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REVIEW / DERLEME

Minimally Invasive Access Cavities

Minimal İnvaziv Giriş Kaviteleri

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ABSTRACT

Preparing an appropriate access cavity is critical to successful root canal treatment, allowing adequate visibility and access to the canals. Traditional endodontic access cavities often require significant removal of dental tissue, which raises concerns about tooth fracture resistance. In response, a minimally invasive approach has been introduced that emphasizes the preservation of dental tissue. The choice between minimally invasive and traditional access cavities requires careful consideration. The impact of these cavities on teeth remains controversial. Tools such as CBCT, a microscope, and ultrasonic tips are required to treat these access cavities effectively. Further and long-term studies are necessary to draw definitive conclusions regarding the advantages and disadvantages of minimally invasive access cavities, the risk of complications and malpractice, whether they provide adequate root canal cleaning, the tooth's fracture resistance, and overall treatment success. In this review, the specified factors have been evaluated based on findings from various studies, and a general perspective has been presented.

Keywords: Conservative access cavity, traditional access cavity, endodontics, access cavity, root canal morphology.

ÖZ

Kanallara yeterli erişim ve görünürlüğü sağlayan uygun bir giriş kavitesi açmak, başarılı bir kök kanal tedavisi uygulamak için önemlidir. Geleneksel endodontik giriş kavitelerinin önemli miktarda dental doku kaybına neden olması, dişin kırılma direnciyle ilgili endişeler doğurmuştur. Buna karşılık, diş dokusunun korunmasını öneren minimal invaziv yaklaşım ortaya çıkmıştır. Minimal invaziv giriş kaviteleri ve geleneksel giriş kaviteleri arasındaki seçim dikkatli bir değerlendirme gerektirir. Çünkü bu kavitelerin diş üzerindeki etkisi tartışmalıdır. Bu kavitelerin efektif bir şekilde tedavide kullanılabilmesi için CBCT, mikroskop ve ultrasonik uçlar gibi aletlerin kullanılması gerekir. Minimal invaziv giriş kavitelerinin avantaj ve dezavantajlarına, komplikasyon ve malpraktis oluşma riskine, yeterli bir kök kanal temizliği sağlayıp sağlamadığına, dişin kırılma direncine ve genel olarak tedavi başarısına dair kesin sonuçlara ulaşmak için daha fazla ve uzun dönem çalışmaların yapılması gereklidir. Bu derlemede, belirtilen faktörler farklı çalışmalardaki bulgulara göre değerlendirilmiş ve genel bir bakış açısı sunulmuştur.

Anahtar Kelimeler: Konservatif giriş kavitesi, geleneksel giriş kavitesi, endodonti, giriş kavitesi, kök kanal morfolojisi.

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INTRODUCTION

A successful root canal treatment is essential for the patients to maintain the health and function of their tooth for many years. Preparing a suitable access cavity is one of the most essential steps in achieving a successful root canal treatment (Ballester et al., 2021). Traditional endodontic access cavities require the removal of caries and restorations within the tooth. The configuration of the access cavity depends on the tooth type and pulp morphology. The entire pulp chamber roof must be removed to access the canals, along with any cervical dentin projections. Adequate access is fundamental to the progress of treatment, as it is crucial to ensure that all canal orifices are visible from the cavity to avoid treatment failure. Meeting these requirements is necessary under the traditional approach. However, this method results in significant tooth tissue loss, leading to reduced fracture resistance (Tang et al., 2010).

An approach that aims to preserve dental tissue as much as possible is gaining traction in dentistry. Endodontics has adopted the minimally invasive trend, which is becoming popular across dentistry, with a system that advocates for creating smaller access cavities. This method emphasizes preserving dentin around the tooth's cervical region and the pulp chamber's roof while minimizing dental tissue loss. Preserving dental tissue is advised to reduce the likelihood of tooth fractures. The minimally invasive endodontic approach prioritizes the preservation of as much pericervical dentin as possible due to its benefits for tooth resistance. This area includes 4 millimeters below and 4 millimeters above the bone (Plotino, 2021).

The purpose of this review is to explore the classifications of minimally invasive access cavities in the literature, define the commonly accepted cavity types, introduce the necessary armamentarium, and evaluate the impact of minimally invasive access cavities on key aspects of endodontic treatment in comparison to traditional access cavities.

1. Minimally Invasive Access Cavities

In dentistry, minimally invasive access cavities represent a conservative approach to tooth preparation, particularly in restorative dentistry and endodontics. The objective is to minimize the removal of healthy tooth structures while providing access to the affected area. Traditionally, dental procedures involve larger access cavities to ensure adequate visibility and access to the dental pulp or affected region (Ballester et al., 2021). However, the concept of minimally invasive access cavities promotes a more conservative method, focusing on preserving as much healthy tooth structure as possible. These cavities are typically smaller and strategically positioned to maintain the tooth's integrity and strength (Chan et al., 2022).

Minimally invasive access cavity preparations have become a significant concept in endodontics, primarily preserving pericervical dentin while achieving the necessary treatment outcomes. Pericervical dentin is crucial in distributing stress across the tooth, contributing to long-term stability and fracture resistance (Plotino, 2021). The underlying assumption is that preserving this dentin can enhance the tooth's fracture resistance (Silva et al., 2018).There are some concerns regarding the impact of traditional access preparations on tooth survivability and long-term strength. In contrast, minimally invasive access preparations prioritize the preservation of natural tooth structure. The idea is to minimize the loss of healthy tissue because unnecessary removal can weaken the tooth and endanger its prognosis.

However, it is crucial to take a critical approach when considering the concept of minimally invasive endodontics. While preserving tooth structure is advantageous, evaluating the potential drawbacks and limitations is essential. Each case should be assessed individually, considering factors such as the extent of the pathology, the overall health of the tooth, and the accessibility of the root canal anatomy. Selecting the most appropriate treatment requires careful consideration of these factors.

1.1. Terminology and Classification

In this field, standardized terminology has yet to be fully established. Different articles and textbooks have proposed various names and classifications, also the anatomical borders of these cavities are not clearly defined (Silva et al., 2018). However, for clarity, it is essential to standardize the terminology. In this review, access cavities are examined under seven headings.

1.1.1. Traditional Access Cavity

In posterior teeth, the entire pulp chamber roof is removed, and a straight-line access is created to reach the canal orifices (Fig. 1). In anterior teeth, the pulp chamber ceiling, pulp horns, and lingual shoulder of dentin are removed to achieve straight-line access to the canal openings. Removing the lingual shoulder is crucial for establishing this straight-line access .

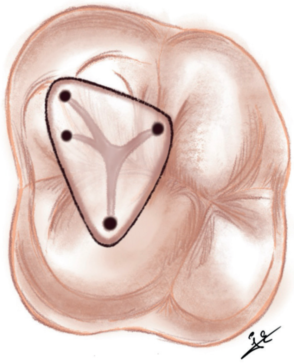

Figure 1: Illustration of traditional access cavity on maxillary first molar.

1.1.2 Conservative Access Cavity

This approach emphasizes preserving the remaining healthy tooth structures compared to traditional endodontic cavities. In posterior teeth, the access cavity starts at the central fossa of the occlusal surface and extends only as far as is necessary to locate the canal orifices (Ballester et al., 2021). Achieving complete straight-line access is not essential. The cavity walls are prepared to converge towards the occlusal surface, allowing visibility of the pulp chamber and canal orifices while preserving part of the roof (Fig. 2). Alternatively, the walls can be prepared with a divergent design (Shabbir et al., 2021). Clinicians can visualize the chamber area and floor by tilting the mirror. In anterior teeth, a small triangular or oval-shaped access cavity is created, enhancing the possibility of preserving the pulp horns and pericervical dentin, which refers to the tooth structure located 4 mm above and 4 mm below the alveolar bone crest (Chan et al., 2022; Ingle et al., 2019).

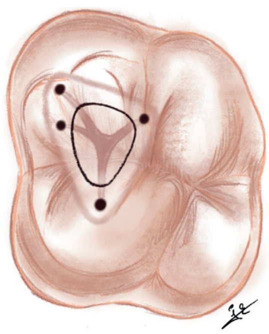

Figure 2: Illustration of conservative access cavity on maxillary first molar.

1.1.3. Ultra-Conservative Access Cavity

Also known as “ninja” access cavities, this method focuses on extreme preservation of the pulp chamber ceiling by creating a highly constricted cavity with sharply convergent walls. The process begins similarly to the conservative approach, creating access through the central fossa, but without further extensions (Fig. 3). In anterior teeth, where the lingual surfaces may exhibit attrition or deep concavities, access is made through the incisal edge parallel to the tooth’s axis (Chan et al., 2022; Ingle et al., 2019).

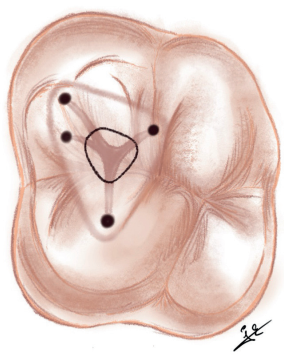

Figure 3: Illustration of ultra-conservative access cavity on maxillary first molar.

1.1.4. Truss Access Cavity

The method is also called an orifice-directed dentine conservation access cavity (Chan et al., 2022). This technique involves creating multiple small cavities to reach the canal openings in teeth with multiple roots while maintaining the dentinal bridge that separates them. For example, three distinct cavities can be created in the molars of the upper jaw (Fig. 4). Likewise, a total of two separate access cavities can be created for mandibular molars, one for the mesial canals and one for the distal canals. Even separate access cavities can be created for each channel.

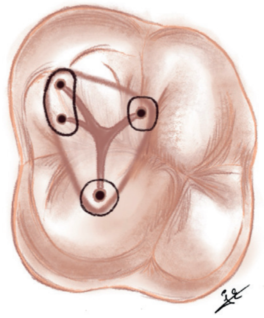

Figure 4: Illustration of truss access cavity on maxillary first molar.

1.1.5. Caries-Driven Access Cavity

This approach removes all decayed tissues while preserving the healthy tooth structure (Fig. 5). Access to the canals is achieved by eliminating the decayed areas only (Plotino, 2021; Chan et al., 2022).

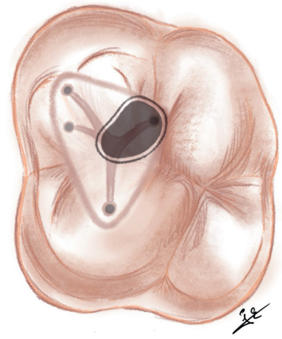

Figure 5: Illustration of caries-driven access cavity on maxillary first molar.

1.1.6. Restorative-Driven Access Cavity

In restored teeth without cavities, the pulp chamber is accessed by entirely or partially removing the existing restorations while preserving the remaining tooth structure (Fig. 6). This method is advantageous because it utilizes the loss of structure due to the restoration of canal access, eliminating the need to enlarge the pre-existing cavity (Plotino, 2021).

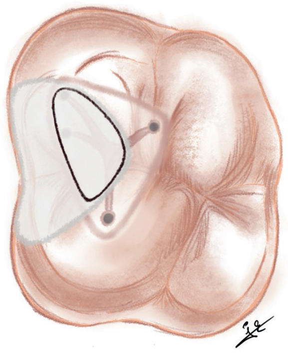

Figure 6: Illustration of restorative-driven access cavity on maxillary first molar.

1.1.7. Computer-Assisted Cavities

Computer-assisted access cavity preparations utilize software and 3D imaging to aid clinicians in creating a precise pathway to the root canal while preserving the tooth's integrity. These tools are also particularly useful in managing calcified structures. Two categorization can be made for these cavities (Shabbir et al., 2021).

Guided Access Cavity

Guided access cavities require intraoral scanners and imaging techniques to fabricate a customized stent that provides precise guidance for the drill. This approach is conservative and goal-oriented. After intraoral scanning, cone beam computed tomography (CBCT) scanning is carried out. Following that, a virtual drill path are developed on the computer screen by combining intraoral scans and CBCT data. On the basis of virtual planning, templates for guidance, access cavities, and sleeves are created (Zehnder et al., 2016). However, it may involve longer planning times and limited accessibility, particularly posterior teeth. There is also a risk of overheating during drilling, and artifacts may affect the accurate location of canals (Shabbir et al., 2021).

Dynamic-Navigated Access

This method employs real-time navigation by using CBCT, and software to guide the drilling process. Unlike guided access cavities, dynamic-navigated access does not require extensive planning, but it is more expensive due to the need for multiple intraoral attachments. It is a freehand approach (Shabbir et al., 2021).

1.2. Armamentarium

This section describes the tools required to apply minimally invasive access cavities in clinical practice.

1.2.1. Burs

The primary tool used to access the pulp chamber of all teeth is a diamond, slightly tapered bur with a rounded end. This bur can be either cylindrical or conical in shape. Various sizes are available, depending on the dimensions of the tooth. Typically, a size #10–12 burs is used for accessing smaller teeth or calcified pulp chambers, while size #12–14 burs are used for larger teeth or those with substantial pulp chambers. The unique, rounded end of the bur helps create smoother cavities. High-speed ball burs can cause excessive tooth tissue removal, which is not desirable for minimally invasive access cavities but a multi-blade carbide stainless-steel bur, specifically a ball bur in sizes #12 or #14, is recommended for use with low-speed handpieces. These burs can be used to remove caries and pulp tissue, after using diamond burs. Endodontic access burs can be used to remove pulp horns and reduce the possibilty of excess removal of tooth tissue, and can also be helpful when working with difficult cases where canal orifices located deep within tooth. Low-speed Munce discovery burs, Clark's EG3 micro-access burs, Endo-Z burs and Endoguide burs are suggested in different studies (Plotino, 2021; Freitas et al., 2021; Moore et al., 2016; Roperto et al., 2019).

1.2.2. Canal Preparation Instruments

In traditional endodontic approaches, Gates Glidden burs and Peeso reamers are commonly used to enlarge the coronal portion of the canals, providing straight access. However, these instruments are known for being aggressive, potentially over-enlarging the canals and leading to complications such as furcation strip perforation or canal misalignment. According to the principles of minimally invasive dentistry, excessive canal enlargement is detrimental to the overall prognosis of the tooth. However, the future of endodontics looks promising with the use of nickel-titanium (NiTi) instruments. Made from NiTi alloy, these instruments are flexible and maintain their shape within the canal, offering greater resistance to metal fatigue (Plotino, 2021).

1.2.3. Operating Microscope and Loupe

An operating microscope (OM) is crucial for minimally invasive endodontic access cavity procedures. Most studies comparing traditional access cavities with minimally invasive approaches have shown that operating microscopes and loupes are essential tools. The OM provides better vision and ergonomics for the operator, allowing clear visualization of the pulp chamber and easier identification of important landmarks. In minimally invasive endodontics, operating microscopes and loupes significantly enhance the clinician's chances of success.

Loupes are highly recommended, specifically those with a magnification of 4.5 to 5. Nearly 80% of endodontic cases can be resolved using loupes. However, certain situations, such as locating calcified root canals, removing broken instruments, or extracting fiber posts, may require a microscope. Additionally, LED lights can be mounted on loupes to improve visibility, which is especially beneficial in challenging cases (Plotino, 2021).

1.2.4. Ultrasonic Instruments

Ultrasonic instruments play a crucial role in minimally invasive cavity preparation by effectively cleaning and removing obstructions such as pulp stones or calcifications. These instruments allow for the removal of calcifications without disturbing the canal walls or floor (Plotino, 2021). Additionally, they are valuable for locating additional canals. Ultrasonic tips offer a less aggressive method for identifying the canal orifice than traditional dental drills or handpieces. Combining an operating microscope with ultrasonic instruments enhances the success and predictability of root canal treatment, providing better control and visibility during the procedure (Chan et al., 2022).

1.2.5. CBCT

The advent of CBCT has significantly advanced the practice of minimally invasive endodontics, ushering in a new era of detailed imaging and precision (Chan et al., 2022). CBCT is particularly useful in retreatment and endodontic surgery cases, offering detailed imaging to detect apical pathosis, pulp canal calcifications, and complex tooth anatomy. It is invaluable for identifying missed canals, ledge formation, perforations, and fractured files. In such cases, CBCT can assist in designing the access cavity, and unique guides made of silicon metal can be prepared for completely calcified canals, like those used in implant procedures. This ensures more accurate preparation of access cavities, paving the way for more precise and effective treatments in the future.

Intraoperative 3D navigation, adapted from implant-guided surgery, allows clinicians to monitor the procedure in real time using CBCT images. Implementing this method in endodontics would offer significant advantages, enabling more precise and controlled treatment (Plotino, 2021).

1.3. Effects of Different Cavities on Root Canal Treatment

This section explores and compares the effects of traditional and minimally invasive access cavities on root canal therapy from various perspectives.

1.3.1. Resistance to Fracture

Changes in tooth biomechanics can result from tissue loss caused by procedures such as caries removal, fractures, and access cavity preparation. Endodontic access alone reduces tooth stiffness by only about 5% (Allen et al., 2018). Subsequent canal instrumentation and obturation cause only a slight decrease in fracture resistance. According to studies, minimally invasive access cavities have minimal impact on tooth biomechanics. However, traditional access cavities involve more extensive preparation. Excessive preparation, including the loss of the marginal ridge, has been shown to reduce fracture resistance significantly (Tang et al., 2010). The depth of the cavity, the width of the isthmus, and the configuration of the cavity are critical factors that influence tooth stiffness and fracture risk.

Most studies on minimally invasive access cavities focus on whether these cavities make teeth more resistant to fractures and cracks. It is generally accepted that traditional access cavity preparations result in a more significant loss of tooth tissue. Since minimally invasive access cavities preserve more tooth structure, they are expected to offer higher fracture resistance. For example, a study by Krishan et al. (2014) demonstrated that mandibular premolar and molar teeth with conservative access cavities had higher fracture resistance. However, no post-endodontic restorations were performed on these teeth.

Two other studies (Plotino et al., 2017; Franco et al., 2020) compared teeth with minimally invasive and traditional access cavities after post-endodontic restorations. They found that teeth with minimally invasive access cavities had higher fracture resistance. Other studies investigating both mandibular and maxillary premolars and molars (Xia et al., 2020; Saberi et al., 2020; Moore et al., 2016; Corsentino et al., 2018; Özyürek et al., 2018) showed no significant difference in fracture resistance between the two approaches.

Overall, minimally invasive access cavities in posterior teeth show no significant difference or result in slightly better outcomes than traditional access cavities. A study on the fracture resistance of anterior teeth (Krishan et al., 2014) found no discernible difference between the two approaches. A comprehensive systematic review (Silva et al., 2018) concluded that no conclusive scientific evidence supports using minimally invasive access cavities to increase fracture resistance. This underscores the need for further research and the ongoing scientific discourse.

A study comparing Truss access cavities with traditional access cavities (Saberi et al., 2020) found that teeth with Truss access cavities exhibited increased fracture resistance. However, another study on the same subject (Barbosa et al., 2020) found no significant difference in fracture resistance between the two types of cavities. It is important to note that both studies may not have accurately replicated in vivo conditions.

Regarding ultra-conservative access cavities, one study (Plotino et al., 2017) reported no significant difference in fracture resistance between conservative and ultra-conservative cavities. However, the study also suggested that ultra-conservative access cavities showed increased fracture resistance compared to traditional access cavities. Conversely, another study (Silva et al., 2020) found no significant difference in fracture resistance between teeth with ultra-conservative and traditional access cavities.

The conflicting results among these studies may be due to several factors, including sample sizes, the type of teeth used, the presence or absence of post-treatment restorations, the decreased hardness of teeth in elderly individuals, and variations in crown-root morphologies and testing parameters. One study (Silva et al., 2020) recommended using CBCT to address these variations. The same study also indicated limited evidence to support increased fracture resistance with ultra-conservative access cavities.

1.3.2. Preservation of Remaining Tooth Structure

Minimally invasive access cavity preparation has been proposed to preserve critical structural dentin. Lin et al. (2020) examined tissue loss from the incisal/occlusal part of the tooth to the cementoenamel junction. The results revealed that teeth with traditional access cavities required the most dentin removal, whereas those with minimally invasive cavities showed less tissue loss.

Another study by Jain et al. (2020) found that teeth treated with dynamically navigated access preparations experienced less substance loss than those with freehand access preparations, particularly in anterior teeth with calcified canals. This was attributed to the more accurate identification of the canal entrance.

Additionally, a study on extracted human intact maxillary incisors, mandibular premolars, and molars (Krishan et al., 2014) demonstrated that coronal dentin was preserved across all three types of teeth. In contrast, a study focusing on the remaining dentin in mandibular premolars during canal instrumentation (Barbosa et al., 2020) found an increased unprepared canal surface area. However, another study on mandibular incisors (Rover et al., 2017) reported no significant difference in dentin preservation. The consensus is that minimally invasive access cavities reduce the amount of coronal dentin loss, contributing to the preservation of important tooth structure.

1.3.3. Canal Orifice Detection

One of the significant challenges in minimally invasive endodontics is the difficulty in locating the canals due to the limited visibility of the pulp chamber (Plotino, 2021). A study conducted on maxillary molars (Rover et al., 2017) divided the canal location process into three stages: the first stage involved locating the canals without magnification; in the second stage, a microscope was used; and in the third stage, both a microscope and ultrasonic troughing were employed. The study found that the first and second stages of conventional access cavities significantly increased the likelihood of identifying the canal orifice. However, there was no significant difference after the third stage.

Another study (Saygili et al., 2018) observed that ultraconservative access cavities, even when used with an operating microscope and ultrasonic tips, reduced the detection rate of additional canals. However, a study simulating a clinical environment (Mendes et al., 2020) demonstrated that when a skilled clinician used an operating microscope and ultrasonic tips, the design of the access cavity—whether traditional or minimally invasive—did not affect the detection of middle mesial canals in mandibular molars. In summary, when an operating microscope and ultrasonic tips are utilized, the design of the access cavity does not significantly impact canal detection. Further research in this area is necessary.

1.3.4. Microbial Cleaning

Effective cleaning of the root canal system requires the removal of all pathological factors to ensure the success of the treatment (Hargreaves et al., 2016). Recent studies have examined the impact of minimally invasive endodontic cavities on root canal instrumentation and disinfection, focusing on the amount of untouched canal area and the bacterial load after debridement.

Some studies on mandibular molars (Krishan et al., 2014; Barbosa et al., 2020) found that teeth with minimally invasive access cavities had more untouched canal area than those with traditional access cavities. These studies also reported a higher percentage of residual pulp in the pulp chamber, which could negatively impact the effectiveness of disinfection. However, other studies (Krishan et al., 2014; Rover et al., 2017; Augusto et al., 2020; Vieira et al., 2020) showed no significant difference in untouched canal area among maxillary and mandibular molars, maxillary premolars, and mandibular incisors. Additionally, the number of positive samples for *E. faecalis* was higher in the group with minimally invasive access cavities after preparation. Overall, the effectiveness of disinfection and instrumentation in minimally invasive cavities remains controversial. The minimally invasive design does not appear to provide any advantage in canal instrumentation or cleaning.

1.3.5. Residual Pulp Tissue and Debris

One of the primary goals of mechanical preparation in endodontics is the thorough removal of pulp tissue, debris, and bacteria to prevent treatment failure. A study by Allen et al. (2018) conducted in a simulated clinical environment with maxillary premolars compared traditional and ultraconservative access cavities. The results indicated that ultraconservative access cavities left more debris in the root canal, which complicated the cleaning process and extended the procedure time. However, a study on mandibular incisors (Rover et al., 2017) found that the shape of the cavity did not significantly affect the amount of remaining pulp tissue and debris. Similarly, another study on maxillary molars (Rover et al., 2017) found no significant differences in accumulated hard tissue debris after preparation. In contrast, a study by Neelakantan et al. (2018) revealed that orifice-directed dentine conservation access cavities on mandibular molars resulted in less thorough cleaning of the pulp chamber. However, this did not affect the cleanliness of the root canals or isthmuses.

1.3.6. Canal Transportation

Canal transportation refers to the unintended shifting of the canal foramen from its original position during endodontic procedures (Ingle et al., 2019). The transportation rates of teeth with minimally invasive access cavities have been a significant research focus. A study on maxillary molars (Rover et al., 2017) found that canal transportation occurred 7 mm from the apical end in the palatal canal of teeth with minimally invasive access cavities. In comparison, canal preparation was more centralized in the palatal canal of teeth, with traditional access cavities at 5 and 7 mm from the apical end. Another study by Alovisi et al. (2018) suggested that traditional access cavities better preserve the original root canal structure compared to minimally invasive access cavities, possibly due to the absence of obstacles in the coronal area, which reduces the need for frequent pecking motions during instrumentation.

Conversely, a study on mandibular molars (Barbosa et al., 2020) that compared conservative and truss access cavities with traditional access cavities found no significant differences in canal transportation. Similarly, two other studies on molars (Augusto et al., 2020; Marchesan et al., 2018) also reported no significant differences. However, a study on premolars by Xia et al. (2020) indicated that apical transportation after instrumentation was significantly greater in minimally invasive access cavities compared to traditional access cavities in premolars with two dental roots.

1.3.7. Instrument Fracture

Instrument fractures are common due to excessive or improper use of dental instruments. Contributing factors include deviations from normal canal morphology, using damaged instruments, inadequate irrigation, excessive force applied to the instrument while working inside the canal, and insufficient access cavity preparation (Ingle et al., 2019).

A study by Silva et al. (2021) investigated the effect of ultraconservative access cavities on the cyclic resistance of NiTi instruments, specifically RECIPROC R25 and RECIPROC Blue R25. The study found that when accessing lower molars with ultraconservative access cavities, both file systems exhibited lower cyclic fatigue resistance than traditional access cavities. This suggests a need for further research to evaluate the efficiency of alternative file systems in ultraconservative access cavities. In contrast, other studies (Krishan et al., 2014; Moore et al., 2016; Rover et al., 2017; Alovisi et al., 2018; Marchesan et al., 2018) examining the impact of minimally invasive access cavities on the fracture resistance of teeth did not report an increased occurrence of instrument fracture. Using flexible NiTi instruments in minimally invasive access cavities has shown the potential to reduce the risk of instrument fracture.

1.3.8. Canal Filling Quality

The goal of obturation is to create a watertight seal along the entire length of the root canal system, from the orifice to the apical end (Torabinejad et al., 2021). This seal prevents the spread of bacteria within the canal and beyond the root, thereby preventing infection.

Research on mandibular incisors (Rover et al., 2017) revealed that the formation of voids was more likely in teeth with minimally invasive access cavities when the single cone and warm vertical compaction techniques were used. Similar results were observed in a study on mandibular premolars (Silva et al., 2020). These findings suggest that the warm lateral compaction method may yield superior results. However, a study comparing traditional, conservative, and truss access cavities in mandibular molars (Silva et al., 2020) found no significant difference in voids within root fillings. Similarly, two other studies on maxillary premolars (Barbosa et al., 2020) and maxillary and mandibular first premolars (Xia et al., 2020) also reported no significant differences in void formation.

1.3.9. Restoration After Root Canal Treatment

Restoring endodontically treated teeth is crucial for the long-term survival of the treated teeth, mainly when restorations are inadequate or missing. It is important to recognize that treated teeth differ structurally from healthy ones, making effective coronal restorations vital to prevent treatment failure. These restorations act as a barrier against microbial infiltration. Even with excellent endodontic treatment, inadequate sealing, especially in the marginal integrity of post-endodontic restorations, can lead to treatment failure. Leakage can occur due to insufficient sealing of temporary restorations (Hargreaves et al., 2016).

Cuspal coverage and a post are generally not required for teeth with only an occlusal endodontic cavity, allowing for direct restoration. If a marginal ridge is lost, a post is usually unnecessary. However, cuspal coverage may be advisable in posterior teeth, depending on the quantity and quality of the remaining tooth structure (Plotino, 2021). The most conservative cavity design can preserve vital tooth tissue, potentially allowing for direct or indirect restorations without cuspal coverage, even without a marginal ridge (Plotino et al., 2017). However, losing all marginal ridges significantly reduces tooth stiffness, necessitating full cuspal coverage and often a post. In most cases, partial adhesive restorations with cuspal coverage are effective. When significant structural loss occurs, a crown with post and cuspal coverage is generally the better option.

1.3.10. Aesthetics

When a tooth loses vitality, it undergoes biochemical changes that affect dentin's light refraction, leading to a shift in its natural color. Insufficient root canal cleaning and the presence of sealer or filling material in the pulp chamber can further contribute to discoloration. Evaluating the impact of minimally invasive techniques on aesthetics, particularly in anterior teeth, is essential. Minimally invasive endodontic access cavities, which involve partial removal of the pulp chamber roof while preserving the pulp horns, present challenges. This approach can prevent the complete removal of pulp remnants and hinder the proper placement of bleaching agents. Despite the use of ultrasonic tips and magnification, operators often struggle to eliminate residual filling material before placing restorations in ultraconservative access cavities, which can lead to prolonged procedures, patient and dentist fatigue, and the risk of tooth discoloration due to residual material, compromising aesthetics (Marchesan et al., 2018).

In the same study (Marchesan et al., 2018), carbamide peroxide bleaching was applied to discolored maxillary central incisors with minimally invasive access cavities. However, the teeth did not regain their previous brightness. In contrast, teeth with traditional access cavities could restore their original brightness. This suggests that opening minimally invasive access cavities in the aesthetic zone may pose some aesthetic challenges.

1.3.11. Treatment Duration

Various factors, including canal morphology and the tooth's position, can influence the duration of endodontic treatment. The design of the access cavity also impacts treatment time, and several studies have focused on this.

Research has consistently shown that minimally invasive access cavities increase canal preparation time (Marchesan et al., 2018; Tüfenkçi et al., 2020; Silva et al., 2020). One study (Silva et al., 2020) noted that cleaning the pulp chamber is more challenging in teeth with ultraconservative access cavities, leading to a longer overall treatment time. Another study (Marchesan et al., 2018) found that minimally invasive access cavity preparation required 2.5 times more canal preparation than traditional cavities. A different study (Tüfenkçi et al., 2020) suggested that the increased treatment time is due to the direct access to the canals provided by traditional access cavities. In contrast, minimally invasive access cavities necessitate more pecking motions to reach the apical foramen, extending the overall treatment duration.

1.4. Decision-Making Criteria

The debate over reducing access cavity width in endodontic procedures remains unresolved, highlighting the need for further research to understand the advantages and disadvantages. Preserving as much tooth tissue as possible is particularly important for post-endodontic restoration, especially in younger patients who may be more susceptible to future caries or fractures. The choice between minimally invasive and traditional approaches should be guided by clinical conditions, which often require deviation from the ideal due to factors like extensive caries or damaged restorations.

When creating an access cavity, extensive caries or damaged restorations may necessitate deviations from the ideal design, limiting the number of cases suitable for minimally invasive access cavities. Criteria for deciding on the approach include minimal occlusal damage, preserved marginal ridges, and the long-term viability of the restoration. The caries-driven approach focuses on retaining non-carious tissue, which may not always provide sufficient access to the canals. In contrast, the restorative-driven approach partially retains existing restorations during access cavity creation. If the restoration is intended to be temporary, the size of the access cavity need not be restricted. However, for long-term restorations, a minimal cavity opening is preferable.

Consideration of canal anatomy is crucial, especially in challenging cases with complex morphologies. Unlocatable canals can negatively impact treatment outcomes, underscoring the importance of thoroughly examining pulp anatomy before beginning treatment. Additional factors such as patient mouth opening, tooth position, and ease of access also play a significant role in decision-making. In complex cases, a minimally invasive approach might complicate the procedure, making traditional access cavities a more practical choice.

Traditional access cavities are often more suitable for retreatment cases, where minimizing restorative material removal and addressing missed canals from the initial treatment are priorities. Advanced equipment, including an operating microscope and ultrasonic tips, can improve the outcomes of minimally invasive access cavities, making them a viable option for experienced dentists with the necessary tools and clinical expertise (Ballester et al., 2021).

CONCLUSION

This review has explored the concept of minimally invasive access cavities in endodontics. In conclusion, using minimally invasive access cavities offers potential benefits in preserving tooth structure and minimizing tissue loss. However, the decision between minimally invasive and traditional access cavities should be made on a case-by-case basis, considering factors such as clinical conditions, canal anatomy, ease of access, and retreatment. Dentists with adequate tools and clinical experience can successfully perform minimally invasive access cavities, while traditional access cavities may be more appropriate in specific situations.

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