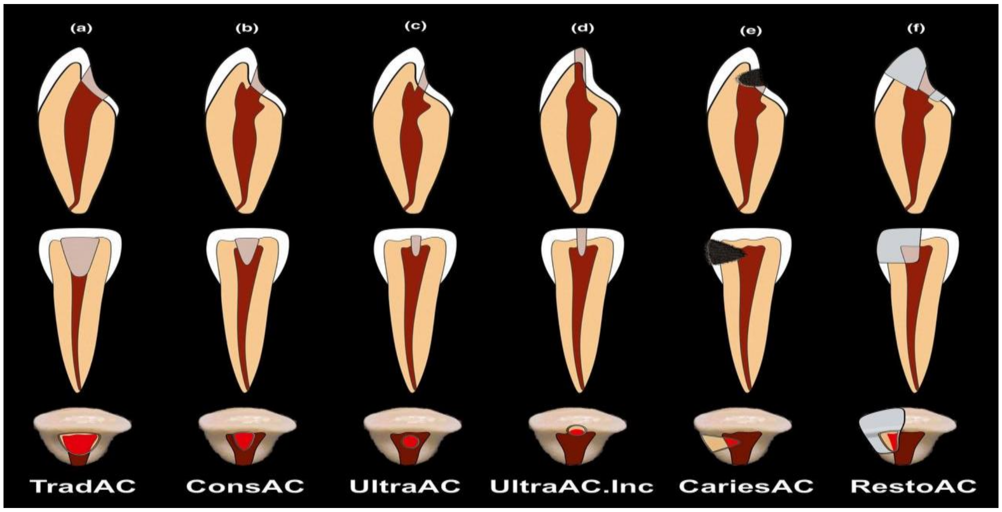

Fig.(1.2) Classification of different kinds of access cavity preparation in anterior teeth.

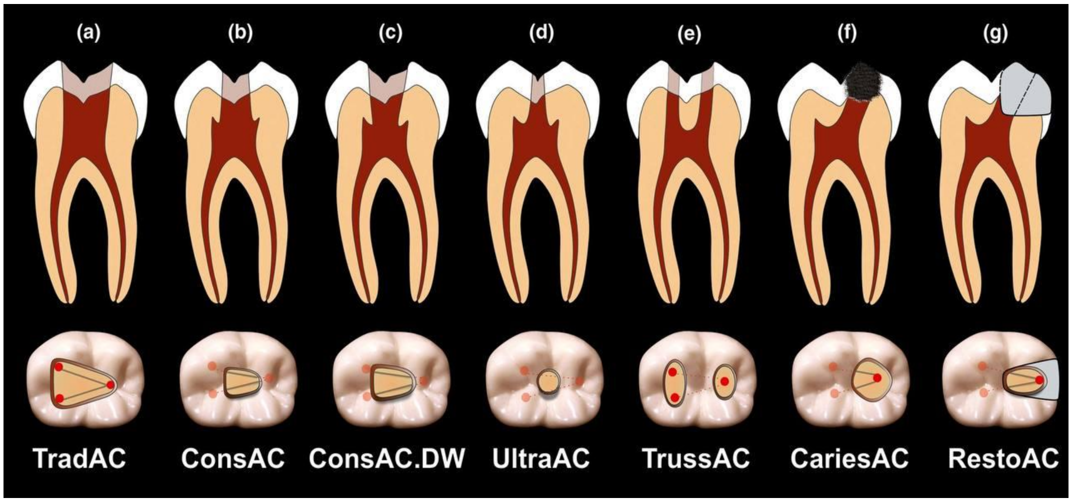

Fig.(1.3) Classification of different kinds of access cavity preparation in posterior teeth.

1.4.2. Cleaning and shaping of root canals

The primary goal of endodontic therapy is to clean and shape the root canal space. Its goal is to prepare the canal space to enhance disinfection along with the use of irrigants as part of chemomechanical preparation, which aims to eliminate microorganisms, residual pulp tissue, and dentinal debris from the root canal system **(Cohen and Hargreaves, 2006).**

Professor Schilder introduced the idea of "cleaning and shaping" in (1974). The term "cleaning" refers to the process of removing all of the contents of the root canal system. "Shaping" is the process of enlarging the canal system to make it easier to place an obturating material that seals the entire canal, including lateral and accessory canals and prevents bacterial microleakage **(Jaber and Abdul-Ameer, 2016).**

Schilder in 1974 outlined five mechanical goals for effective cleaning and shaping, which are as follows **(Schilder, 1974):**

1. Creation of a continuous taper funnel form.

2. Making the canal narrower at the apex, with the smallest cross-sectional diameter at its end.

3. Prepare the canal in multiple planes.

4. Keeping the apical foramen in its original position and

preventing transportation.

5. The apical foramen should be kept as small as possible

1.4.2.a. Taper of Endodontic files :-

The old concept of big, aggressive canal-flaring is no more in practice. More conservative designs leave the tooth much stronger and moreover, there is a very limited evidence that wider canal shapes provide a better seal and fewer endodontic failures **(Sedgley, 1992 ; Huang 1992).**

Enhanced instrumentation in the apical area and larger apical diameters weakens the root due to loss of apical dentin and also a loss of control over the obturation component of treatment. Hence, smaller apical preparations and continuous taper are preferred. This kind of preparation preserves root dentin and promotes resistance form and provides a tight apical seal to create sufficient shape for adequate disinfection **(Buchanan, 2000 ; Ruddle, 2002).**

1.4.2.b. The self-adjusting file (SAF) system :-

The SAF or the Self-adjusting file system has gained popularity due to its minimally invasive approach.The design of the SAF produces minimal stress concentrations in the apical root dentin during shaping of the curved canal, which leads to an increase in the chance of preservation of root dentin integrity with a reduced chance of dentinal defects and apical root cracking **(Weine,1975).**

1.4.2.c. Photon Induced Photo-Acoustic Streaming (PIPS)

The traditionally used laser applications required a conventional preparation for atleast up to size 30 and the laser tip needed to reach up to the apical third of the root. But on the other hand, the PIPS tip can be placed into the coronal reservoir of the root canal. Therefore, this technique allows for minimally invasive preparation of the root canal **(Pathak,2016).**

1.4.2.d. Photodynamic th+666erapy in endodontics (PDT)

PDT is an effective adjunct to standard antimicrobial intracanal cleaning and shaping for the treatment of periapical lesions. When this technique is used efficiently, disinfection of the canals can be obtained without inadvertent instrumentation and removal of excessive dentin **(Plotino, 2019).**

1.4.3. Disinfection and other considerations in minimally invasive endodontics :-

Instrumentation and disinfection are critical to root canal treatment's success. At this point, it is necessary to clean off any remaining dirt and smear layer. There is a strong correlation between root canal infection and treatment failure, as shown by the large majority of patients who do not respond well to regenerativeendodontic **(Elnawam,2022).**

Research by Plotino and colleagues found that an instrument with a 25-size bore provided a better canal surface in the root canal's apical third **(da Silva, 2020).**

Root canals are unlikely to be fully free of bio-burden with existing cleaning and shaping processes because of the present level of technology. In light of the shrinking size of apical preparations, scientists are investigating novel strategies for increasing irrigation effectiveness. “It is possible that future root canal preparation methods will have to balance the ability to disinfect and iatrogenic injury with better debridement and disinfection capabilities **(Gluskin, 2014)**.

Microbial elimination is the major goal of endodontic therapy with the required technological assessment and indirect manipulation of the dentin. For achieving the goal of the treating clinician has to become less simultaneously invasive. Teeth are an important part of the human being and to save this treasure it is the major responsibility of the individual by balancing those in an appropriate routine check-up. The mostconvenient advantage is that MIE is associated with invasive leads for managing the rate of procedural errors (missing canals, perforation, ledging,or instrument separation).Benefits become further provide pooroutcomes with its outweighed measurements **(Shabbir, 2021).**

Hence it is required to be conservative in order to help standardize the microsurgical access preparation that helps to save enamel or dentin at a high rise cost. In the addition to the implementation of the new innovation, in this aspect use of different instruments or tools could be a great sign of success without any potential compromise. Without any unnecessary flaring MIE is capable to preserve the dentin by the synchronized hydraulic condensation. No doubt the efficiency and the merit of the MIE is incredible during the use of potential promotion of disinfectant and other consideration, but the strive of MIE is associated with the negative consequences of preparation for micro-access **(Lara-Mendes, 2018).**

1.4.4 Surgical Endodontics

Traditionally, Apicectomy was performed in teeth with periapical lesions. This is a highly invasive procedure and hence, in the recent years, newer techniques that are less invasive are gaining popularity which include microsurgery and Apexum.

- **Microsurgery in Endodontics**

Endodontic microsurgery is a minimally invasive technique that results in less postoperative pain and edema and faster wound healing **(Floratos et el., 2017).**

performed on the root apices of an infected tooth, which was unresolved with conventional root canal therapy. Generally, procedure for endodontic microsurgery encompasses the removal of the buccal bone in order to accurately locate the root apices of an infected tooth, which may include the removal of intact bone. Then, surgical debridement of pathological peri-radicular tissue is performed, followed by the removal of root-end resection. A minimum of 3 mm preparation depth is required to effectively seal the accessory canals that may be present. Finally, a root-end cavity is obturated with Mineral Trioxide Aggregate (MTA) and the surgical site is sutured **(von Arx,2000).**

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 **(Floratos et el., 2017).**

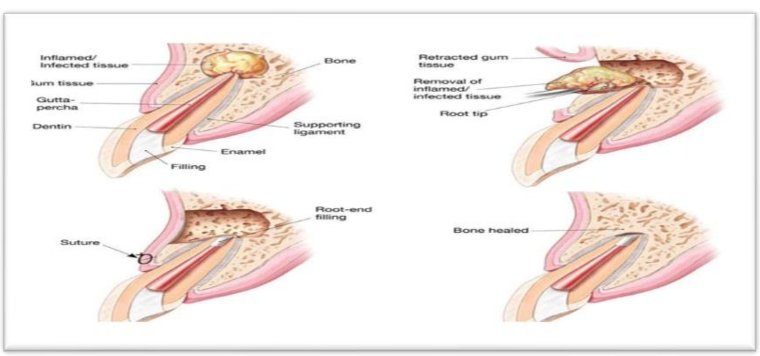

Fig.(1. 4) Apical Microsurgery

1.4.5 Apexum (a non-surgical approach)

This method allows removal of periapical tissues without using scalpels, periosteal elevators or sutures.**(Metzger et el., 2008).**

It is based on a device that removes the chronically inflamed periapical tissues through a root canal access using a procedure that is minimally invasive (Apexum Ablator; Apexum Ltd, Or- Yehuda, Israel) **(Raisingani,2011).**

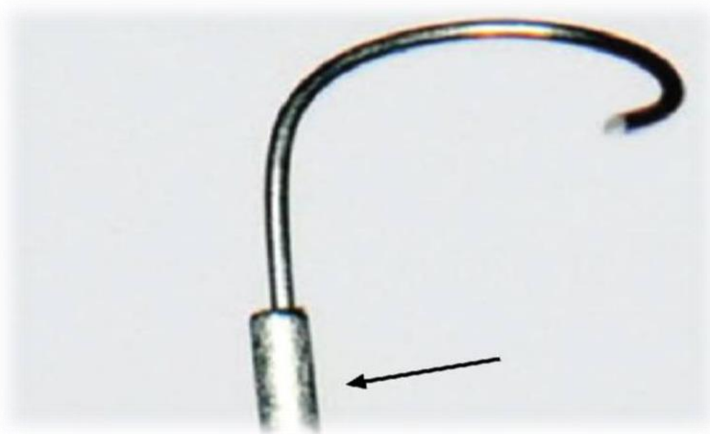

Fig.(1.5) An enlarged view of the active part of the Apexum NiTi Ablator

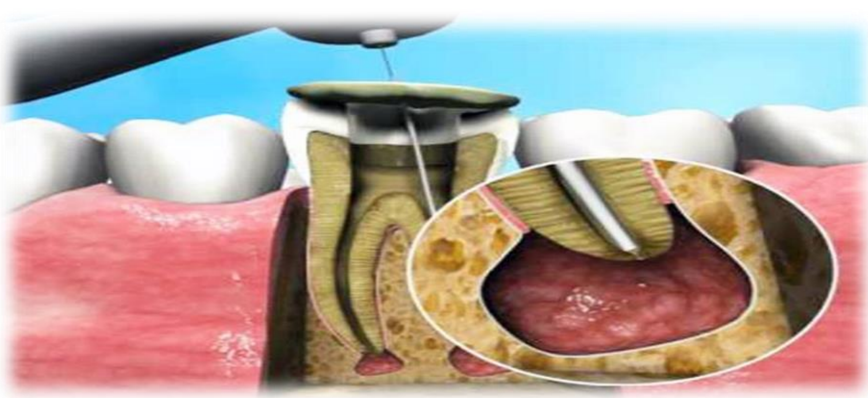

Fig. (1.6) Apexum procedure

1.5. Effects of endodontic access cavity on root canal irrigation

Regarding debris accumulation, Rover et al. (2017) found no difference in the percentage of debris accumulated within the root canal system when comparing maxillary molars with (ConsAC) or (TradAC) **(Rover et al., 2017)**

However, Silva et al. in (2020) found a higher percentage of debris was associated with(UltraAC) canal preparation of maxillary premolars when compared to (ConsAC) and (TradAC) respectively **(Silva et al., 2020a).**

Moreover, it was reported a limited irrigation effectiveness that resulted in more dentinal debris deposition within the root canal system with the increased area of pulp chamber roof associated with small access cavities (UltraAC) **(Neelakantan et al., 2018).**

Well-documented disadvantages of irrigating minimally enlarged canals included limited irrigant penetration, needle wedging, vapor lock effect, and issues connected with sonic/ultrasonic/apical negative pressure irrigation **(Bóveda and Kishen, 2015)**, more research is needed in this area, as disinfection has a direct impact on root canal treatment prognosis

1.6. Effect of endodontic access cavity on obturation procedure

Astudy by Niemi et al. in (2016) searched the influence of (ConsAC) and (TradAC) on the consistency of root canal filling in oval-shaped canals of mandibular premolars. The researchers discovered that while utilizing a single-cone approach, the smaller dimensions of minimally invasive access inhibited the guttapercha cone's adaptability and impeded the continuous condensation wave process. Warm lateral compaction is the greatest solution for filling canals in teeth with less invasive access preparation for these reasons **(Niemi et al., 2016).**

Silva et al. in (2020) used (UltraAC) and (TradAC) to examine the proportion of voids generated after filling root canals of two-rooted maxillary premolars with round cross-sectional forms and found that the access design did not affect canal filling, but this could be due to the round cross-section of the root canal **(Silva et al., 2020a).**

Prior to the restoration of teeth using (UltraAC), difficulties were encountered in eliminating residues of filling materials from the pulp chamber, even with the use of ultrasonic tips; magnification and extra time required to complete treatment, as a result of this lengthy procedure, patients and dentists may become exhausted, and the filling remnants may affect aesthetics by causing the tooth crown to discolor over time **(Lenherr et al., 2012).**

Chapter Two

Discussion

New types of cavity preparations are presented as alternatives to traditional endodontic cavities (TECs). Conservative access cavities (CACs), ultraconservative access cavities (UCACs) and truss access cavities (TRACs) have been described in the literature as a means of minimizing weakening of the structure **(Silva et al., 2020) (Figures 2.1 and 2.2).**

Different results were obtained in studies examining various cavity. designscompared the rate of hard tissue removal among various types of access cavities. The results showed that the volume of dentin and enamel removed increased in order from UCAC to CAC, and finally to TAC. The authors suggested standardization using CBCT to distinguish between different endodontic cavities in subsequent studies **(Isufi, 2020).**

This could help to identify cavities and avoid confusion among researchers.

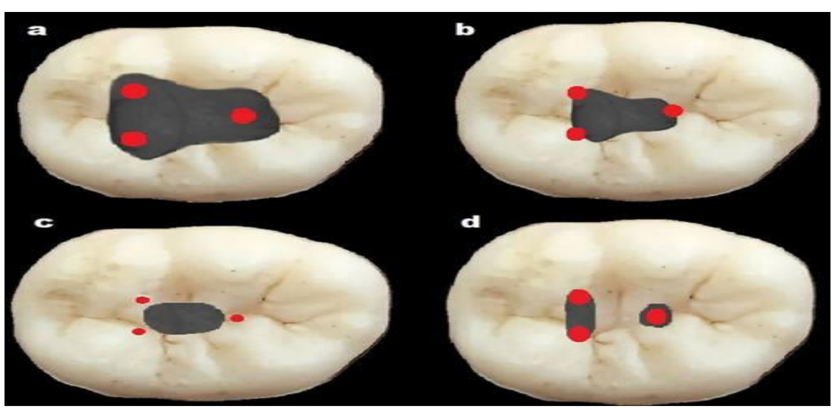

Fig. (2.1) Occlusal view in lower molar tooth: (a) traditional endodontic access cavity illustration; (b) conservative endodontic access cavity; (c) ultraconservative endodontic access cavity; (d) truss endodontic access cavity.

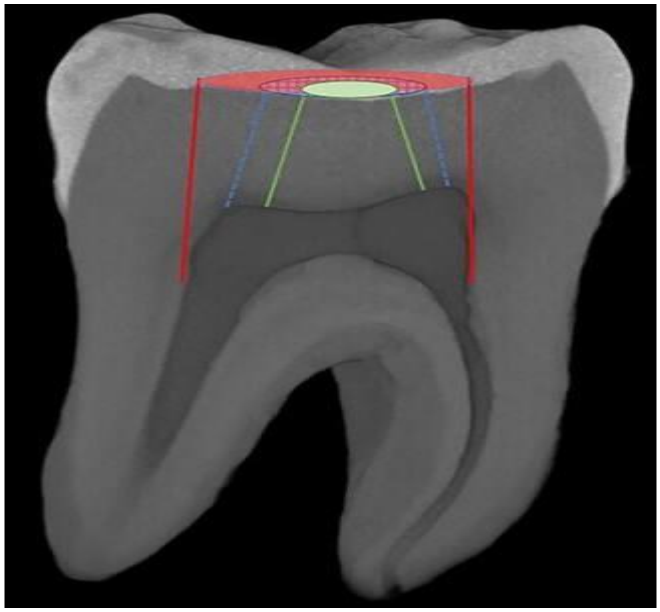

Fig.(2.2) Micro-ct image of lower molar tooth from lateral view. Red area and lines indicate border of traditional endodontic access cavity. Blue area and lines indicate border of conservative endodontic access cavity. Green area and lines indicate border of ultraconservative endodontic access cavity.

Dental fractures are serious because they can necessitate tooth extraction **(Sabti,2018).**

Minimally invasive approaches reduce the risk of fracture in teeth with filled root canals. Removal of decayed tissue and creation of an access cavity are important in root canal treatment. reported that a TEC may make the tooth more susceptible to fracture than a minimally invasive design. It has been suggested that root fracture may occur depending on the amount of tissue removed from the pericervical area during preparation of the access cavity. Previous studies indicated that the cervical area is exposed to greater stress as the cavity volume increases **(Allen et al.,2018).**

Yuan et al. reported that the use of a minimally invasive approach reduced the stress distribution in the crown and cervical areas **(Yuan, 2016).**

On the other hand, silva et al. reported that UCACs were not associated with resistance to fracture **(silva et al.,2021).**

Consistent with this view, Sabeti et al. reported that there was no significant difference in fracture resistance between TACs and CACs **(Sabeti, 2018).**

Maske et al. showed that the cavity type does not affect the fracture resistance of endodontically treated teeth. Despite the results of the above studies, the authors acknowledged the contribution of preservation of the tooth structure around the pulp chamber and pericervical region to durability **(Maske et al., 2021).**

Saberi et al. examined thermal stresses in teeth using a device that simulates temperature changes in the oral cavity. In their study comparing TRACs and TACs, the TRAC design increased the fracture resistance of endodontically treated teeth under thermal loads **(Saberi et al., 2020).**

The occlusal surface of the crown of the maxillary first molar teeth has grooves and cristae that extend between the mesiopalatal and distobuccal tubercles. Zhang et al. reported that the mesial groove is the beginning point of fracture in first molar teeth with the application of force. The same study indicated that stress in the cervical region was higher in TAC and modified cavity teeth than in CAC.

In addition, it was emphasized that removing less hard tissue during preparation increases the fracture resistance of the teeth **(Zhang et al., 2019).**

In another study performed in the maxillary first molar, a similar stress distribution was observed on the occlusal surface in different types of cavities, but the stress on the pericervical dentin was more evident in large cavities **(Jiang et al., 2018).**

Effective shaping, cleaning, and filling are important for successful root canal treatment. Many instruments varying in flexibility and metallurgical properties have been produced for canal preparation. Performing canal instrumentation by removing less tissue with a minimally invasive technique is a new approach. Using smaller tapered files supports preservation of root dentin and reduces stress, especially in the coronal third of the tooth **(Lin et al., 2020).**

However, removal of less dentin from the canal has disadvantages, such as inadequate disinfection of necrotic pulp. Effective irrigation is essential for cleaning the root canals from microorganisms. If root canals are not cleaned sufficiently, apical periodontitis cannot heal in infected teeth **(Vieira et al., 2020).**

Therefore, clinicians must decide whether a given case is suitable for minimally invasive treatment. Wang et al. reported that while a small tapered canal preparation reduces stress on teeth, the design of the access cavity is more important. Mechanical instrumentation and disinfection play major roles in the success of root canal treatment. At this stage, elimination of the residual debris and smear layer is an important consideration. The amount of debris produced from the canal wall varies among files with different designs and tapers **(Wang et al., 2020).**

Plotino et al. observed that a 25-size instrument created a cleaner canal surface than a 20-size one in the apical third of the root canal. Moreover, apical enlargement should be sufficient to achieve strong antimicrobial efficacy, even if the irrigation solution is activated with a sonic device **(Perez et al., 2018).**

highlighted another point that unprepared canal area was observed after each increase in preparation size. After preparation, the canal diameter can affect the resistance of the root to forces generated during function. However, in another study, decreasing the taper to 4% did not statistically increase the fracture resistance of maxillary premolars treated endodontically compared to the 6% taper **(Zogheib et al., 2018).**

The endodontic access cavity affects the operator's ability to manipulate and shape the root canal with a suitable file system. According to Moore et al. [Citation27], CACs in maxillary molars did not seem to affect the instrumentation efficacy and biomechanical responses compared with TACs.

On the other hand, Alovisi et al. reported that TACs may supply a better protection of the original canal anatomy during shaping compared with CACs, especially the apical third. If the instrument works more inner surface of the canal, apical transportation can occur **(Alovisi et al., 2018).**

Unfortunately, this can be observed in minimally accessed teeth. Interestingly, in the study of Freitas et al. there was no difference between cavity designs in the operation of the instrument in curved root canals **(Freitas et al., 2021).**

Chapter Three

Conclusions

Minimally invasive treatments have been widely adopted in endodontics recently. Generally, this type of treatment is intended to reduce hard tissue loss. Based on our literature review, it is not possible to conclude definitively that minimally invasive approaches should always be applied. However, with appropriate case selection, minimally invasive treatment can provide a good prognosis while maintaining the tooth structure.

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