

Traditional and Conservative Molar Endodontic Access Cavity Designs: A Classification and Overview

SADJ August 2022, Vol. 77 No. 7 p407 - p412

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ABSTRACT

Minimally invasive endodontics' specific focus on dentine preservation is gaining popularity. Before deciding on the appropriate endodontic access cavity design, clinicians should investigate the advantages and disadvantages associated with different treatment modalities.

The purpose of this article is to provide a summary of possible advantages and disadvantages of different endodontic access cavity designs with the focus on traditional, conservative and ultra-conservative endodontic access cavities, specifically in molar teeth.

No conclusive evidence is found in the literature favouring one access cavity design above another and clinicians are advised to evaluate each case individually when deciding on the appropriate access cavity design for that specific case. Fracture resistance, proper shaping in order to facilitate irrigation and disinfection, as well as canal location and orifice detection are some of the contributing factors in selecting an appropriate access cavity design that will be highlighted in this article.

Introduction

Non-surgical endodontic treatment starts with the preparation of an endodontic access cavity (EAC). Many variations and modifications on EAC designs can be found in literature with more recent EAC focussing on the preservation of tooth structure. The exact parameters of each of the different EAC designs however remain largely undefined. EAC preparation includes the removal of caries, the removal of the pulp roof, straight-line access and the identification and location of root canal orifices whilst preserving dentine.¹ Advances in clinical dentistry has made more conservative access cavity preparations a viable option. These advances include magnification, cone beam computed tomography (CBCT), irrigation activation devices and solutions, as well as improved metallurgy for the manufacturing of endodontic shaping instruments resulting in increasing flexibility and fracture resistance.^{2,3}

The greatest challenge in terms of the long-term success/longevity of endodontically treated teeth is still the reduction of fracture resistance. Fracture of endodontically treated teeth is a major reason for extraction post endodontic treatment.^{4,5} Tooth structure integrity and the preservation of dentine during access cavity preparation and canal shaping are considered to optimize the biomechanical behaviour of these teeth and increase their long-term resistance to failure due to possible fracture.⁶⁻⁹

Research shows that the susceptibility of endodontically treated molar teeth to fracture can mainly be contributed to significant tooth strength decrease during access cavity preparation and root canal cleaning and shaping.⁹⁻¹² Corsentino et al.¹³ reported that the loss of one or more marginal ridges, regardless of the amount of dentine loss or size of access cavity preparation, should be considered the major contributing factor in the decrease in fracture resistance of endodontically treated molars. Therefore the amount of remaining dentine after access cavity preparation and root canal shaping as well as the structural integrity of marginal ridges appears to be the major contributing factors in determining the fracture resistance and long-term prognosis in teeth post-endodontic treatment.¹⁴

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Author contributions:

1. **Dr Martin Vorster:** 70%
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3. **Prof George Markou:** 10%

All authors have contributed significantly and all authors are in agreement with the manuscript. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Structural integrity of pericervical dentine specifically could be a key factor in determining the long-term prognosis with specific reference to fracture resistance of endodontically treated teeth.¹⁵ The term pericervical dentine was first described by Clark and Khademi¹⁶ and refers to an area roughly 4mm coronal to the crestal bone and 6mm apical to the crestal bone (Fig 1). It is considered to be critical dentine for tooth strength and should be conserved as much as possible to ensure long-term retention of the tooth.

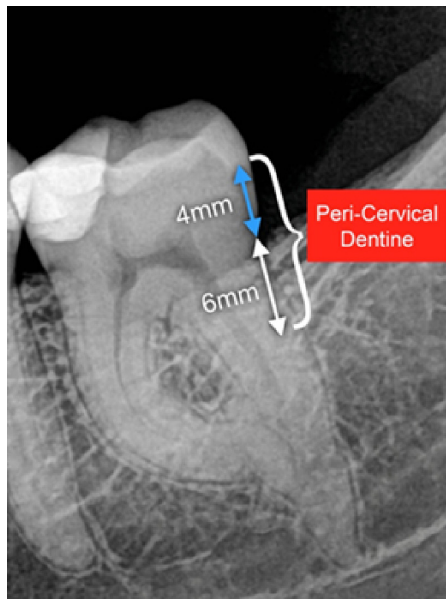


Figure 1: Pericervical dentine: 4mm coronal to the crestal bone and 6mm apical to the crestal bone.

In a study by Ozyurek et al.¹⁷ the authors concluded that conservative access cavity design did not increase the fracture resistance compared to traditional access cavity preparation groups. On the contrary, Zhang et al.¹² in a recent study found that conservative access cavity preparations increased the fracture resistance of endodontically treated teeth compared to the conservative access cavity preparation groups.¹²

In this article the authors will give a classification of different molar access cavity designs as well as provide insight in the possible benefits and disadvantages of each of the proposed access cavity designs.

Classification of Endodontic Access Cavities

Literature shows a wide variety of minimally invasive access cavity designs with a significant amount of discrepancies in their definitions, descriptions and dimensions. Below the authors will highlight the three main access cavity designs in molars and give a description that is mostly accepted in literature.

Traditional access cavities (TAC)

Traditional access cavities are prepared by obtaining straight line access into the coronal and middle third of the root canal systems (Fig 2). The entire roof of the pulp chamber has to be removed, resulting in more loss of pericervical dentine.^{1,18,19}

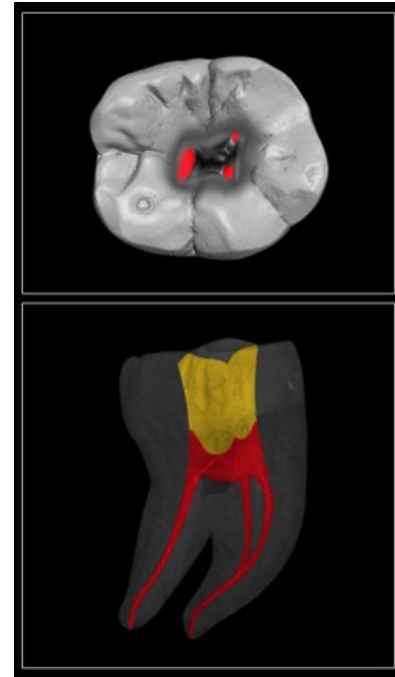


Figure 2: Micro-computed tomographic illustration of a mandibular molar showing a traditional access cavity preparation from occlusal and buccal views.

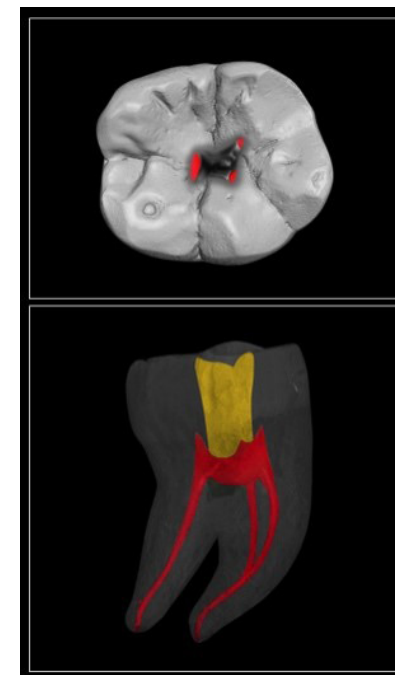


Figure 3: Micro-computed tomographic illustration of a mandibular molar showing a conservative access cavity preparation from occlusal and buccal views.

Conservative access cavities (CAC)

Recently, a new concept of conservative access cavity (CAC) preparation has been developed, aiming for a minimally invasive dentistry and dentine preservation (Fig 3).²⁰ This design limits the removal of dentine of the chamber roof allowing for the location of root canals without necessarily achieving straight line access. Preparation starts at the central fossa extending the access in such a way that the canals

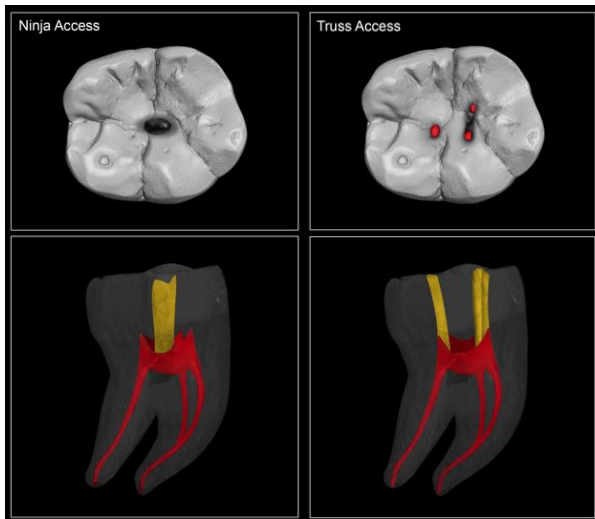


Figure 4: Micro-computed tomographic illustration of a mandibular molar showing ultra-conservative access cavity preparations (a: Ninja access b: Truss access) from occlusal and buccal views.

are detected without deroofing the entire pulp. Access cavity walls can either be convergent or divergent.^{12,13} The emphasis being on partial removal of the pulp chamber roof. This design minimizes the amount of dentine and specifically pericervical dentine removal.

Ultra-conservative access cavities (UAC)

Ultra-conservative access cavities aim to preserve as much as possible tooth structure. Pericervical dentine preservation is the only objective and straight-line access or visibility is often compromised. Ninja access cavities (Fig 4a) is a form of ultra-conservative access cavity preparation prepared by a “point access” in the central fossa.²¹ Truss access (Fig 4b) is another form of UAC designs. The design is aimed in targeting the canal orifices without breaking the dentine structure between the mesial and distal canals.²²

Review of Literature

When evaluating remaining tooth structure there is consensus that CAC and UAC preserves more coronal tooth structure and pericervical dentine than TAC preparations. Many authors however reported no difference between different access cavity designs and the amount of dentine removed from the root canal system itself.²²⁻²⁶

When evaluating the stress distribution between TAC and CAC, most studies concluded that TAC showed a significant higher stress generation than CAC.^{12,27} Moore et al.²⁰ found no difference in fracture resistance nor instrumentation efficacy between CAC and TAC groups in maxillary molars. Chlup et al.²⁸ also found no significant difference between the two EAC groups when evaluating fracture resistance. They did however report that higher fracture load was required in the CAC group to initiate fractures. Although most studies indicated no significant difference in fracture resistance between these two types of EAC preparations in posterior teeth^{21,22} some studies found a decreased fracture resistance in TAC compared to CAC in posterior teeth.^{12,18,29} A study by Plotino et al.³⁰ evaluating the fracture resistance of endodontically treated teeth with

different access cavity designs found that teeth with TAC designs showed lower fracture resistance than teeth with CAC designs. In this study the UAC did not show any increase in fracture resistance compared to the CAC designs.³⁰ Zhang et al.¹² investigated the effect of different access cavity designs on the fracture resistance of first maxillary molars by using the extended finite element method. The authors found that CAC designs lower the stresses in the cervical region, resulting in increased fracture resistance compared to TAC design. The authors therefore recommended minimal removal of dentinal hard tissue in order to increase the fracture resistance of endodontically treated teeth.¹²

Santosh et al.³¹ also found that minimally invasive access cavity designs improved fracture resistance in mandibular endodontically treated molars. The authors further found that in the CAC groups more favourable, restorable fractures were seen with an increase in long term survival of endodontically treated teeth.³¹ Krishan et al.²⁹ also concluded in a study evaluating fracture resistance of endodontically treated teeth with different EAC designs, that although CAC has an improved fracture resistance compared to TAC, there is an increased risks of inadequate canal instrumentation as well as an increased risk of procedural errors.

When the amount of uninstrumented areas of the root canal system is evaluated in posterior teeth, using micro-CT, some studies favour the TAC^{22,26,29} while others showed no difference between the two groups with regards to uninstrumented canal space.^{19-21,32} A study by Neelakantan et al.¹⁸ showed that access cavity design type had a significant effect on the debridement of the mesial pulp chambers in mandibular molars. The results of this study suggest that the orifice-directed approach shows inferior debridement compared to TAC. This is a key factor to consider as failure to debride the pulp chambers could lead to increased failure of the endodontic treatment.¹⁸

Vieira et al.³³ also reported that although the preservation of dentine remains important in fracture prevention, disinfection was improved in endodontically treated teeth with TAC's when compared to teeth with CAC designs.

When evaluating centering ability and canal transportation between different access cavity design groups in posterior teeth conflicting results were found. Most studies showed no difference in transportation and centering ability^{22,32} whilst two studies showed an increased likelihood of transportation in CAC compared to TAC.^{19,34} Alovisei et al.³⁴ showed that TAC resulted in better original canal anatomy preservation than CAC. This was particularly evident in the apical portion of the canals.² Rover et al.¹⁹ reported a higher incidence of canal transportation in CAC design groups as well as a reduced ability to locate canals compared to the TAC design groups.

Sabeti et al.⁹ investigated the effect of root canal preparation taper in conjunction with different access cavity designs on the fracture resistance of endodontically treated teeth. They found that an

increase in the taper of root canal preparation had a negative effect on the fracture resistance. Elkholy et al.³⁵ evaluated the impact of root canal taper and access cavity design on the life span of endodontically treated mandibular molars. They concluded that the life span of endodontically treated teeth is affected more by the type of access cavity design than the root canal preparation taper. They further reported that stress patterns were found to migrate more apically rather than concentrate in the pericervical area.³⁵

When evaluating microbial reduction and remaining pulpal tissue between TAC and CAC, it seems that most studies found no significant difference between the two endodontic access cavity preparation groups.^{19,21,22,36,37} When evaluating canal location, a study by Saygili et al.³⁸ reported higher incidence of successful MB2 canal location in CAC and TAC designs compared to UCA designs while the authors could not find any literature that favours a specific access cavity design with regards to successful canal location in molars. Literature shows increased preparation times in all the conservative or ultra-conservative access cavity preparations compared to traditional access cavity preparations.^{21,32,39} A reduction in preparation time as well as increased amount of remaining gutta percha (in retreatment cases) on canal walls were found in cases with minimally invasive (CAC) compared to more traditional EAC designs (TAC).^{40,41}

DISCUSSION

When evaluating the preservation of dentine in molars as the main reason for minimally invasive or conservative access cavities a review study of Shabbir et al.⁴² indicated that a few discrepancies exist in the results of these studies. Shabbir et al.⁴² mentioned that there is a large variation in definition and extension of the access cavity designs. The authors also noted a lack of proper sample size, standardization and distribution as well as types of study designs used.

They further noted that in some studies access cavities were restored and in others the cavities were left unrestored with fracture resistance tests. This had a significant effect on the outcome of these studies. Shabbir⁴² et al. also reported large discrepancies between drawings of different types of access cavities in molars. The authors commented that this "free-hand" approach cannot be standardised due to anatomical variations between teeth and operators. In order to accurately compare these groups it was suggested that teeth should be matched on size and volume using micro-CT analysis.

A study by Corsentino et al.¹³ showed that the loss of a marginal ridge may negatively affect fracture resistance more than the access cavity design. Shabbir et al.⁴² further suggested in a review article that there is little evidence supporting the fact that minimally invasive access cavities increase fracture resistance. Although fracture resistance and the reduction of stress on pericervical dentine remains the main focus of minimally invasive EAC, secondary aspects should also be taken into consideration when deciding on the preferred access cavity preparation. These include irrigation efficacy, canal shaping and preparation times, pulp tissue debridement, microbial reduction, centering ability, transportation, non-vital

bleaching and obturation space. Although inadequate literature exists on the evaluation of remaining pulp tissue as well as bacterial reduction, literature suggests both of these factors are in some way negatively affected by conservative / ultra-conservative access cavities. Little evidence exists for the beneficial use of these minimally invasive access cavity preparations compared to traditional access cavity preparations.⁴²

In a review article by Maqbool et al.⁴³ the authors also concluded that little evidence is available to suggest CAC or UAC designs aids in the retention of endodontically treated teeth by increasing their fracture resistance. Shabbir et al.⁴² concluded that there was an increased risk compared to the benefit in terms of endodontic outcomes, when comparing minimally invasive to traditional access cavity designs. The authors further advise that clinicians should apply minimally invasive access cavities only in selected cases.⁴²

CONCLUSION

Literature provides no consensus or conclusive evidence favouring conservative or ultra-conservative molar access cavities above traditional molar access cavities in terms of fracture resistance and post-endodontic treatment. The role of selecting the appropriate post endodontic restoration method as well as material should also be emphasised. Similarly, no conclusive evidence exists on whether conservative or ultra-conservative access cavity designs allow for proper shaping and disinfection or not, or even if these access cavities have any negative effect on the probability of missing canals during endodontic treatment. Conservative/minimally invasive access cavities could also comprise endodontic treatment in terms of debridement, canal location and proper irrigation whilst trying to preserve dentine.

The authors therefor strongly recommend the use of advanced endodontic irrigation protocols, adjunct irrigation devices as well as CBCT and magnification in cases where conservative or minimally invasive endodontic access cavities are considered. The authors further recommend that clinicians should evaluate each case based on preserving dentine, whilst balancing the risks associated with removing too little dentine during access cavity preparation when deciding on the ideal molar access cavity design prior to endodontic treatment. Advanced armamentarium should be implemented and be available when considering conservative or ultra-conservative endodontic access cavities. Traditional endodontic access cavities still remain an accepted treatment modality in cases where the correct armamentarium is unavailable.

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