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Endodontic Access Cavities: Current Approaches to Design Principles and Clinical Outcomes

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Review

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ABSTRACT

The preparation of the access cavity plays a critical role in the success of endodontic treatment. This process is essential for effectively cleaning infected pulp tissue and properly shaping the root canal system. Traditional methods often result in significant loss of dental tissue due to the need for broad and straight-line access, whereas modern minimally invasive techniques aim to minimize this loss. However, as the size of the access cavity decreases, visualizing the pulp chamber, cleaning infected tissues, and locating, shaping, and filling the root canals become increasingly challenging. A small access opening can create serious obstacles in clinical practice due to the limited space; this situation can hinder a thorough examination of the pulp chamber, making it difficult to perform necessary interventions effectively. Particularly in anatomically complex dental structures, narrow access areas can lead to uncertainties in clinical decision-making processes, thereby adversely affecting treatment success. Consequently, the preparation of the access cavity is not merely a mechanical step but an essential strategic component that determines the long-term success of endodontic therapy. Minimally invasive techniques enhance treatment effectiveness while preserving the structural integrity of the tooth and significantly contribute to achieving safe and predictable clinical outcomes in modern endodontic practice. In clinical applications, the advantages and disadvantages of these techniques should be carefully considered, and clinicians must take into account patients' individual circumstances and current conditions to determine which methods are most appropriate.

Keywords: Dental pulp cavity, endodontics access cavity preparation, preparation, root canal theraphy, root canal preparations.

Endodontik Giriş Kavitesi: Tasarım Prensipleri ve Klinik Sonuçlara Yönelik Güncel Yaklaşımlar

Derleme

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ÖZ

Giriş kavitesi hazırlığı, endodontik tedavinin başarısında kritik bir role sahiptir. Bu süreç, enfekte pulpa dokusunun temizlenmesi ve kök kanal sisteminin etkili bir şekilde şekillendirilmesi için gereklidir. Geleneksel yöntemler genellikle geniş ve doğrusal erişim gereksinimleri nedeniyle diş dokusunda önemli kayıplara yol açabilirken, modern minimal invaziv teknikler bu kaybı en aza indirmeyi hedefler. Ancak, giriş kavitesinin boyutu ne kadar küçülürse, pulpa odasının görselleştirilmesi, enfekte dokuların temizlenmesi ve kök kanallarının bulunup şekillendirilmesi, temizlenmesi ve doldurulması o kadar zor hale gelir. Küçük bir erişim boşluğu, sınırlı alan nedeniyle klinik uygulamada ciddi zorluklar yaratabilir; bu durum, pulpa odasının detaylı incelenmesini engelleyerek, gerekli müdahalelerin etkin bir şekilde gerçekleştirilmesini zorlaştırabilir. Özellikle anatomik olarak karmaşık diş yapılarında, dar erişim alanları, klinik karar verme süreçlerinde belirsizliklere yol açarak tedavi sürecinin başarısını olumsuz etkileyebilir. Sonuç olarak, giriş kavitesi hazırlığı yalnızca mekanik bir aşama değil, aynı zamanda endodontik tedavinin uzun süreli başarısını belirleyen temel bir stratejik unsurdur. Minimal invaziv teknikler, dişin yapısal stabilitesini koruyarak tedavi etkinliğini artırmakta ve modern endodonti pratiğinde güvenli ve öngörülebilir klinik sonuçlar elde edilmesine önemli katkılar sağlamaktadır. Klinik uygulamalarda, bu tasarımların avantajları ve dezavantajları dikkate alınmalı ve klinisyenler, hangi tekniklerin en uygun olduğunu belirlemek için hastaların bireysel durumlarını ve mevcut koşulları göz önünde bulundurmalıdır.

Anahtar Kelimeler: Diş pulpası kavitesi, endodontik giriş kavitesi hazırlama, kök kanalını hazırlama, kök kanal tedavisi.

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Introduction

An endodontic access cavity (EAC) preparation is the initial clinical step in endodontic therapy and serves as a cornerstone for healing pulp and periapical infections. Although it may be one of the most technically challenging aspects of endodontic treatment, it remains a critical determinant of therapeutic success.[1] The EAC must enable endodontists to remove obstructions in the pulp chamber, identify canal orifices, and thoroughly clean the root canal system while maximizing the preservation of coronal tooth structure.[2] In anterior teeth, the endodontic access

cavity is typically created from the palatal or lingual surface to preserve aesthetics. This approach also provides the most direct route to the pulp chamber. The access extends from the incisal edge to approximately 2 mm above the cingulum, ensuring the complete removal of the pulp chamber in both cervico-incisal and mesiodistal dimensions. Generally, incisors have a triangular-shaped access cavity, while canines exhibit an oval-shaped design.[3,4] In posterior teeth, traditional access cavity (TradAC) preparation involves the complete deroofing of the pulpal chamber and achieving straight-line access to the first curvature or the apical portion of the canal.[5] Other access cavity designs have been proposed in posterior teeth to be minimally invasive, either by being conservative or ultraconservative.

Teeth are subjected to high masticatory forces within the oral cavity. During EAC preparation, a substantial portion of the coronal tooth structure, including pericervical dentin, is removed. This removal increases stress concentration on both the crown and root surfaces, thereby compromising the tooth's fracture resistance.[6] TradAC involves the complete removal of the roof of the pulp chamber, minimizing coronal interventions and ensuring that the endodontic instrument penetrates the root canal in the most linear manner possible. This approach enhances the instrument's effectiveness while reducing the risk of complications.[7] However, both iatrogenic and non-iatrogenic dentin loss are risk factors for fractures. Therefore, to minimize the risk of fractures - particularly in endodontically treated teeth- it is crucial to ensure optimal distribution of these forces. For effective force distribution, preserving the enamel and dentin structure that covers the pulp chamber roof is essential.[8]

The term 'minimal invasive endodontics (MIE),' first introduced by Clark and Khademi,[9] refers to the removal of minimal amounts of dental tissue during the cavity opening stage. Krishan et al.[10] report that a smaller access cavity reduces the necessary fracture strength in premolars and molars compared to the TradAC. This approach aims to enhance treatment effectiveness while preserving the structural integrity of the tooth through less invasive intervention. However, previous research has indicated that a more conservative design of endodontic access can negatively impact the essential principles of chemo-mechanical preparation.[11] Another study found that while the minimal access cavity offers some benefits in increasing the fracture resistance of teeth, it is also associated with the risk of compromising the quality of canal instrumentation.[10] Furthermore, it has been emphasized that minimally invasive access may cause endodontic instruments to primarily engage with the inner surface of the root canal, potentially leading to apical transportation.[12] Nevertheless, innovations in therapeutic devices used in endodontics hold significant potential for mitigating these adverse effects. A recent study evaluated, the effects of MIE and TradAC designs on disinfection and shaping using XP-endo Shaper instruments (XPS, FKG Dentaire SA, La Chaux-de-Fonds, Switzerland), and no significant differences were reported.[13] In this literature overview, we describe and classify the various access designs proposed in the endodontic literature and compare the advantages, disadvantages, and clinical findings of the existing published data.

1. Traditional Access Cavity

Traditional access cavities are constructed to completely reveal the pulp chamber, expose all pulp horns, and establish a direct route to the root canal. This methodology enables the clinician to directly visualize the pulp floor and canal orifices without requiring alterations in their line of sight (Figure 2a).[14] In order to ensure unimpeded access for endodontic instruments to the canals, it is essential that the roof of the pulp chamber be entirely excised to create a sufficiently broad and linear pathway.[15] Generally, the creation of a TradAC can be summarized in three main steps:

1. Fully open the pulp chamber to expose the pulp horns.
2. Establishing a clear and unobstructed pathway to the root canal orifices.
3. Maintaining the integrity of healthy tooth structure.[16]

This cavity type aims to minimize procedural errors such as perforations, instrument fractures, and the formation of ledges. Additionally, it allows all canal orifices to be visible without tilting the mirror, facilitates the straightforward use of root canal instruments due to straight-line access, and enables the effective delivery of irrigation solutions into the canals.[17,18] However, the removal of a significant amount of tooth structure, including pericervical dentin, occurs during the procedure. This loss of dentin reduces the fracture resistance of teeth subjected to high occlusal loads. Furthermore, the lost tooth structure cannot be completely restored with restorative materials, leading to a decrease in the tooth's strength and overall integrity.[19]

While some authors classify this cavity design as a technique focused on the dentist's convenience, others dispute this perspective, arguing that completely removing the pulp chamber roof significantly enhances infection management and reduce the likelihood of procedural errors.[20] The established principles for TradAC have largely remained unchanged for many years, primarily due to the technical limitations of endodontic instruments. However, over the past two decades, significant advancements in endodontic technology have enabled the development of minimally invasive approaches, including conservative access cavities (ConsAC). These techniques aim to preserve tooth structure while adhering to the fundamental biological and mechanical principles of root canal treatment.[21]

Silva et al.[22] identified and categorized various abbreviations and terminology found in the literature to describe different access cavity geometries. Based on this classification, the types of access cavities are as follows (Figure 1):

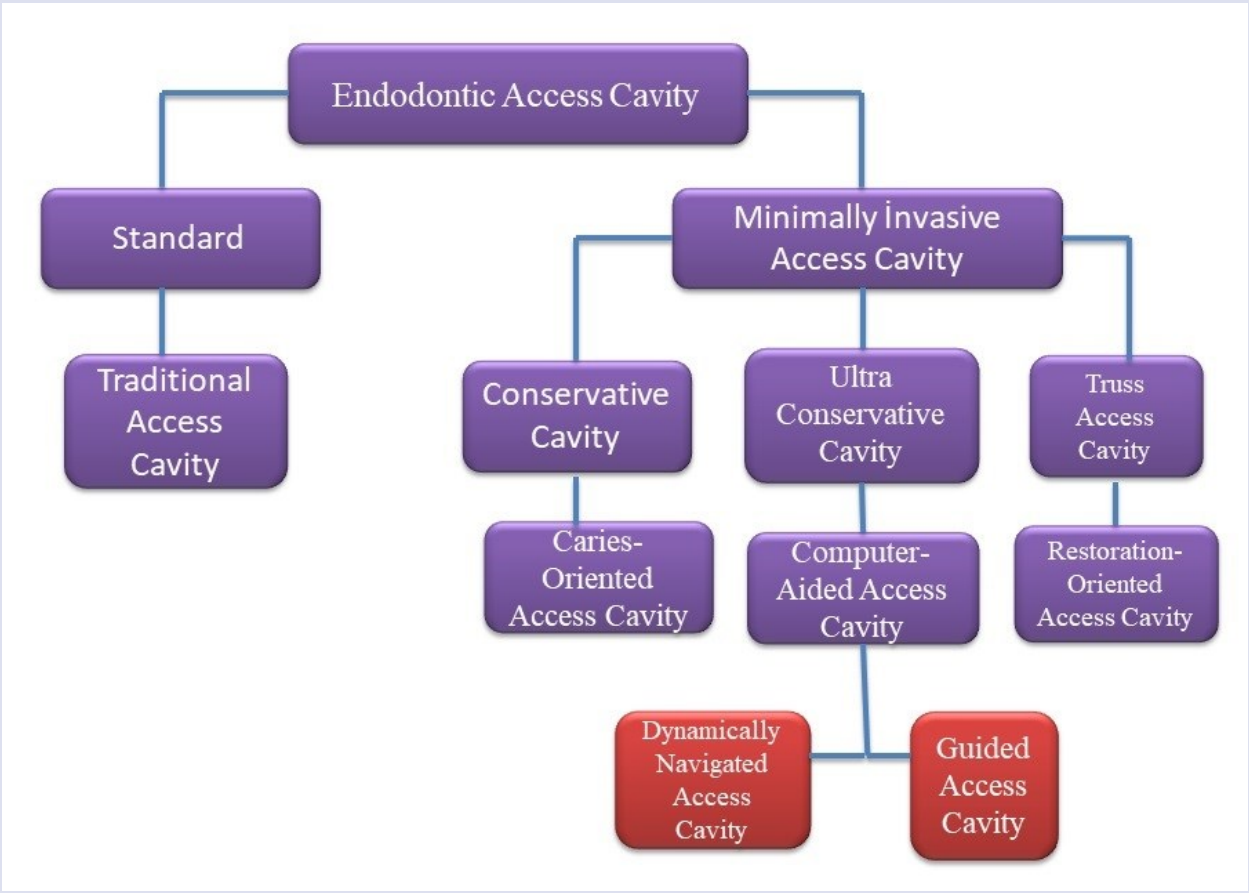

Figure 1. Access cavity types diagram.

- Traditional Access Cavity
- Conservative Access Cavity
- Ultra-Conservative Access Cavity
- Truss Access Cavity
- Caries-Oriented Access Cavity
- Restoration-Oriented Access Cavity
- Computer-Aided Access Cavity
    - *Guided Access Cavity*
    - *Dynamic Navigation-Assisted Access Cavity*

2. Minimally Invasive Access Cavities

Minimally invasive endodontics is an approach aimed at preserving the maximum amount of enamel and dentin to reduce the risk of tooth fractures and, consequently, extend the longevity of the tooth. This method emphasizes the preservation of not only the occlusal tooth structure but also the pericervical dentin. Pericervical dentin refers to the area located 4 mm above and below the crestal bone, playing a crucial role in distributing forces to the roots. This makes it an essential component for ensuring the long-term survival and proper function of the tooth.[23,24]

Nevertheless, creating an access cavity that is too small can pose significant risks during the later stages of root canal treatment. A small cavity can make it difficult to identify the canal openings and complicate essential procedures such as cleaning, shaping, and filling the canals. Furthermore, it may increase the risk of iatrogenic complications, including missed canals, ledging, or instrument fracture.[25] Maintaining the integrity of the pulp chamber roof may hinder the removal of pulp tissue, blood, filling materials, and other debris. This can result in tooth discoloration, promote microbial growth, and adversely affect materials like root canal sealers and composites.[26]

Some authors suggest that modifying conventional endodontic treatment by designing access cavities that preserve critical dentin structures may enhance the tooth's durability, resistance to fractures, and long-term outcomes. This approach has been proposed as a way to reduce the necessity for full crowns on endodontically treated teeth, with the choice of restoration depending on the amount of remaining tooth structure.[27,28]

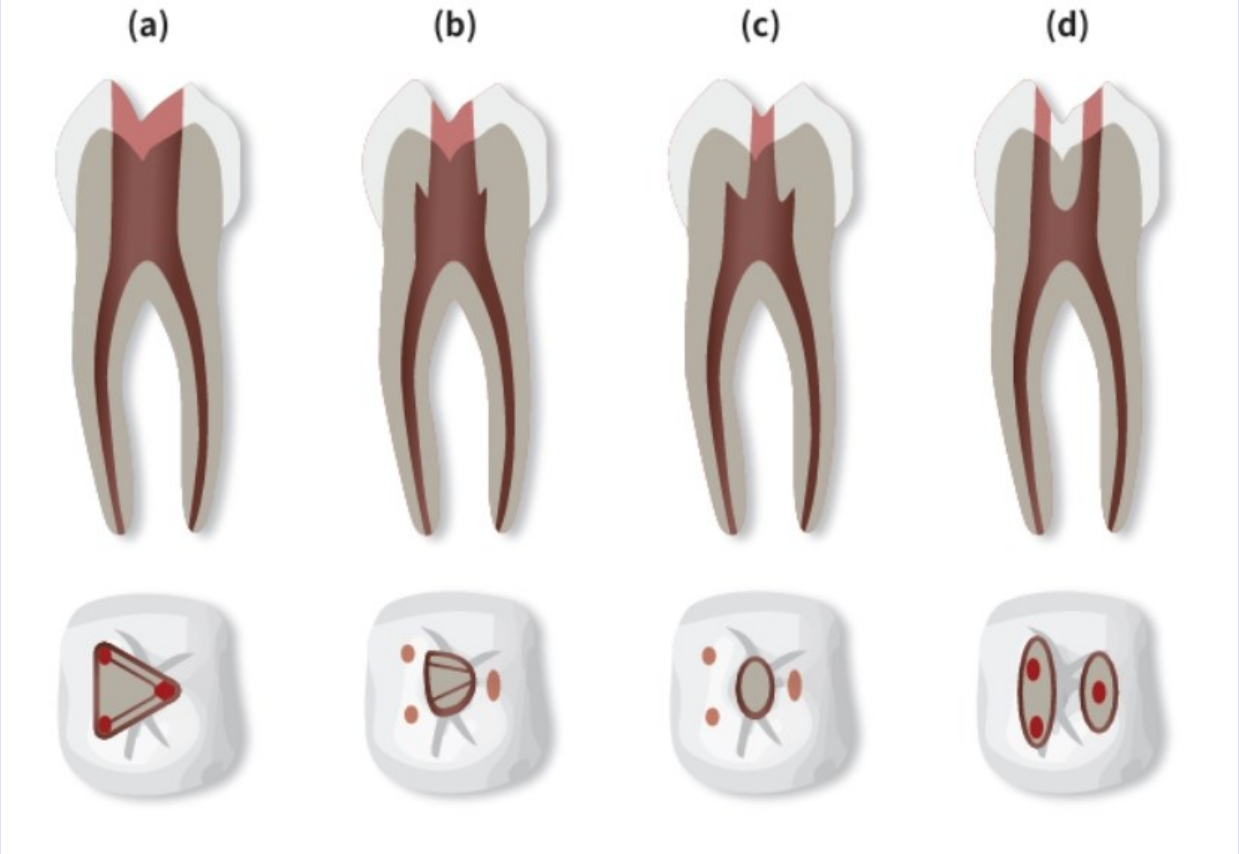

Figure 2. Classification of the access cavity designs in posterior teeth; Traditional access cavity (a). Conservative access cavity (b). Ultraconservative access cavity (c). Truss access cavity (d).

2.1. Conservative Access Cavity

ConsAC are designed to preserve the pulp horns while removing only a partial section of the pulp chamber roof (Figure 2b). Their walls exhibit a slight convergence and are angled toward the occlusal surface. This technique provides a clear view of one root canal from the pulp chamber, while allowing for the assessment of other canal openings from various angles. Unlike conventional methods that require the complete removal of the pulp chamber roof for direct access, conservative cavities utilize cone-beam computed tomography to guide the pathway toward the canal orifices. For molars and premolars, the preparation typically begins at the central fossa on the occlusal surface and extends upward, featuring axial walls that gradually converge.[14]

The cavity margins are adjusted just enough to expose the canal openings. As a result, a greater amount of healthy tooth structure and pericervical dentin is preserved compared to conventional access designs that prioritize straight-line access.[29] Preserving pericervical dentin is crucial for the proper distribution of occlusal stresses from the crown to the root. Studies demonstrate that conservative access cavity designs, which maximize dentin preservation, significantly enhance fracture resistance.[30] The potential drawbacks of conservative cavities include an increased risk of missing canals, reduced instrumentation efficiency, and inadequate removal of pulp tissue and debris, which may outweigh their benefits. Furthermore, the primary objective of endodontic therapy is to eliminate bacteria within the infected pulp tissue. According to some authors, the limited access in conservative cavities may adversely affect instrumentation efficiency, making it a significant concern.[19,23,31] The conservative access cavity provides a strategically extended, vision-focused, and stepwise approach.[29] Therefore, rather than adhering to a fixed template, it is crucial to consider individual variations in tooth anatomy and morphology. Most existing studies have been conducted on intact teeth in laboratory settings. In this context, uncertainties persist regarding carious, extensively restored, and crowned teeth.[26,32,33]

2.2. Ultra-conservative Access Cavity

Often called the ninja access cavity, this design begins at the central fossa or the deepest area of the occlusal surface, aiming to retain most of the pulp chamber roof while minimizing unnecessary extension (Figure 2c). This technique focuses on progressing apically while keeping the access cavity expansion to a minimum.[17,34.]

In anterior teeth with considerable wear, the access cavity can be created from the biting surface, aligned with the tooth's long axis. The objective of this technique is to access the canals while minimally removing the pulp chamber roof and preserving the pulp horns. Additionally, the cavity boundaries are designed to maintain the integrity of the occlusal enamel.[35]

The conservative access cavity (ConsAC) approach optimizes tooth structure conservation, thereby reducing fracture risk while enhancing mechanical stability, functionality, and long-term tooth longevity.[26] While ConsAC preserve tooth structure, they pose technical challenges, including increased difficulty in canal identification, cleaning, shaping, and obturation; a higher risk of missed canals; compromised irrigation efficacy; and prolonged treatment duration, necessitating thorough pre-treatment planning with advanced imaging (e.g., CBCT) and enhanced magnification/illumination to mitigate procedural errors.[21,34,36] Ultraconservative access cavities (UltraAC) aim to maximize the retention of dental tissue but may compromise visibility and working comfort. These techniques focus on maintaining a large portion of the pulp chamber roof and the cervical dentin.

2.3. Truss Access Cavity

The truss access cavity (TrussAC) involves creating distinct access openings on the occlusal surface to expose the canal orifices while preserving the intervening dentin (Figure 2d). In mandibular molars, this technique results in two separate cavities: one for the mesial canals and another for the distal canals. In maxillary molars, a single access cavity is created for the mesiobuccal and distobuccal canal orifices, while the palatal canal is accessed through a separate cavity.

The primary objective of the TrussAC is to enhance fracture resistance by preserving the dentin between the canal orifices. Furthermore, this approach aims to enable less complex, less invasive, and more cost-effective post-endodontic restorations.[37] Preservation of mesial and distal ridges by the TrussAC further contributes to improved fracture resistance and reduces the need for complex and costly post-endodontic restorations.[32,38]

TrussAC present several disadvantages in dental procedures. Firstly, they are not suitable for all teeth, which limits their application and may render them unfeasible in certain cases. Additionally, the use of truss access cavities can result in increased instrumentation time, potentially prolonging the overall treatment process. There is also a higher risk of leaving residual pulp tissue behind, which can compromise the effectiveness of the treatment. Furthermore, if the shaping and cleaning protocols are not meticulously adhered to, the outcomes of endodontic treatment may be suboptimal, potentially leading to complications in the future. These factors must be carefully considered when deciding whether to utilize truss access cavities in dental practice.[38]

According to a study by Neelakantan et al.[26] the inability to effectively remove debris and pulp remnants from truss access cavities adversely affects irrigation and canal shaping procedures. Consequently, additional irrigation activation systems have been recommended for these cavities. Further research is necessary to gain a deeper understanding of how this access cavity design influences the effectiveness of canal debridement and shaping processes.

2.4. Caries-Oriented Access Cavity

Caries-driven access cavities are created to reach the pulp chamber by eliminating decayed tissue while conserving all intact healthy tooth structures.[39] This method also focuses on removing damaged restorations rather than healthy tooth structure. The utilization of carious lesions is recommended to prevent unnecessary loss of healthy tooth tissue.[35]

Nevertheless, this approach cannot be universally adopted as a standard practice, as the resulting alignment and the remaining tooth structure at the pulp floor may not offer sufficient access to the root canals. Additionally, the structure and location of each carious lesion vary, necessitating a case-specific approach. Furthermore, this approach fails to address the importance of pre-endodontic restoration, which is essential for improving the efficiency of irrigation activation in the apical third area.[40]

To reach a viable carious source, cavities are designed to target the most active areas of decay. This typically requires an opening around the weakest point of the tooth. A well-designed caries-oriented access cavity increases the success rates of treatment. However, due to its minimal structure, it places increased stress and strain on instruments, leading to a higher risk of instrument fracture. Additionally, it may result in inadequate debridement, irrigation, and cleaning.[41] The caries-oriented access cavity represents a caries-focused approach in dentistry and is crucial in facilitating effective treatment. When applied correctly, it can yield effective and successful results, improving patient comfort. The ability of dentists to design and implement such cavities effectively can directly impact the success of the treatment process.

2.5. Restoration-Oriented Access Cavity

In non-carious, restored teeth, existing restorations are partially or completely removed to reach the pulp space while conserving the maximum amount of healthy dental tissue.[20,35] This approach helps maintain the maximum amount of remaining tooth structure.

3. Computer-Aided Access Cavity

The computer-aided access cavity is a technique designed to preserve tooth structure while establishing a reliable route to the root canal system. This method utilizes software and three-dimensional imaging technologies. Initially derived from implant dentistry, this method is recognized as a minimally invasive access technique and is classified into two distinct types.[42]

3.1. Guided Access Cavity

The guided access cavity technique utilizes a custom-made stent, designed with the aid of intraoral scanners and cone-beam computed tomography, to precisely direct access to the intended area. This method is minimally invasive, developed for a specific purpose, and independent of the operator.[42] Guided endodontics offers an innovative approach for handling challenging cases where conventional methods may increase the risk of

procedural errors. It serves as an accurate, efficient, and user-friendly clinical application. This approach integrates technological resources and digital planning into endodontic practice, enhancing predictability in clinical cases.[43-45] Guided Access Cavity has a reduction of operative steps through technological advancements. Lower risk of errors due to the elimination of procedural steps.[46]

Guided access cavities have several disadvantages that can impact their effectiveness in dental procedures. One notable drawback is the longer treatment planning time required, which can lead to procedural delays and increased overall treatment duration. Additionally, the method necessitates a straight path to the canal entrance, making it less versatile for certain anatomical variations. Accessing posterior teeth can pose a significant challenge, as their positioning may complicate the application of this technique. There is also a risk of overheating during the procedure, which can adversely affect the surrounding tissues. Furthermore, the feasibility of guided access cavities is limited to the linear segment of the root canal, restricting their use in more complex cases. Lastly, artifacts during cone-beam computed tomography (CBCT) scanning can negatively impact the accurate identification of canals, ultimately complicating the treatment process. These limitations highlight the need for careful consideration when opting for guided access cavities in endodontic treatments.[46]

3.2. Dynamically Navigated Access Cavity

The other computer-aided design method is known as the dynamically navigated access cavity. This approach relies on a freehand technique that guides the drilling procedure instantly using passive optical technology, cone-beam computed tomography imaging, and a software-assisted dynamic navigation interface. Although it requires less preoperative planning compared to the guided access cavity, it involves the use of an expensive device with multiple attachments that must be placed intraorally before the procedure.[47]

The dynamically navigated access cavity technique offers several advantages, particularly in the treatment of calcified canals, where traditional methods might struggle. This promising approach is particularly efficient in identifying canals, allowing for the formation of a more conservative access cavity, which can help preserve healthy tooth structure.[48] However, this technique is not without its drawbacks. One of the most significant disadvantages is the high cost associated with the necessary equipment and technology, which can be a barrier for many dental practices. Additionally, the method requires extensive preoperative preparation, as well as additional cone beam computed tomography (CBCT) scans, which can increase the overall complexity and time required for treatment. As such, while the dynamically navigated access cavity presents distinct advantages, these considerations must be weighed carefully in the context of overall dental practice management.[49]

Studies have concluded that the use of a dynamically navigated access cavity can improve the advantages of a minimally invasive technique by enabling exact control over the drill's angle while reaching the pulp chamber and canal openings, all while preserving tooth structure by avoiding excessive removal.[20]

4. Modern Approaches and Technological Advances

Technological advancements may facilitate the clinical adoption of the concept of minimal endodontic access cavities that preserve the pericervical region. The development of cone-beam computed tomography, magnification, and microscopes has enabled endodontists to plan access cavities more effectively and identify canal entries with greater accuracy. This aligns with the concept of preserving tooth structure in minimally invasive endodontics, allowing for a less destructive access approach. Furthermore, advancements in endodontic ultrasonics have enhanced the effective activation of irrigants in the root canal, allowing for a more conservative treatment approach.[50]

4.1. Ultrasonic Instruments in Minimally Invasive Cavity Preparation

Ultrasonic instruments play a crucial role in minimally invasive cavity preparation by effectively removing obstructions such as pulp stones and calcifications without causing damage to canal walls or the cavity floor.[51] Additionally, they offer a more precise and controlled approach than conventional burs and hand instruments in locating canal entrances and identifying extra canals.[52]

In conservative cavities, maintaining the pulp chamber roof limits the space available for irrigant flow. Therefore, activating irrigation solutions is recommended, particularly in minimally invasive access cavities, to increase the contact area.[53] A study found that minimal cavity designs activated with ultrasonic and laser techniques led to reduced smear layer and debris levels when compared to the non-activated group.[54]

Laser activation enhances the penetration of irrigants into dentinal tubules and apical areas, making smear layer removal more effective. Laser energy creates vapor bubbles within the irrigation fluid, causing them to expand and subsequently implode. The implosion of these bubbles generates shear forces and shock waves, which aid in the removal of the smear layer from dentin walls and improve the action of the irrigant.[55]

When considering burs used for access cavity preparation, those with small-diameter tips and long shanks are preferred in minimal cavities to improve visibility and preserve tooth structure. Studies investigating minimal cavity designs frequently use diamond burs, such as the round diamond FG 1012, due to their precision.[29]

Clinical Outcomes and Research

Several studies have examined the effect of access cavity design on fracture strength, chemomechanical preparation, canal transportation, treatment duration,

and instrument fractures. A meta-analysis found that when all marginal ridges were preserved, meaning a Class I cavity design, teeth with CAC and TrussAC had significantly higher fracture resistance than those with TAC. However, when one or both marginal ridges were lost (Class II cavity design), cavity shape had no significant effect on fracture resistance.[56]

In 2017, Plotino et al.[17] demonstrated that the average load at fracture was significantly higher for teeth with conservative access cavities compared to those with conventional access cavities, concluding that conservative cavities provide relatively greater fracture resistance. Minimal invasive dentistry focuses on preventing unnecessary loss of dental tissue by maximizing preservation of the coronal tooth structure. In this context, the CAC approach has been proposed as an alternative to the TAC preparation, with the goal of maintaining the structural integrity of the tooth as much as possible. It is believed that CAC designs enhance the long-term durability of root-filled teeth by increasing their fracture resistance. This suggests that shaping the access cavity using minimally invasive methods may not always yield a positive impact on mechanical resistance.[57,58] Therefore, when designing the access cavity, it is essential to consider not only the preservation of coronal tissues but also the overall durability of the tooth. Research indicates that an increase in the dimensions of the EAC correlates with a reduction in stress within the cervical region, while simultaneously enhancing stress transmission to the more apical regions. In more straightforward terms, a smaller access cavity results in a higher concentration of stress in the cervical area. Conversely, as the access cavity expands, the stress in the cervical region decreases, leading to a greater transfer of stress to the apical region.[59]

Conversely, meta-analyses have demonstrated that root canal treatments and retreatment procedures conducted using CAC require significantly more time than those executed with TAC.[60-63] In comparison to TAC, the UltraAC approach demands an extended duration to finalize root canal treatment. Although the time allocated for canal access and preparation was comparable, UltraAC required substantially more time for the processes of root canal filling and the cleaning of the pulp chamber.[34]

Gambill et al.[64] define root canal transportation as the deviation of the prepared canal from its original axis, measured in millimeters, following instrumentation in comparison to pre-treatment measurements. Additionally, centering ability refers to the capacity of the instrument to maintain its position centrally within the canal. Rover et al.[65] demonstrated that the palatal canal exhibited reduced transportation and greater centralization in the use of TAC compared to CAC, likely due to the straight-line access afforded by the TAC. Krishan et al.[10] reported a detrimental effect of CAC on the preparation of distal canals in lower molars. Additionally, Eaton et al.[66] confirmed that the original canal anatomy in lower molars was altered when prepared using CAC as opposed to TAC. Conversely, Moore et al.[1] found no significant differences in canal transportation and centering ability between TAC and CAC in upper molars.

Neelakantan et al.[26] found that, following chemomechanical preparation with rotary instruments and conventional syringe irrigation, mandibular molars with truss access cavities retained more residual pulp tissue in the pulp chamber compared to those with conventional access cavities. According to their findings, the presence of the remaining pulp chamber roof obstructed the mechanical movement of instruments and disrupted the flow of irrigation solutions. On the other hand, Tüfenkçi and Yılmaz observed no difference in bacterial reduction in mandibular molars between conventional and conservative access cavities when irrigation solutions were activated for one minute with XP-endo Finisher instruments.[67] Although this result supports the use of irrigation activation to improve root canal cleaning and sterilization in minimally invasive cavities, it is also recognized that factors like the restricted reach of irrigation needles, the vapor lock effect, and the difficulties with sonic/ultrasonic/apical negative pressure irrigation can introduce further challenges when irrigating minimally opened cavities and widened canals.[21] Therefore, since disinfection plays a key role in determining the success of root canal therapy, additional studies are necessary in this critical area.[68]

Conservative access methods allow the pulp chamber to be opened only partially, which helps to keep the pericervical dentin layer thicker. This approach is based on the assumption that the long-term durability of an endodontically treated tooth is directly related to the amount of remaining tooth structure. In other words, the more tooth structure is preserved, the higher its resistance to fracture will be. This access preparation method, especially in anterior teeth, moves the preparation to a more incisal position, creating a direct line from the incisal edge to the pulp. However, this application requires that the pulp horns remain untouched, unlike traditional access preparation. This new approach contradicts established guidelines that suggest the complete removal of all pulp cornua for the thorough elimination of pulp remnants and the easy placement of bleaching agents when necessary.[69] In the study conducted by Marchesan et al.,[70] it was determined that teeth with CAC access did not completely return to their initial (prestaining) color after the bleaching process. In contrast, teeth with TAC access were considered to have reached their original color after the second bleaching session. Bleaching procedures performed with both access cavity designs yielded statistically similar results. However, the TEC access design is considered the preferred method because it provides a clinically acceptable threshold value in terms of color change.

The potential for file fractures associated with various access cavity designs is another crucial factor, as it can fail endodontic treatments.[71] More conservative access cavities have been found to alter the angle of endodontic instruments, thereby increasing the likelihood of instrument fractures.[72] A study by Barbosa et al.[73] found

that, although the exact canals were not specified, mandibular molars with conservative access cavities exhibited a higher rate of file fractures compared to those with conventional access cavities.

Potential Issues and Complications

A successful cavity preparation should ensure the safe removal of all structures that hinder access to the root canal system, such as the pulp chamber roof, dystrophic calcifications, dentin formations, and restorations.[74,75] Missed canals, perforation, and the irreversible destruction of the tooth to an unrepairable extent are among the complications of access cavity preparation. The most frequent mistake in these cases is perforation. Factors such as improper bur usage, calcification within the pulp chamber and at canal entrances, misidentification of canals, sharp crown-root angles, and over-removal of coronal dentin can contribute to iatrogenic errors in the coronal or furcation areas.[76,77] Following a few essential steps during access cavity preparation can help prevent these complications: [78]

- The pulp chamber floor always has a darker tone compared to the surrounding dentin walls. This color difference creates a distinct boundary between the walls and the floor of the pulp chamber.
- Root canal orifices are always located at the junctions of the pulp chamber walls and floor.
- Root canal orifices are positioned in the angular regions where the pulp chamber floor meets the walls.

On the other hand, the hard tissue loss resulting from endodontic cavity preparation causes fundamental changes in the biomechanics of the tooth. Several studies suggest that the hard tissue loss caused by a conservative access cavity preparation only affects tooth resistance by approximately 5%.[79,80] However, with the addition of canal preparation, fracture resistance further decreases. Particularly, wide access cavities accompanied by marginal ridge loss contribute to the most significant reduction in tooth durability. For teeth that have suffered substantial coronal tooth structure loss, treatment options include posts, crown restorations, endocrown restorations, and indirect adhesive restorations.

Conclusions

Endodontic access cavity design is a critical stage that directly influences the success of root canal treatment. While traditional approaches enhance the efficacy of cleaning and shaping by providing wide access, they also increase the risk of fracture due to dentin loss. In contrast, minimally invasive techniques (such as conservative, ultra-conservative, and truss access) aim to preserve tooth structure and improve biomechanical resistance, although they may have limitations in canal identification and disinfection efficiency. Technological advancements (CBCT, dynamic navigation, ultrasonic activation) play a crucial role in addressing this dilemma. In particular, guided systems and laser-assisted irrigation have enhanced cleaning efficiency in minimally invasive cavities, making them competitive with conventional methods. However, high costs and the need for specialized training limit their widespread adoption. In clinical decision-making, several factors should be considered: tooth anatomy, caries and restoration status, complexity of canal morphology, and the patient's long-term restorative needs. In conclusion, the ideal access cavity should adopt a patient-specific approach that balances "maximum tissue preservation" with "optimal disinfection." In the future, the integration of digital planning and biomaterials may further enhance the prognosis of endodontic treatments. Ongoing research in this field will provide clinicians with evidence-based guidance.

References

1. Moore B, Verdelis K, Kishen A, Dao T, Friedman S. Impacts of Contracted Endodontic Cavities on Instrumentation Efficacy and Biomechanical Responses in Maxillary Molars. J Endod 2016;42:1779-1783.
2. Patel S, Rhodes J. A practical guide to endodontic access cavity preparation in molar teeth. Br Dent J 2007;203:133-140.
3. Watson A. Pulp space anatomy and access cavities. In: B. S. Chong (eds). Harty's Endodontics in Clinical Practice. Elsevier 2010:35.
4. Mannan G, Smallwood E, Gulabivala K. Effect of access cavity location and design on degree and distribution of instrumented root canal surface in maxillary anterior teeth. Int Endod J 2001;34:176-183.
5. Shabbir J, Zehra T, Najmi N, Hasan A, Naz M, Piasecki L, Azim A. Access Cavity Preparations: Classification and Literature Review of Traditional and Minimally Invasive Endodontic Access Cavity Designs. J Endod 2021;47:1229-1244.
6. Lin CY, Lin D, He WH. Impacts of 3 Different Endodontic Access Cavity Designs on Dentin Removal and Point of Entry in 3-dimensional Digital Models. J Endod 2020;46(4):524-530.
7. Schroeder KP, Walton RE, Rivera EM. Straight line access and coronal flaring: effect on canal length. J Endod 2002;28:474-476.
8. Wang D, Wang W, Li YJ, Wang YR, Hong T, Bai SZ, Tian Y. The effects of endodontic access cavity design on dentine removal and effectiveness of canal instrumentation in maxillary molars. Int Endod J 2021;54:2290-2299.
9. Clark D, Khademi JA. Case studies in modern molar endodontic access and directed dentin conservation. Dent Clin North Am 2010;54:275-289.
10. Krishan R, Paque F, Ossareh A, Kishen A, Dao T, Friedman S. Impacts of conservative endodontic cavity on root canal instrumentation efficacy and resistance to fracture assessed in incisors, premolars, and molars. J Endod 2014;40:1160-1166.
11. Alovisi M, Pasqualini D, Musso E, Bobbio E, Giuliano C, Mancino D, Scotti N, Berutti E. Influence of Contracted Endodontic Access on Root Canal Geometry: An In Vitro Study. J Endod 2018;44:614-620.
12. Elnaghy AM, Elsaka SE. Evaluation of root canal transportation, centering ratio, and remaining dentin thickness associated with ProTaper Next instruments with and without glide path. J Endod 2014;40:2053-2056.
13. Vieira GCS, Perez AR, Alves FRF, Provenzano JC, Mdala I, Siqueira JF, Jr., Roças IN., Impact of Contracted Endodontic Cavities on Root Canal Disinfection and Shaping. J Endod 2020;46:655-661.

14. Shabbir J, Zehra T, Najmi N, Hasan A, Naz M, Piasecki L, Azim A. Access cavity preparations: classification and literature review of traditional and minimally invasive endodontic access cavity designs. J Endod 2021;47:1229-1244.
15. Hülsmann M, Schäfer E. Preparation of the coronal and radicular spaces. In: Ingle JI, Chong BS, Baumgartner LG (eds). Ingle's Endodontics. Quintessence 2019:557-633.
16. Xu T, Tay FR, Gutmann JL, Fan B, Fan W, Huang Z, Sun Q. Micro–computed tomography assessment of apical accessory canal morphologies. J Endod 2016;42:798-802.
17. Plotino G, Grande NM, Isufi A, Ioppolo P, Pedullà E, Bedini R, Gambarini G., Testarelli L. Fracture strength of endodontically treated teeth with different access cavity designs. J Endod 2017;43:995-1000.
18. Krishan R, Paqué F, Ossareh A, Kishen A, Dao T, Friedman S. Impacts of conservative endodontic cavity on root canal instrumentation efficacy and resistance to fracture assessed in incisors, premolars, and molars. J Endod 2014;40:1160-1166.
19. Moore B, Verdelis K, Kishen A, Dao T, Friedman S. Impacts of contracted endodontic cavities on instrumentation efficacy and biomechanical responses in maxillary molars. J Endod 2016;42:1779-1783.
20. Silva EJNL, De-Deus G, Souza EM, Belladonna FG, Cavalcante DM, Simões-Carvalho M, Versiani M.A. Present status and future directions–Minimal endodontic access cavities. Int Endod J 2022;55:531-587.
21. Bóveda C, Kishen A. Contracted endodontic cavities: the foundation for less invasive alternatives in the management of apical periodontitis. Endod Top 2015;33:169-186.
22. Silva E, Pinto KP, Ferreira CM, Belladonna FG, De-Deus G, Dummer PMH, Versiani M.A. Current status on minimal access cavity preparations: a critical analysis and a proposal for a universal nomenclature. Int Endod J 2020;53:1618-1635.
23. Gideon PAG, van Z, William PB, Christian W, Volker S. Introduction: Crack Distribution and Durability of SHCC. In: Van Zijl G, Slowik V. A Framework for Durability Design with Strain-Hardening Cement-Based Composites (SHCC). State-of-the-Art RILEM Rep. Springer. 2017;22:1-26.
24. Chlup Z, Žižka R, Kania J, Přibyl M. Fracture behaviour of teeth with conventional and mini-invasive access cavity designs. J Eur Ceram Soc 2017;37:4423-4429.
25. Lang T, Steiner I, Ditz A, Weich KW, Nguyen DQ-V, Gaengler P. Review of Endodontic Instrumentation via Different Access Cavities–from Randomized In-Vitro Studies to Clinical Applications. 2024.
26. Neelakantan P, Khan K, Ng GPH, Yip CY, Zhang C, Cheung GSP. Does the orifice-directed dentin conservation access design debride pulp chamber and mesial root canal systems of mandibular molars similar to a traditional access design? J Endod 2018;44:274-279.
27. Jiang Q, Huang Y, Tu X, Li Z, He Y, Yang X. Biomechanical properties of first maxillary molars with different endodontic cavities: a finite element analysis. J Endod 2018;44:1283-1288.
28. Auswin MK, Ramesh S. Truss access new conservative approach on access opening of a lower molar: a case report. J Adv Pharm Ed Res 2017;7:345-348.
29. Clark D, Khademi J. Modern molar endodontic access and directed dentin conservation. Dent Clin North Am 2010;54:249-273.
30. Asundi A, Kishen A. Stress distribution in the dento-alveolar system using digital photoelasticity. Proc Inst Mech Eng H 2000;214:659-667.
31. Sabeti M, Kazem M, Dianat O, Bahrololumi N, Beglou A, Rahimipour K, Dehnavi F. Impact of access cavity design and root canal taper on fracture resistance of endodontically treated teeth: an ex vivo investigation. J Endod 2018;44:1402-1406.
32. Corsentino G, Pedullà E, Castelli L, Liguori M, Spicciarelli V, Martignoni M, Ferrari M, Gradini S. Influence of access cavity preparation and remaining tooth substance on fracture strength of endodontically treated teeth. J Endod 2018;44:1416-1421.
33. Eaton JA, Clement DJ, Lloyd A, Marchesan MA. Micro–computed tomographic evaluation of the influence of root canal system landmarks on access outline forms and canal curvatures in mandibular molars. J Endod 2015;41:1888-1891.
34. Silva A, Belladonna F, Rover G, Lopes R, Moreira E, De-Deus G, Silva E. Does ultraconservative access affect the efficacy of root canal treatment and the fracture resistance of two-rooted maxillary premolars? Int Endod J 2020;53:265-275.
35. Silva E, Pinto K, Ferreira C, Belladonna F, De-Deus G, Dummer P, Versiani M. Current status on minimal access cavity preparations: a critical analysis and a proposal for a universal nomenclature. Int Endod J 2020;53:1618-1635.
36. Al-Helou N, Zaki AA, Al Agha M, Moawad E, Jarad F. Which endodontic access cavity is best? A literature review. Br Dent J 2023;234:335-339.
37. Mookhtiar H, Hegde V, Srilatha S, Chopra M. Conservative endodontics: A truss access case series. Int J Appl Dent Sci 2019;5:213-218.
38. Zhang Y, Liu Y, She Y, Liang Y, Xu F, Fang C. The effect of endodontic access cavities on fracture resistance of first maxillary molar using the extended finite element method. J Endod 2019;45:316-321.
39. Clark D, Khademi J, Herbranson E. The new science of strong endo teeth. Dent Today 2013;32:112-117.
40. Kharouf N, Pedullà E, La Rosa GRM, Bukiet F, Sauro S, Haikel Y, Mancino D. In vitro evaluation of different irrigation protocols on intracanal smear layer removal in teeth with or without pre-endodontic proximal wall restoration. J Clin Med 2020;9:3325.
41. Lup VM, Malvicini G, Gaeta C, Grandini S, Ciavoi G. Glide path in endodontics: a literature review of current knowledge. Dent J (Basel) 2024;12:257.
42. Dianat O, Nosrat A, Tordik PA, Aldahmash SA, Romberg E, Price JB, Mostoufi B. Accuracy and efficiency of a dynamic navigation system for locating calcified canals. J Endod 2020;46:1719-1725.
43. 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;46:1745-1751.
44. Kostunov J, Rammelsberg P, Klotz A-L, Zenthöfer A, Schwindling FS. Minimization of tooth substance removal in normally calcified teeth using guided endodontics: an in vitro pilot study. J Endod 2021;47:286-290.
45. Torres A, Lerut K, Lambrechts P, Jacobs R. Guided endodontics: use of a sleeveless guide system on an upper premolar with pulp canal obliteration and apical periodontitis. J Endod 2021;47:133-139.
46. Decurcio DA, Bueno MR, Silva JA, Loureiro MAZ, Sousa-Neto MD, Estrela C. Digital planning on guided endodontics technology. Braz Dent J 2021;32:23-33.
47. Sônia TdO, Camila de Freitas MB, Santa-Rosa CC, Machado VC. Guided endodontic access in maxillary molars using cone-beam computed tomography and computer-aided

design/computer-aided manufacturing system: a case report. J Endod 2018;44(5):875-879.
48. Aishwarya V, Sneha SS, Rene JS, Durga TS, Velmurugan N. Dynamic Navigation in Guided Endodontics – A Systematic Review. Eur Endod J 2022;7:81–91.
49. Moreno-Rabié C, Torres A, Lambrechts P, Jacobs R. Clinical applications, accuracy and limitations of guided endodontics: a systematic review. Int Endod J 2020;53:214-231.
50. Bürklein S, Schäfer E. Minimally invasive endodontics. Quintessence Int 2015;46:119-124.
51. Plotino, G., Turchi, M. Strategies for the Restoration of Minimally Invasive Endodontically Treated Teeth. In: Plotino, G. (eds) Minimally Invasive Approaches in Endodontic Practice. Springer, Cham. 2021:171–201.
52. Chan MYC, Cheung V, Lee AHC, Zhang C. A literature review of minimally invasive endodontic access cavities-past, present and future. Eur Endod J 2022;7:1-10.
53. Mancini M, Cerroni L, Iorio L, Dall'Asta L, Cianconi L. FESEM evaluation of smear layer removal using different irrigant activation methods (EndoActivator, EndoVac, PUI and LAI). An in vitro study. Clin Oral Investig 2018;22:993-999.
54. Gündüz H, Özlek E. The effects of laser and ultrasonic irrigation activation methods on smear and debris removal in traditional and conservative endodontic access cavities. Lasers Med Sci 2023;38:148.
55. Thapak G, Arya A, Grewal MS, Arora A. A comparative evaluation of smear layer removal using erbium: YAG laser-activated irrigation, sonic irrigation, and manual dynamic irrigation: a scanning electron microscope study. Journal of Lasers Med Sci 2021;12:e22.
56. Ballester B, Giraud T, Ahmed HMA, Nabhan MS, Bukiet F, Guivarc'h M. Current strategies for conservative endodontic access cavity preparation techniques—systematic review, meta-analysis, and decision-making protocol. Clin Oral Investig 2021;25:6027-6044.
57. Silva AA, Belladonna FG, Rover G, Lopes RT, Moreira EJL, De-Deus G, Silva E. Does ultraconservative access affect the efficacy of root canal treatment and the fracture resistance of two-rooted maxillary premolars? Int Endod J 2020;53:265-275.
58. Ozyurek T, Ulker O, Demiryurek EO, Yilmaz F. The Effects of Endodontic Access Cavity Preparation Design on the Fracture Strength of Endodontically Treated Teeth: Traditional Versus Conservative Preparation. J Endod. 2018;44:800-805.
59. Saber SM, Hayaty DM, Nawar NN, Kim HC. The Effect of Access Cavity Designs and Sizes of Root Canal Preparations on the Biomechanical Behavior of an Endodontically Treated Mandibular First Molar: A Finite Element Analysis. J Endod 2020;46:1675-1681.
60. Alovisi M, Pasqualini D, Musso E, Bobbio E, Giuliano C, Mancino D, Scotti N, Berutti E. Influence of contracted endodontic access on root canal geometry: an in vitro study. J Endod 2018;44:614-620.
61. Marchesan MA, Lloyd A, Clement DJ, McFarland JD, Friedman S. Impacts of contracted endodontic cavities on primary root canal curvature parameters in mandibular molars. J Endod 2018;44:1558-1562.
62. Fatima K, Nair R, Khasnis S, Vallabhaneni S, Patil JD. Efficacy of rotary and reciprocating single-file systems on different access outlines for gutta-percha removal in retreatment: An: in vitro: study. J Conserv Dent 2018;21:354-358.
63. Niemi TK, Marchesan MA, Lloyd A, Seltzer RJ. Effect of instrument design and access outlines on the removal of root canal obturation materials in oval-shaped canals. J Endod 2016;42:1550-1554.
64. Gambill JM, Alder M, del Rio CE. Comparison of nickel-titanium and stainless steel hand-file instrumentation using computed tomography. J Endod 1996;22:369-375.
65. Rover G, Belladonna FG, Bortoluzzi EA, De-Deus G, Silva E, Teixeira CS. Influence of Access Cavity Design on Root Canal Detection, Instrumentation Efficacy, and Fracture Resistance Assessed in Maxillary Molars. J Endod 2017;43:1657-1662.
66. Eaton JA, Clement DJ, Lloyd A, Marchesan MA. Micro-Computed Tomographic Evaluation of the Influence of Root Canal System Landmarks on Access Outline Forms and Canal Curvatures in Mandibular Molars. J Endod 2015;41:1888-1891.
67. Tüfenkçi P, Yılmaz K. The effects of different endodontic access cavity design and using XP-endo Finisher on the reduction of Enterococcus faecalis in the root canal system. J Endod 2020;46:419-424.
68. Restrepo-Restrepo F, Cañas-Jiménez S, Romero-Albarracín R, Villa-Machado P, Pérez-Cano M, Tobón-Arroyave S. Prognosis of root canal treatment in teeth with preoperative apical periodontitis: a study with cone-beam computed tomography and digital periapical radiography. Int Endod J 2019;52:1533-1546.
69. Plotino G, Buono L, Grande NM, Pameijer CH, Somma F. Nonvital tooth bleaching: a review of the literature and clinical procedures. J Endod 2008;34:394-407.
70. Marchesan MA, James CM, Lloyd A, Morrow BR, Garcia-Godoy F. Effect of access design on intracoronal bleaching of endodontically treated teeth: An ex vivo study. J Esthet Restor Dent 2018;30:E61-E7.
71. Nair P. On the causes of persistent apical periodontitis: a review. Int Endod J. 2006;39:249-281.
72. Kosti E, Zinelis S, Molyvdas I, Lambrianidis T. Effect of root canal curvature on the failure incidence of ProFile rotary Ni–Ti endodontic instruments. Int Endod J 2011;44:917-925.
73. Barbosa A, Silva E, Coelho B, Ferreira C, Lima C, Sassone L. The influence of endodontic access cavity design on the efficacy of canal instrumentation, microbial reduction, root canal filling and fracture resistance in mandibular molars. Int Endod J. 2020;53:1666-1679.
74. Berutti E. Preparation techniques for endodontic therapy. In: Castellucci A. Endodontics. Edra Publishing 2022;1:393-394.
75. Burns R. Access openings and tooth morphology. In: Cohen S, Hargreaves KM. Pathways of the Pulp 12th ed. Elsevier 2023;145-160.
76. Kvinnsland I, Oswald R, Halse A, Grønningsaeter A. A clinical and roentgenological study of 55 cases of root perforation. Int Endod J 1989;22:75-84.
77. Kwon Y, Lee SJ. Iatrogenic perforations in endodontics. In: Hargreaves KM, Berman LH (eds). Cohen's Pathways of the Pulp 2017:312-315.
78. Krasner P, Rankow HJ. Anatomy of the pulp-chamber floor. J Endod. 2004;30:5-16.
79. Lang H, Korkmaz Y, Schneider K, Raab W-M. Impact of endodontic treatments on the rigidity of the root. J Dent Res 2006;85:364-368.
80. Reeh ES, Messer HH, Douglass WH. Reduction in tooth stiffness as a result of endodontic and restorative procedures. J Endod 1989;15: 512–516.