International Journal of Health Sciences and Research
Volume 14; Issue: 10; October 2024
Website: www.ijhsr.org
ISSN: 2249-9571

Review Article

Effect of Minimal Intervention Access Cavity Designs on Endodontic Treatment Outcomes: A Review

Dr Harshini P[1], Dr Sylvia Mathew[2], Dr Anu Elsa Swaroop[3], Dr Shruthi Nagaraja[4]

[1]Final year Post Graduate Student, Dept of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, M S Ramaiah University of Applied Sciences
[2]Professor, Dept of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, M S Ramaiah University of Applied Sciences
[3]Associate Professor, Dept of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, M S Ramaiah University of Applied Sciences
[4]Professor and Head, Dept of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, M S Ramaiah University of Applied Sciences

Corresponding Author: Dr Anu Elsa Swaroop

DOI: https://doi.org/10.52403/ijhsr.20241022

ABSTRACT:

Aim: To review the existing literature on the different Minimal intervention access cavity design on the outcome of endodontic treatment.
Materials and methods: Relevant scientific literature related to the topic was searched, critically analysed and their data were extracted.
Results: Evaluating the influence of minimally invasive access cavity designs on the different stages of root canal treatment (orifice location, canal detection, chemo-mechanical debridement, irrigation, disinfection, obturation and mishaps in endodontic treatment). The studies reported inadequate and/or inconclusive results on the utility of minimally invasive access preparations. Furthermore, they offered limited scientific evidence to support the use of minimally invasive access cavities to improve the outcome of root canal treatment.
Conclusion: Within the limitations of this review, there is unsatisfactory results with no scientific evidence demonstrating a real benefit of minimally invasive access cavity designs on the endodontic outcome. Future research and long-term clinical trials are required to substantiate the obtained results.

Keywords: Minimal Intervention, Access cavity, Conservative.

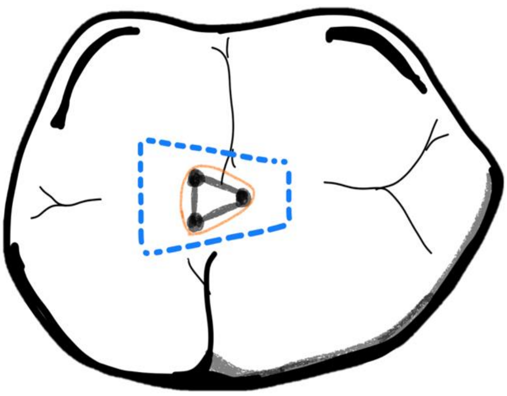
INTRODUCTION

Traditional dental practice focused on removal of diseased dental tissues often at the expense of healthy tooth structure, due to limitations in diagnostics, preparation technologies, and adhesive restorative materials[1].
The evolution towards minimal intervention dentistry rooted with a better understanding of caries, prioritizes prevention, halting progression, and use of advanced adhesive materials challenging the concept of "extension for prevention" by G.V. Black [2]. Minimal intervention strategies thus aim to extend the life of restored teeth with as less intervention as possible.
In Endodontics , minimum intervention access cavities preserve Peri-Cervical

Dentine (PCD), and increasing fracture resistance and long-term integrity of root canal-treated teeth [3]. This review aims to list the most relevant minimal invasive access cavity designs and their influence on treatment outcomes.

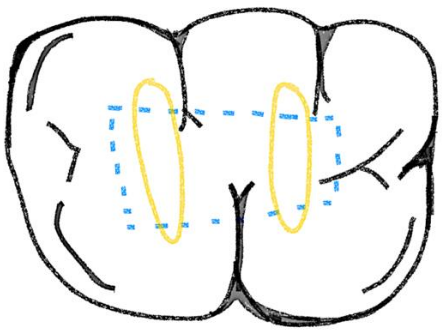
ADVANCES IN CONSERVATIVE ACCESS DESIGNS

1. **Conservative endodontic access cavity:** David Clark and Khademi have refined access cavity techniques focusing on preserving tooth structure employing magnification and CBCT. Their approach involves central penetration at the fossa and careful extension to locate canal orifices while preserving the pulp chamber floor and peri-cervical dentin. Research shows that while conservative methods don't increase tooth strength compared to traditional ones, they emphasize preserving the tooth's integrity by minimizing unnecessary removal of dentin and occlusal anatomy.



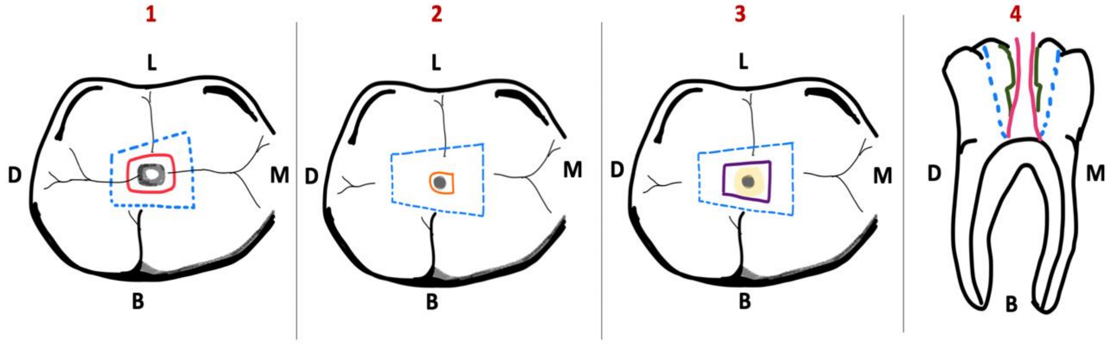
[Figure1: A representation of traditional cavity (blue dots) and conservative cavity (grey line) in mandibular molar]

2. **Truss Access Cavity (TREC) / Dentin Conservation and Orifice-Directed Access Cavity:** TREC, also known as the "truss" access cavity, involves creating separate cavities over the mesial and distal canals of mandibular teeth and mesio- and distobuccal canals of maxillary teeth, leaving a strategic dentinal bridge or pulp chamber roof "truss" between them[3]. Guided by computed tomographic images, TREC minimizes the need for extensive post-endodontic restorations. However this design may be a challenge in inclined teeth and those with anatomical complexities and can impair cleaning and shaping[3]. There is limited clinical evidence and long-term outcome data supporting this design.



[Figure 2: A representation of traditional cavity (blue dots) and truss cavity (yellow circles) in mandibular molar]

3. **Ninja Endodontic Access Cavity (NEC) / Point Endodontic Access Cavity (PEAC) / Ultraconservative Endodontic Cavity (UEC):** This is an ultraconservative technique starting from the central fossa and moving towards the canal orifices with an oblique projection creating a very small cavity on the occlusal surface to access all canal orifices while preserving dentin. The outline form follows the enamel cut at 90° or greater to the occlusal area, simplifying the tracing of root canal orifices. Utilizes CBCT for precise canal identification. [4] However, the conservative design may hinder complete removal of infected pulp tissue and complicate access to canal and instrumentation. There is limited clinical evidence and long-term outcome data.



[**Figure 3:** 1-4 sketches showing, occlusal view (1-3) and sagittal view (4) of designs of access cavity of lower molars (first). Traditional access cavity (1-4) (blue-dashed line), conservative access cavity (1,3 and 4) (red, purple), and the "ninja" ultraconservative cavity (2-4) (orange). Comparing the 3 kinds of access cavity designs; in no.4 (sagittal view) and in no.3 (occlusal view) respectively. A good portion of pericervical dentin is seen in the sagittal view of conservative access cavity "M"-mesial, "D"- distal, "B" - buccal, "L"- lingual]

4. **Incisal Access:** initiating access on the incisal edges of anterior teeth rather than the cingulum minimizes cuspal deformation, preserves bulk of peri-cervical dentin and reduces restorative needs. Additionally it avoids inverse funnelling, gouging and blind tunnelling often seen with traditional designs. Advanced skills are required to access all canal orifices through the incisal edge and could complicate instrumentation and cleaning.

5. **Calla lily enamel preparation:** In this preparation, enamel is cut at a 45-degree angle to engage the enamel rods and create a favourable C factor. The preparation resembles a Calla Lily, with almost complete involvement of the occlusal surface, which helps resist compressive forces better as compared to the traditional method. This shape is ideal for bondable substrates like enamel or porcelain that can be etched, and for the use of bondable restorative materials such as composite resin. Calla Lily enamel preparation is based on the principle of ICE:

"I"-Infinity edge
"C"-Compression based
"E"-Enamel driven (engage 70% enamel and 30% dentin)

[Figure 5: Traditional access cavity (parallel-sided) 90° to the occlusal table (A), compared with the Calla Lily access preparation where enamel is cut at 45° (B)]

6. **Image-Guided Endodontic Access Preparations:** Utilizes advanced imaging techniques such as CT Dynamic access and CT/CBCT guided static 3D templates to customize the size and location of the access cavity, aiming to preserve dentin and precisely prepare the smallest possible access cavity. It can be time-consuming to plan and execute and may involve additional costs for imaging and template creation.

7. **Caries-Driven Access:** This design focuses on minimal removal of tooth tissue to reach the pulp chamber. This approach is categorized into two main

types: Caries-Driven Access Cavity and Restorative-Driven Access Cavity. However, it offers a limited view of the pulp chamber floor, requiring advanced techniques like ultrasonic troughing and magnification to overcome challenges.

Effect of minimal intervention access cavity designs on the outcome of endodontic treatment

1. **Orifice location:**
   Minimally invasive access cavities give limited view of the pulp chamber floor. Rover et al. observed that Traditional Endodontic Cavities (TEC) had a higher detection rate of second mesiobuccal canals (MB2) in maxillary molars compared to conservative Endodontic cavities (CEC), regardless of magnification. Another study reported MB2 detection rates of 60% for TradAC, 53.3% for ConsAC, and 31.6% for Ultra-conservative access cavities (UltraAC)[6]. However, according to Mendes et al. the type of access cavity (TEC or ConsAC) did not affect the detection of middle mesial canals (MMC) in mandibular molars when performed by an experienced endodontist using an operating microscope and ultrasonic tips.[7]
2. **Canal detection and negotiation:**
   The effectiveness of canal detection in Minimally Invasive Endodontic Cavities (MIEC) depends largely on the use of operating microscopes (OM) and ultrasonic instruments. While similar canal detection rates are expected between Conservative Endodontic Cavities (CEC) and Traditional Endodontic Cavities (TEC) when using these tools, Ultra-conservative Endodontic Cavities (UEC) significantly impair the ability to detect extra canals like MB2, even with additional diagnostic aids [7].
3. **Chemo-mechanical debridement:**
   Studies indicated that MIEC resulted in compromised instrumentation in mandibular molars, leaving more untouched canal areas compared to TEC [8,9]. Additionally, mandibular molars in MIEC groups may retain more pulp tissue remnants impacting disinfection [10]. While recent studies showed similar bacterial elimination efficacy between CEC and TEC [8,11], Vieira et al. found significantly more bacteria-positive cultures in the CEC group than in the TEC group, though similar unprepared areas were noted between the two groups in a subsequent study [12].
4. **Root canal filling quality/ obturation**
   Teeth with CEC showed more voids in root canal obturation using the single cone and warm vertical compaction technique in mandibular incisors [5] and mandibular premolars [13] leading to recommendations for warm lateral compaction instead. However, another study found no significant differences in voids with the single cone technique [14]. Niemi et al. (2016) noted that in mandibular premolars with oval canals, ConsAC impeded cone adaptation and recommended warm lateral compaction for MIEC preparations [13]. Silva et al. (2020) found no difference in void formation between UltraAC and TEC in maxillary premolars, but UltraAC posed difficulties in removing filling remnants, potentially affecting aesthetics and causing patient discomfort [15].
5. **Fracture resistance of teeth:**
   Krishan et al. found that ETT prepared with CEC had higher fracture resistance than those with TEC in mandibular premolars and molars, but these results should be viewed cautiously as the specimens lacked post-endodontic restorations [9]. No studies have explored CEC's effects on anterior teeth, but CEC generally shows comparable or better fracture resistance in posterior teeth than TEC. A recent review found no strong evidence to justify a shift to MIEC[16]. Ozyurek et al. reported that mandibular first molars prepared with CEC and restored with Class II composite had more restorable fractures than those with

TEC, despite similar fracture strengths, suggesting CEC positively impacts fracture mode [17]. Conversely, Plotino G et al. and Augusto C M et al. found no significant difference between TEC and CEC in fracture outcomes [4,18]. While minimally invasive endodontic concepts aim to preserve dentin and maintain tooth strength, evidence supporting their impact on fracture resistance remains inconclusive [3].

6. **Mishaps during root canal preparation:**

MIEC is technically challenging and requires specific skills, as coronal dentinal interference can obstruct the instrument's ability to follow canal anatomy, increasing the risk of iatrogenic errors such as canal transportation, straightening, perforation, and apical issues [19]. Studies show that a contracted access can cause early Ni-Ti instrument failure with longer tip separation lengths due to increased stress [20, 21]. Using a dynamic navigation system (DNS) for minimally invasive access can preserve dentin and enamel while reducing complications [22].

a. **On canal curvature and transportation:**

ConsAC often result in significant deviations from the original canal anatomy, particularly at the apical level of palatal canals in maxillary molars [5] and mesial canals in mandibular molars [19,23]. Rover et al. found no difference between ConsAC and Traditional Access Cavities (TEC) in maxillary molars. However, Silva et al. noted that UltraAC in maxillary premolars led to more debris accumulation compared to TradAC [5,16], likely due to the larger pulp chamber roof in small access cavities, which impaired irrigation efficiency.

b. **On instrument separation:**

Impact of UEC and TEC on the cyclic resistance of two NiTi instruments, RECIPROC R25 and RECIPROC Blue R25 was compared and it showed that both files had lower cyclic fatigue resistance in lower molars with UEC access due to increased canal curvature stress. This study only tested two file systems from one manufacturer, leaving the performance of other systems in UEC-prepared teeth unexplored. Other studies do not report any correlation between instrument separation and access cavity design. However use of flexible NiTi instruments along with magnification in MIEC might reduce instrument fracture incidence[9,19].

7. **Root canal retreatment:**

Only one study assessed the influence of different access designs on retreatment procedures. Using sectioning method to evaluate the effectiveness of rotary systems on the removal of root filling materials from oval-shaped canals of single-rooted mandibular premolars. Teeth with CEC were associated with more remnants on root canal walls as compared to TEC.

8. **Quality of the post-endodontic restoration:**

Composite restorations of endodontically treated teeth with UEC had more voids in bulk fill composite, though gap formation did not increase, probably due to challenges in handling filling materials within the restricted access cavity[24].

9. **Aesthetics:**

In anterior teeth, MIEC often involves creating access from the incisal edge and partial deroofing of the pulp chamber, which can hinder the complete removal of pulp remnants and the restricted placement of intracoronal bleaching agents leading to tooth discoloration. Marchesan et al. observed that maxillary central incisors treated with 35% carbamide peroxide in the CEC group did not regain their original lightness, unlike those in the TEC group [15].

10. **Treatment time:**

Several authors have reported significantly longer canal preparation time for teeth accessed with the CEC or UEC. Marchesan et al. measured the treatment time used in the CEC and TEC and found that a 2.5-fold greater time was needed for canal instrumentation in the former design which may be regarded as an additional disadvantage of MIEC [15].

CONCLUSION

While minimally invasive endodontic cavities (MIEC) hold promises for preserving tooth structure and improving treatment outcomes, several factors need to be considered before widespread adoption in clinical practice. The majority of studies have been conducted on intact teeth ex vivo, limiting their applicability to clinically relevant scenarios involving carious or previously restored teeth. Moreover, procedural challenges such as canal location, instrumentation, and disinfection may be more pronounced in vivo compared to ex vivo settings. Long-term clinical studies are needed to assess methods to enhance debridement, disinfection, cleaning, shaping, and obturation in teeth with MIEC.

While the preservation of tooth structure is paramount, it is essential to strike a balance between traditional and minimalistic cavity preparations. Over-reliance on MIEC may lead to procedural challenges and suboptimal clinical outcomes, including compromised disinfection and periapical healing.

Therefore, clinicians should carefully consider the risks and benefits of both traditional and MIEC approaches before deciding on the most appropriate treatment strategy for each patient. The complete transition to MIEC requires further validation, and its indiscriminate use in routine endodontic practice should be approached with caution.

Declaration by Authors

Ethical Approval: Not Applicable
Acknowledgement: None
Source of Funding: None
Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

1. Singh H, Kaur M, Dhillon J, Mann J, Kumar A. Evolution of restorative dentistry from past to present. Indian Journal of Dental Sciences. 2017;9(1):38.
2. Frencken JE, Peters MC, Manton DJ, Leal SC, Gordan VV, Eden E. Minimal intervention dentistry for managing dental caries - a review: report of a FDI task group. Int Dent J. 2012;62(5):223-43.
3. Clark D, Khademi J. Modern molar endodontic access and directed dentin conservation. Dent Clin North Am. 2010;54(2):249-73.
4. Plotino G, Grande NM, Isufi A, et al. Fracture Strength of Endodontically Treated Teeth with Different Access Cavity Designs. J Endod. 2017;43(6):995-1000.
5. Rover G, Belladonna F, Bortoluzzi E, De-Deus G, Silva E, Teixeira C. Influence of Access Cavity Design on Root Canal Detection, Instrumentation Efficacy, and Fracture Resistance Assessed in Maxillary Molars. J Endod. 2017; 43:1657-62
6. Saygili G, Uysal B, Omar B, Ertas ET, Ertas H. Evaluation of relationship between endodontic access cavity types and secondary mesiobuccal canal detection. BMC Oral Health. 2018; 18:121.
7. Mendes EB, Soares AJ, Martins JNR, Silva EJNL, Frozoni MR. Influence of access cavity design and use of operating microscope and ultrasonic troughing to detect middle mesial canals in extracted mandibular first molars. Int Endod J. 2020;53(10):1430-37.
8. Barbosa AFA, Silva EJNL, Coelho BP, Ferreira CMA, Lima CO, Sassone LM. 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(12):1666-79.
9. 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(8):1160-66.
10. Neelakantan P, Khan K, Hei Ng GP, Yip CY, Zhang C, Pan Cheung GS. 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(2):274-79.
11. 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(3): 419-24.
12. Vieira GCS, Pérez AR, Alves FRF, et al. Impact of Contracted Endodontic Cavities on Root Canal Disinfection and Shaping. J Endod. 2020;46(5):655-61.
13. 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(10):1550-54.
14. Franco ABG, Franco AG, de Carvalho GAP, Ramos EV, Amorim JCF, de Martim AS. Influence of conservative endodontic access and the osteoporotic bone on the restoration material adhesive behavior through finite element analysis. J Mater Sci Mater Med. 2020;31(4):39.
15. 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(10): 1558-62.
16. Silva EJNL, Rover G, Belladonna FG, De-Deus G, da Silveira Teixeira C, da Silva Fidalgo TK. Impact of contracted endodontic cavities on fracture resistance of endodontically treated teeth: a systematic review of in vitro studies. Clin Oral Investig. 2018;22(1):109-18.
17. Özyürek T, Ülker Ö, Demiryürek EÖ, Yılmaz 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(5):800-5.
18. Augusto CM, Barbosa AFA, Guimarães CC, et al. A laboratory study of the impact of ultraconservative access cavities and minimal root canal tapers on the ability to shape canals in extracted mandibular molars and their fracture resistance. Int Endod J. 2020;53(11):1516-29.
19. Alovisi M, Pasqualini D, Musso E, et al. Influence of Contracted Endodontic Access on Root Canal Geometry: An In Vitro Study. J Endod. 2018;44(4):614-20.
20. Mauney DK III, Versluis A, Tantbirojn D, Cosby HT, Phebus JG. File Breakage in Conventional Versus Contracted Endodontic Cavities. Eur Endod J. 2023;8(4):262-67.
21. Shabbir J, Zehra T, Najmi N, et al. Access Cavity Preparations: Classification and Literature Review of Traditional and Minimally Invasive Endodontic Access Cavity Designs. J Endod. 2021;47(8):1229-44.
22. Gambarini G, Galli M, Morese A, et al. Digital Design of Minimally Invasive Endodontic Access Cavity. Appl Sci. 2020;10(10):3513.
23. Freitas GR, Ribeiro TM, Vilella FSG, de Melo TAF. Influence of endodontic cavity access on curved root canal preparation with ProDesign Logic rotary instruments. Clin Oral Investig. 2021;25(2):469-75.
24. Silva EJNL, Oliveira VB, Silva AA, et al. Effect of access cavity design on gaps and void formation in resin composite restorations following root canal treatment on extracted teeth. Int Endod J. 2020; 53(11):1540-48.

How to cite this article: Harshini P, Sylvia Mathew, Anu Elsa Swaroop, Shruthi Nagaraja. Effect of minimal intervention access cavity designs on endodontic treatment outcomes: a review. *Int J Health Sci Res.* 2024; 14(10):207-213. DOI: *10.52403/ijhsr.20241022*

******