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Various Endodontic Access Cavity Designs: A Narrative Review

Dr. Akshayraj Langaliya[1], Dr. Girish Parmar[2]

[1]PhD Scholar, Gujarat University, Department of Conservative Dentistry and Endodontics, AMC Dental College and Hospital, Ahmedabad, India
Corresponding Author Email: *akshaylangalia[at]gmail.com*
Mobile No. +91 9898898004

[2]PhD Guide, Gujarat University, Department of Conservative Dentistry and Endodontics, Government Dental College and Hospital, Ahmedabad, India
Mobile No. +91 94260 06569
Email: *drgjp[at]rediffmail.com*

Abstract: ***In recent years, there has been a noticeable shift within the dental community towards embracing minimally invasive treatments, a trend firmly rooted in scientific research. Dentistry has naturally followed suit, with a growing focus on minimal access preparation in the realm of endodontics. The core aim of this approach is to preserve dentine tissue to the fullest extent possible, driven by the belief that it can effectively mitigate the risk of post-treatment tooth fractures. While certain studies have indicated enhanced fracture resistance in teeth treated with minimally invasive access cavity designs, concerns persist regarding their potential impact on the efficiency and efficacy of subsequent root canal procedures. Challenges such as the identification and navigation of canals, thorough cleaning of the root canal system, and ensuring the quality of filling materials may be compromised. Furthermore, the heightened risk of procedural errors and potential compromises in aesthetic outcomes add complexity to this evolving landscape. This review endeavours to offer a comprehensive examination of the evolution of minimally invasive techniques in endodontic access cavities and consolidate the existing clinical evidence in this domain.***

Keywords: Access cavity, Dentin preservation, minimally invasive, Fracture resistance, Treatment efficacy

1. Introduction

The concept of minimally invasive dentistry underscores the importance of preserving natural tissue structure to minimize patient harm and leverage the body's self-healing abilities (Murdoch-Kinch & McLean, 2003). Early pioneers in adapting this concept to access cavity preparation were Clark and Khademi (2010a, 2010b). They advocated it for preserving the integrity of the pulp chamber roof, referred to as the soffit, and pericervical dentin to improve tooth survival. Although lacking empirical support, they challenged conventional endodontic principles, drawing analogies to a stabilizing ring in a wooden barrel and emphasizing the need for research to validate its strength.[1]

Minimally invasive endodontic access cavities (MIECs) aim to maintain healthy tooth structure while providing access to the root canal system. Techniques such as “contracted access”, "ninja" access, and "truss" access are commonly employed. Proponents argue that preserving tooth structure can enhance the long-term survival of endodontically-treated teeth (ETT) by reducing fracture risk. However, clinical validation of this assertion is pending, and concerns exist regarding potential drawbacks. Constricted access designs may compromise visibility and hinder procedural steps such as canal instrumentation and disinfection, leading to challenges in treatment orientation.[2,3,4]

The widespread adoption of these minimally invasive access cavities has captured the attention of researchers and clinicians. Four years after the proposal by Clark and Khademi, the impact of these cavities on tooth fracture resistance was experimentally tested for the first time by Krishan et al. (2014). They assessed the effect of access cavity size on the fracture resistance of incisors, premolars, and molars using a combination of micro-computed tomographic (micro-CT) analysis and conventional maximum load to failure testing. While they observed some improvement in fracture resistance with minimal access cavities, there was also a potential risk of compromising the quality of canal instrumentation. Since then, numerous studies on this subject have been conducted, yielding conflicting results (Silva et al., 2020c). While some studies have reported an enhanced resistance to fracture in teeth with minimally invasive access cavities (Abou-Elnaga et al., 2019; Makati et al., 2018; Marinescu et al., 2020; Plotino et al., 2017; Saberi et al., 2020; Santosh et al., 2021), the majority of research fails to demonstrate such an effect (Augusto et al., 2020; Barbosa et al., 2020; Chlup et al., 2017; Corsentino et al., 2018;; Lima et al., 2021; Maske et al., 2021; Özyürek et al., 2017; Pereira et al., 2021; Rover et al., 2017, 2020; Roperto et al., 2019; Sabeti et al., 2018; Silva et al., 2020a, 2021b; Xia et al., 2020).

The objective of this literature review is to provide a summary of the advantages and disadvantages associated with minimally invasive endodontic access cavities (MIEC) based on the existing evidence.

Within the category of minimally invasive endodontic access cavities(MIEC), conservative endodontic cavities (CECs) specifically emphasize preserving a substantial portion of the pulp chamber roof and pericervical dentin.[5] Additionally, the truss cavity technique allows direct access from the occlusal surface to reveal the mesial and distal canal orifices while leaving the intervening dentin intact.[6] For those advocating an ultra-conservative approach, point endodontic cavities and ninja endodontic cavities (NECs) have been proposed. These cavities involve removing the minimal amount of tissue necessary to access the root canals.[7] Some studies suggest that such radical approaches have significantly enhanced tooth resistance to fracture and reduced the need for complex, costly prosthodontic restorations.[8]

2. Methodology

A systematic literature search was conducted, utilizing electronic databases including PubMed (from 1987 to 2024), and Web of Science (from 1976 to 2024). The search criteria consisted of terms such as ("Endodontic" OR "root canal") AND ("access cavity" OR "access cavities") AND ("minimally invasive"). Following elimination of duplicates, 23 articles remained. Additional sources were identified by scrutinizing the reference lists of articles selected for full-text examination.

Traditional concepts:

A well-prepared access cavity is essential for facilitating subsequent clinical procedures, such as identifying the canal orifice, chemo-mechanical debridement, root canal obturation, and minimizing the risk of inadvertent damage.[9] Central to the traditional endodontic access cavity (TEC) is ensuring a clear path for introducing endodontic instruments into the canals without obstruction.[10] This requires sufficiently enlarging the access cavity through selective removal of tooth structure. For instance, the TEC approach typically involves removing the entire roof of the pulp chamber. Maximizing tooth structure preservation during treatment has become a driving force behind modern endodontics, as the preparation of the access cavity has been shown to contribute to the loss of tooth structure during non-surgical root canal treatment.[11] Excessive removal of sound tooth structure can lead to a significant decrease in fracture resistance and increased cuspal flexure of endodontically treated teeth (ETT) under functional loading.[12] This compromised structural integrity of ETT is recognized as a key factor contributing to tooth fractures.[13] Consequently, adjustments to the form and size of the access cavity, canal taper, and apical preparation size have been proposed.[14,15]

Contemporary Advancements:

The concept of MIEC (Minimally Invasive Endodontic Cavity) serves as the foundation for the development of the conservative endodontic access cavity (CEC). Similar to the traditional endodontic access cavity (TEC), all defective restorations and caries are removed before preparing the CEC. However, in CEC, the emphasis is on preserving more of the remaining sound tooth structure compared to TEC. This is achieved by preparing the access cavity from the central fossa and extending it only as far as necessary to locate the canal orifices, rather than gaining complete straight-line access to them. Additionally, the axial walls of CEC are often slightly convergent and occlusally bevelled. This design allows for better visualization of the pulp chamber and canal orifices from different angles, enhancing the precision of the endodontic procedure.[16] In addition to the more constrained occlusal outline in the conservative endodontic access cavity (CEC) compared to the traditional endodontic access cavity (TEC), the CEC also aims to preserve part of the pulp chamber roof and pericervical dentine (PCD). Pericervical dentine refers to the tooth substance located 4 mm above and 4 mm apical to the alveolar bone crest. Preserving the PCD structure is considered crucial as it helps distribute the occlusal load from the occlusal table to the root. This preservation supports the structural integrity of the tooth and reduces the risk of fracture, contributing to the long-term success of the endodontic treatment.[17]

Taking the conservative approach to an even greater extent, an ultraconservative endodontic access cavity (UEC), also referred to as "ninja" access, has been proposed. The UEC design involves an extreme preservation of the pulp chamber roof and forms severely convergent walls. This creates a very narrow access cavity focused on identifying the root canal openings while preserving much of the pulp horns and occlusal enamel. This approach prioritizes minimal removal of tooth structure, offering a more conservative option for endodontic treatment.[18]

An alternative form of the narrowed cavity design has surfaced, commonly referred to as the "truss" endodontic access cavity (TREC). In TREC, a dentine bridge and the enamel above it are preserved between separate cavities, each directed towards the canal orifices in multi-rooted teeth.[19] This approach, also termed "orifice-directed dentine conservation access," focuses on conserving dentine surrounding the canal orifices, providing a conservative approach to accessing the root canal system while maintaining structural integrity.[19,20]

A recent survey conducted among members of the American Association of Endodontists found that 43% of respondents opted for a "conservative" approach to access cavity preparation, while 57% followed the "traditional" approach. Interestingly, only 0.7% of participants reported using the "ultraconservative" access preparations.[21] The design of conventional endodontic cavities considerably damages tooth structure. Consequently, conservative access cavities have demonstrated effectiveness in reducing the risk of fractures in teeth treated with endodontic treatment. However, further research is required to support their regular use in clinical practice.[22]

Introduction of New Terminology and Standardization:

Silva et al (2020c)[4] suggested a fresh classification system, merging various terms concerning access cavity shapes into eight categories. This aims to establish a shared vocabulary and easily understandable abbreviations:

1) Traditional Access Cavity (TradAC): In posterior teeth, complete elimination of the pulp chamber roof is followed by achieving direct access to the canal orifices, with smoothly divergent axial walls, ensuring all orifices are visible within the outline form. In anterior teeth, direct access is achieved by removing the pulp chamber roof, pulp horns, lingual dentine shoulder, and extending the access cavity further to the incisal edge[23].
2) Conservative Access Cavity (ConsAC): In posterior teeth, preparation typically begins at the central fossa of the occlusal surface and extends with smoothly convergent axial walls to the occlusal surface, only as

far as necessary to locate the canal orifices, while preserving part of the pulp chamber roof [24,25]. This type of access can also be created with diverging walls (ConsAC.DW)[26]. In anterior teeth, it involves shifting the entry point away from the cingulum toward the incisal edge on the lingual or palatal surface by creating a small triangular or oval cavity, conserving the pulp horns and maximum pericervical dentin[27].

3) Ultra-Conservative Access Cavity (UltraAC): Known as "ninja" access, these cavities begin as described in the ConsAC but without further extensions, preserving as much of the pulp chamber roof as possible [28]. In anterior teeth, if there is attrition or a deep concavity in the lingual aspect of the crown, access can be made in the middle of the incisal edge, parallel to the tooth's long axis (UltraAC, Inc.).
4) Truss Access Cavity (TrussAC): Aims to maintain the dentinal bridge between two or more small cavities prepared to access the canal orifices in each root of multi-rooted teeth. For example, in mandibular molars, two or three separate cavities can be made to reach the mesial and distal canals [29].
5) Caries-Driven Access Cavity (CariesAC): Access to the pulp chamber is achieved by removing caries while preserving all remaining tooth structures, including the soffit structure, which refers to the underside of an architectural element like the ceiling, the junction of the ceiling and wall, or the corners where they meet [30].
6) Restorative-Driven Access Cavity (RestoAC): In restored teeth without caries, access to the pulp chamber is accomplished by totally or partially removing existing restorations and preserving all possible remaining tooth structures.

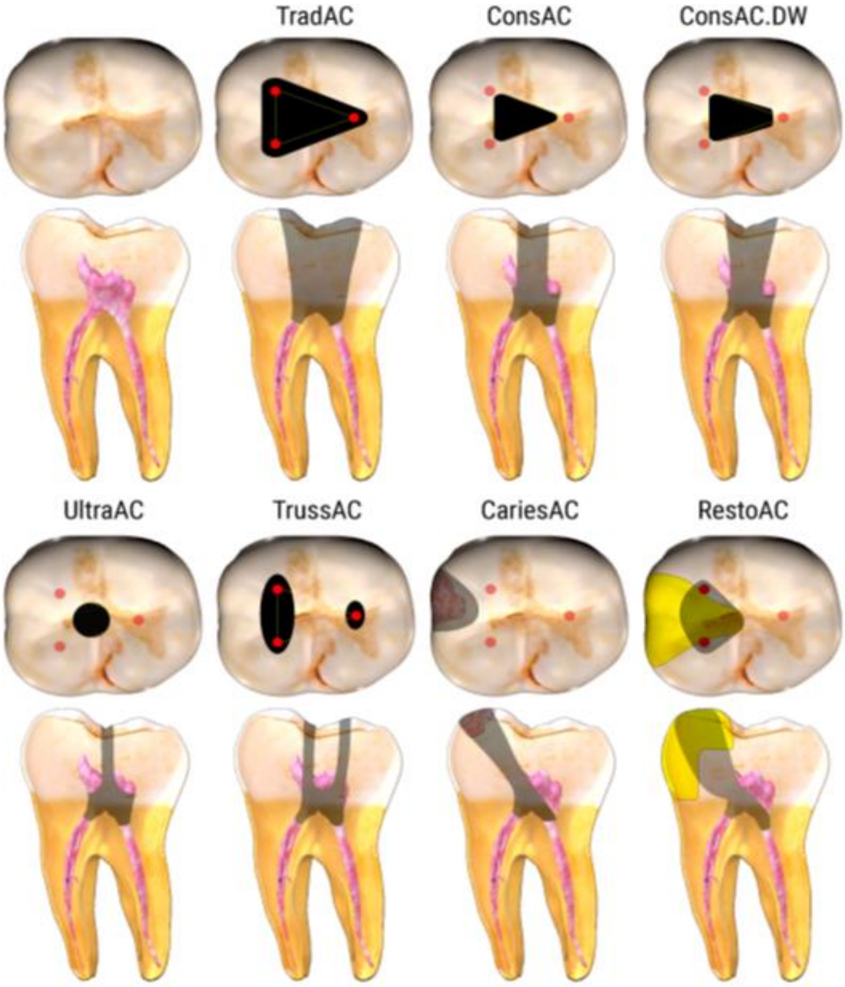

Figure 1: Silva et al. (2020) classification of the access cavity designs in posterior teeth. [4] Traditional access cavity (TradAC); conservative access cavity (ConsAC); conservative access cavity with divergent walls (ConsAC.DW); ultra-conservative access cavity (UltraAC); truss access cavity (TrussAC); caries-driven access cavity (CariesAC); and restorative-driven access cavity (RestoAC). Picture Courtesy: Silva AA et al[31]

Tools for Minimally Invasive Access Preparation:

In recent decades, advancements in three-dimensional computed tomographic imaging, such as Cone Beam Computed Tomography (CBCT), have revolutionized diagnostic capabilities in endodontics. CBCT provides more precise research and clinical methods due to its ability to render three-dimensional information, making it the preferred imaging modality for complex situations requiring detailed localization and description of tooth anatomy compared to conventional dental radiographs. Combining CBCT with intra-oral optical scanning of the region of interest allows for guided-access cavity preparation, enhancing the accuracy of drilling teeth with anatomical anomalies or pulp calcification [32].

Visual Magnification and Illumination:

Minimally invasive access cavities pose a significant challenge in accurately mapping the pulp chamber floor to identify root canal orifices. The principle of preserving the pulp chamber roof as much as possible results in reduced light propagation to the pulp chamber. Therefore, magnification and illumination tools, such as loupes, and particularly the operating microscope, are crucial for providing operators with sufficient vision of the narrowed operative field. These access cavity preparations have also become popular thanks to improved magnification and lighting, enabling practitioners to visualize the pulpal space more clearly during treatment. Ideally, conservative access cavities necessitate magnification, which may not be available to all clinicians. In contrast, traditional access cavities typically take less time and offer a more predictable approach to locating canal orifices, delivering irrigation effectively, minimizing iatrogenic damage during biomechanical preparation, and achieving better obturation.[33]

Optimized Irrigation:
Optimized irrigation techniques have been proposed for application in cases involving minimal access cavities. This is because the preservation of the pulp chamber roof limits the available space for the irrigant solution to penetrate, potentially hindering the intracanal disinfection process. These improved protocols encompass various methods such as the utilization of ultrasonic devices[34,35], high-power sonic irrigation, multisonic ultracleaning systems, and laser-assisted activation [36,37,38.]

Highly Flexible NiTi Instruments:
The utilization of NiTi alloy in manufacturing instruments for mechanical root canal preparation has significantly elevated the standards of endodontic practice. Technological advancements, coupled with proprietary metallurgical treatments of the NiTi alloy, have led to the development of instruments containing substantial amounts of a stable martensite phase[39] . This condition enhances flexibility and fatigue resistance[40,41]. Due to these enhanced properties, heat-treated high-flexible NiTi instruments can effectively manage root canals with severe curvatures[42,43] and facilitate their insertion into teeth prepared with minimal access cavities, as they can be easily pre-bent.

3. Conclusion

While the importance of preserving tooth structure is widely acknowledged, this literature review suggests that the complete transition to Minimally Invasive Endodontic Cavity (MIEC) has not yet been fully substantiated. Therefore, the adoption of MIEC in clinical practice necessitates careful consideration, weighing the risks and benefits against those of the Traditional Endodontic Cavity (TEC). Moreover, the available evidence currently does not sufficiently support the indiscriminate use of MIEC in routine endodontic practice. It is crucial for the concept of minimally invasive access to undergo population-based validation before its clinical application can be deemed worthwhile. Given the current ambiguity regarding the benefits of minimal access cavities, advocating for them as superior to the traditional approach should be approached with caution [44].

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