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Systematic review

Impact of Traditional Access Cavity and Conservative Access Cavity on Root Canal Therapy Outcome: Review of the Literature

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Abstract
There has been a renewed emphasis on conservative access cavity designs in endodontics in recent years, given such designs' large contribution to tooth structure conservation, especially pericervical dentin, and potentially leading to improved fracture resistance of endodontically treated teeth. This study aims to highlight the effects of different access cavity preparation techniques on the results of root canal treatment, including fracture resistance, efficacy of cleaning and disinfection, procedural errors, root canal location, and quality of root canal fill. An extensive literature review was performed to find relevant published articles on various access cavity preparation techniques and how these affect root canal treatment results, particularly fracture resistance, cleaning and antimicrobial treatment, procedural errors, root canal location, and root canal obturation within endodontics. This search was performed on articles of all languages and was conducted on some of the most utilized electronic databases, including PubMed, ResearchGate, Web of Science, ScienceDirect, Wiley Online Library, and Google Scholar. Many studies have been carried out to evaluate the impact of conservative access cavity preparation, comparing its efficiency and efficacy with conventional access cavity preparation. There was a total of 41 articles on which the studies were based. Out of these, 30 articles were aimed at determining the effect of access cavity preparation on fracture resistance of remaining tooth structure, 12 were on root canal instrumentation, 7 were on the incidence of procedural error during treatment, 3 were on root canal detection, and another 3 were on the quality of root canal obturation. In summary, access cavity preparation for fracture resistance is still somewhat restrained and controversial. Conservative access cavities can include endodontic therapy regarding instrument size, canal orientation, and obturation of canals; in addition, it could also prolong treatment and create iatrogenic complications.
Keywords: *Access Cavity, Canal Detection, Conservative Access Cavity, Fracture Resistance, Iatrogenic Problems, Traditional Access Cavity.*

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Introduction

A properly prepared access cavity is an essential factor determining the success of root canal therapy. An access cavity prepared suboptimally can, on the other hand, negatively affect processes of instrumenting, cleaning, and finally obturation, resulting in uncertain healing. Preparation of access cavity is a coronal procedure that allows free access to canal orifices, provides unobstructed access to the apical foramen, offers complete control within the process of instrumenting, and provides efficient obturation. For many decades, the complete removal of the pulp chamber roof, also known as the traditional access cavity (TAC), was the only procedure used for access cavity preparation, representing the first step in endodontic treatment procedures. Recently, with the advent of magnification techniques like endo-microscopes and improved root canal devices, less invasive endodontic therapy attempts to improve traditional root canal treatment [1]. Removal of dental tissue due to caries excavation, access cavity preparation, and extensive removal of root dentin when preparing root canals often leads to an enhanced risk of fractures [2,3]. Endodontically treated teeth show a lower resistance to fracture when compared with non-treated teeth, along with having less survival for longer durations [4,5]. It has been seen from studies that preservation of cervical dentin is the most essential for returning a normal function and lifespan of the tooth [6]. The main goal of Tooth Access Cavity (TAC) preparation is to allow direct access to the root canal and to enhance biomechanical efficiency and reduce the possibilities of errors that occur during various phases of treatment [7]. For achieving a direct access path to the root canal, an access cavity is created in a particular pattern depending on the type of tooth being treated.

It has been reported that one of the most common reasons for endodontic treatment failure is the extreme loss of dental tissue due to untreated caries and fractures of endodontically treated teeth [8]; this is also directly related to the amount of tissue lost and specific cavity form [8,9].

In 2010, David Clark and Khademi clarified that the traditional models of endodontic therapy do not lead to long-term success and that the traditional approach to endodontic access is fundamentally flawed. To preserve the remaining structure of the tooth and maintain its mechanical stability for long-lasting

survival and function, they introduced a paradigm shift in the design of access cavity preparations and developed conservative or constricted access cavities [10]. In forming a conservative access cavity, the setup is adjusted so that it is no longer reliant on a preconceived access cavity shape. Instead, this technique employs an accurate, step-by-step approach to remove dental tissue from the beginning and is expanded progressively until adequate visibility is obtained.
The CAC approach leads to the partial removal of the pulp chamber roof, the preservation of the pulp horn, and minimal beveling and concavity of the cavity walls. These changes enhance the clinicians' capacity to visualize the pulp chamber and all root canal orifices from multiple angles [11].
The concept of conservative access cavity assumes that maximum preservation of the pulp chamber roof would maintain the teeth's fracture resistance following root canal treatment. However, the smaller access cavity may hinder the visualization and debridement of the pulp chamber as well as the location, shaping, cleaning, and filling of the canals. In addition, a small access cavity may increase the risk of iatrogenic mishaps due to poor visibility, which makes the treatment outcome questionable [6]. According to Silva et al (2020), there are six groups of status on minimal access cavity preparations (Fig. 1): traditional access cavity, conservative access cavity, ultra-conservative access cavity, truss access cavity, caries-driven access cavity, and restorative-driven access cavity [6].

Conventional access cavities (CAC)
This technique includes the removal of the pulp chamber roof for access directly into the coronal and mid-thirds of the root canal. It should be noted, however, that such a technique often leads to the removal of a considerable amount of pericervical dentine [12,13].

Conservative access cavity
This approach does not necessitate gaining direct linear access to the root canals. It is centered on selective roof removal of the pulp chamber. Preparatory stage is initiated at the central fossa, enabling an access pathway such that identification of canals can occur without requiring total removal of the pulp chamber roof. Access cavity walls can either diverge or converge. Such an arrangement reduces the amount of removal of dentin efficiently, particularly pericervical dentin [14,15].

Ultra-conservative access cavities or ninja access cavities (UAC)
Ninja access cavities are a means of ultra-conservative cavity preparation obtained from a "point access" technique within the central fossa. This specific form of access often compromises straight-line access or visibility and is generally aimed at preserving the pericervical dentine [16].

Truss access cavity
In this technique, separate small cavities are prepared to support the dentinal bridge between these cavities. For mandibular molars, two separate cavities are prepared to access the mesial and distal canals; however, for maxillary molars, a single cavity is prepared for the mesio- and disto-buccal canals, and another cavity is prepared for the palatal canal [17].

Caries-driven access cavity
In this process, decayed tissue is scrupulously extracted without touching any other dental structure, including the soft tissue, which is considered a necessity to help the tooth remain stable [6].

Restorative-driven access cavity
This type of design entails the removal of all or part of the existing restorations in restored teeth showing no evidence of recurrent caries, thus providing access to the pulp chamber and maintaining all healthy remaining parts of the tooth [6].
It is the aim of this study to clarify how different methods of access cavity preparation affect the efficiency of root canal therapy, with special reference to factors including resistance to fracture, cleaning and disinfection methods, procedural errors, root canal identification, and root canal filling.

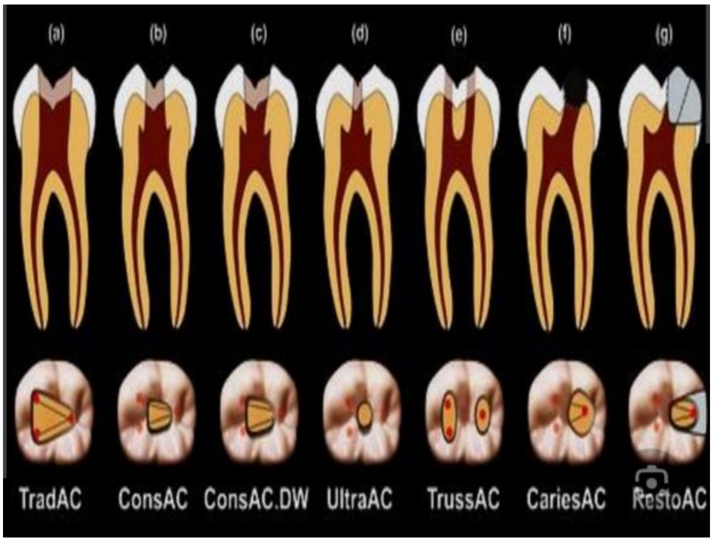

Figure 1. Classification of Endodontic Access Cavities [6].

Methods

An extensive study was carried out to find relevant published studies relating to different access to cavity preparation methodologies and their impact on root canal treatment. Factors, such as fracture resistance, cleaning and decontamination efficacy, procedural errors, root canal diagnosis, and filling protocols, were investigated within the field of endodontics. Literature searching was conducted from April 2010 [10] until February 2024 [18] and included articles in several languages, from key electronic sources such as PubMed, ResearchGate, Web of Science, ScienceDirect, Wiley Online Library, and Google Scholar. Search terms utilized a wide collection of keywords, including traditional access cavity, Conservative access cavity, Ultra-conservative access cavities, Ninja access cavities, Truss access cavity, Caries-driven access cavity, and Restorative-driven access cavity.

Peer-reviewed journal articles examining the effect on the effectiveness of root canal treatment of different access cavity designs have been retrieved from trustworthy online databases. Individual case reports, non-English-language articles, and articles deviating from the set search criteria were ruled out for consideration. After removal of duplicate entries, relevant articles were cross-referenced, and their bibliographies were thoroughly screened for additional literature that would help improve comprehension of the topic. The analysis of data has resulted in the computation of weighted averages for various categories, including fracture resistance, cleaning and disinfection, procedural errors, identification of root canals, and obturation of root canals.

Inclusion and exclusion criteria

To be eligible for inclusion, the studies should have a main aim of evaluating the effect of endodontic access cavity designs on fracture resistance, root canal instrumentation, incidence of procedural error, root canal detection, and quality of root canal obturation by comparing conservative endodontic cavities. The study also has to be in English language. Any study didn't meet this criteria has excluded.

Results

Considerable research has examined the consequences of conservative access cavity preparation, assessing its efficiency and efficacy relative to other ways of preparing access cavities. Many of these studies centered on how various accesses to cavity preparation designs affect the fracture resistance of the remaining dental structure. On the other hand, a lesser number of studies have investigated how access cavity shapes affect the instrumentability of root canals, procedural errors made during treatment, recognition of root canals, and root canal obturation quality. Several different morphologies of teeth were utilized for these studies, and sample sizes were characterized by inconsistencies and variabilities due to the methodologies adopted by the in vitro studies, including an assortment of techniques like cone beam computed tomography (CBCT), finite element analyses, radiographic assessments, universal testing machines, and video recordings, among others.

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In this study, a systematic analysis was done after the initial database search yielded 1250 records. After duplicate removal, 800 unique records were screened at the title and abstract level, resulting in 116 papers for full-text assessment. Of these, 87 were excluded based on relevance criteria, leaving 30 relevant studies. An additional 11 sources were identified through reference list screening and expert consultation, bringing the total number of included studies to 41. (Figure 1) shows PRISMA-style flow diagram illustrating the systematic literature search and selection process.

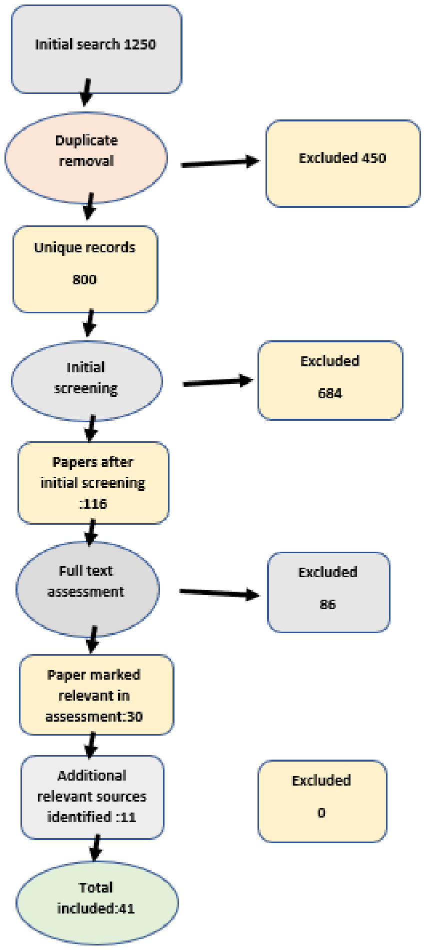

Figure 1. PRISMA-style flow diagram illustrating the systematic literature search and selection process.

A systematic analysis was done on a total of 41 research articles. These articles were peer-reviewed studies listed on various databases such as PubMed, ResearchGate, Web of Science, ScienceDirect, Wiley Online Library, and Google Scholar. Out of these 41 articles analyzed, 30 were on assessing how access cavity form influences fracture resistance of the remaining tooth structure, and 12 were on root canal instrumentation. Moreover, 7 articles were on procedural errors on treatment, 3 on the detectability of roots, and another 3 on assessing the quality of obturation of roots. (Table 1) shows different studies conducted to evaluate the impact of access cavity design on root canal therapy outcome.

Table 1: different studies conducted to evaluate the impact of access cavity design on root canal therapy outcome.

Fracture resistance		**Root canal instrumentation**		**Incidence of procedural error**		**Root canal detection**		**Quality of root canal obturation**	
Author/s	Date	Author/s	Date	Author/s	Date	Author/s	Date	Author/s	Date
Varghese *et al* [4]	2016	Neelakan- tan *et al* [12]	2018	Rover *et al* [13]	2017	*Rover et al [13]*	*2017*	*Lim et al [35]*	*2021*
Zhang *et al* [14]	2019	Silva *et al* [16]	2020	Augus-to *et al* [30]	2020	*Saygili et al [62]*	*2018*	*Barbosa et al [38]*	*2020*
Langaliya *Et al* [18]	2024	Augusto *et al* [30]	2020	Barbosa *et al* [38]	2020	*Mendes et al [63]*	*2020*	*Rover et al [39]*	*2020*
Allen *et al* [20]	2018	Krishan *et al* [32]	2014	Rover et al [39]	2020				
Srinivasan *et al* [21]	2023	Moore *et al* [37]	2016	Alovisi *et al* [55]	2018				
Plotino *et al* [31]	2017	Rover *et al* [39]	2020	Silva *et al* [55]	2018				
Krishan *et al* [32]	2014	Vieira *et al* [52]	2020	Peng et al [61]	2022				
Nawar *et al* [36]	2023	Tüfenk-çi *et al* [53]	2020						
Liu et al [40]	2024	Freitas *et al* [54]	2021						
Kapadia *et al* [41]	2023	Alovisi et al [55]	2018						
Santosh *et al* [44]	2021	Chando- lu *et al* [56]	2024						
Vorster *et al* [49]	2023	Marche-san *et al* [57]	2018						
Osman & Ahmed [2]	2018								
Rover *et al* [13]	2017								
Corsentino *et al* [15]	2018								
Silva *et al* [16]	2020								
Augusto *et al* [30]	2020								
Silva *et al* [34]	2021								
Lima *et al* [35]	2021								
Moore *et al* [37]	2016								
Rover *et al* [39]	2020								
Sabeti *et al* [42]	2018								
Selvaku-mar *et al* [45]	2023								
Hasna *et al* [48]	2022								
Mowlood *et al* [50]	2022								

Discussion

Efficiency in cleaning, shaping, and filling the root canal requires a carefully prepared access cavity. An improperly formed endodontic access cavity, on the other hand, makes root canal-related procedures difficult. Lack of an access cavity of proper form can hamper root canal treatment success [19]. In normal

endodontic access cavities, removal of peri-cervical dentin, along with reduction of both marginal ridge and dental cusp, increases an access cavity's susceptibility to fracture [20,21]. Growth of restorative dentistry, combined with the need for conservation of dental tissue, has resulted in greater emphasis on minimal access cavity preparation as an acceptable substitute for standard access cavity systems [10-22].
The novel endodontic final cavity form, which maintains coronal and radicular dentin, is expected to improve treatment outcomes by fostering restorative stability and promoting extended retention of the restored tooth after treatment [10,22-25]. Because of the insufficiency of any restorative material and procedure to satisfactorily replace lost dentin biomaterial, especially in key areas of the tooth, minimally invasive preparations are nowadays considered to be 'the gold standard' for restoring endodontically treated teeth [26].
In recent times, the trend for minimally invasive therapy, both within medicine and within dentistry has a scientific background and has become an extremely debated topic within the field of endodontics [27]. The principle of minimally invasive endodontics focuses on the conservation of dental structure through the minimization of the degree of access to cavity preparation, the tapering of canals treated, and the prepared apical area [28]. The move towards minimally invasive endodontics has been made possible by the availability of newer endodontic instruments, such as ultrasonic devices, cone beam computed tomography (CBCT), and the operating microscope (OM) [29].
Despite the benefits inherent in conservative access cavity techniques, some potential disadvantages have been voiced against them. For instance, a minimal access cavity setting can interfere with the visibility of the pulp chamber and canal; reduce efficiency and effectiveness of canal preparation and disinfection techniques, and lead to loss of orientation [13,16,30]. In fact, several studies have shown a slight benefit of CAC over TAC. Additionally, these studies have shown that CAC preparation maintains an improved amount of structure of teeth, especially on the soffit and peri-cervical dentin, and increases the fracture resistance of the teeth after root canal treatment [4,14,18,20,21,31,32,33,36,40,41,44,49].
Therefore, it is essential to preserve pericervical dentin to optimize the response of radicular dentin to biomechanical forces [10]. Pericervical dentin is the dentin 4 mm above and 4 mm below the crestal bone, and it has a critical role in the distribution of functional loads in teeth. Some studies on finite element analysis have proven that the maximum strain is at the cervical third of the teeth [36,40,51]. It has been reported that the CAC design is better at preserving pericervical dentin, as this access cavity design is better at preserving dental tissues; the CAC approach starts from the central fossa and reaches the canal openings without the need for straight-line access.
To improve the visibility of the pulp chamber, the axial walls of the access cavity are often slightly convergent and occlusal beveled [33]. On the contrary, several studies did not show a definitive benefit of CAC versus TAC for fracture resistance of endodontically treated teeth [2,13,15,16,30,34,35,37-39,42,43,45-48,50]. These studies all showed improved fracture resistance with CAC designs, but no statistically significant difference was noted for fracture resistance when conservative access cavities were compared with conventional access cavities.
Optimal coronal access allows linear access, enabling controlled instrumentation and obturation of the root canal system. Existing today, the new therapy irrigation devices and flexible Ni-Ti rotary files acknowledge the CAC form as a conceivable alternative to TAC; yet, several potential weaknesses due to the small access opening area have been mentioned by dental literature. An important problem associated with constricted access is the chemomechanical preparation of efficacy. Some studies looked at how access cavity designs varying from each other affect root canal instrumentation efficacy, and most of them showed an insufficiency of chemomechanical preparation quality when conservative access cavity designs were employed [12,16,30,32,37-39,52-56].
Chandolu *et al* conducted an in vitro study to compare the effect of access cavity design on root canal instrumentation efficacy in molars. They concluded that in CAC design, the volume of dentin removed was lesser in comparison with TAC design, and the amount of untouched canal wall area was significantly less in TAC than in CAC [56]. Furthermore, the lowest value of bacterial (*E. faecalis*) decrease percentage was observed in the CAC design [53]. In addition, within an environment with minimal coronal interferences, TAC preparation showed better maintenance of the natural form of the root canal and less apical transportation than CAC methods [55]. According to existing literature, treatment time was significantly longer when conservative access cavity preparation was used compared to conventional access cavity preparation [57].
Historically, the shaping of access cavities has been considered a safer method to avoid the risk of iatrogenic complications since a constricted shaping of the cavity can negatively affect the treatment of root canals. Instrument fracture, deviations from the natural root canal anatomy [58], and other iatrogenic problems have often been reported with the application of the CAC design, finally leading to treatment failure due to persistent infection [59]. Canal transportation [13,55] and instrument fracture [60] have been reported to occur more frequently when conservative access cavity

(CAC) designs are employed. Nevertheless, several studies found no significant differences in canal transportation or centering ability between CAC and traditional access cavity (TAC) designs [30,38,39,61]. Mauney III et al. demonstrated that the increased stresses in the mid-section of NiTi files associated with CAC designs led to longer tip separation lengths [60]. Recognition of deviations from the location of root canal orifices is an essential component of continuous biomechanical preparation of root canals. This requires that the clinicians know the exact locations of root canal orifices, root and root canal orientation for each type of tooth, and an understanding of pulp chamber anatomy.

Implementation of conservative access cavities (CAC) can make locating canal orifice positions problematic, especially for molar teeth, due to their varied canal anatomy for dentition of this type. In a study of canal position assessments, Saygili et al. [62] revealed an improved percentage of success for MB2 canal recognition in conservative access cavity (53.3%) and standard access cavity (60%) designs, when compared with ultra-conservative access cavity or ninja access cavity (UAC) designs, which also showed a success percentage of 31.6%. However, Rover et al. revealed that a higher percentage of MB2 root canals were recognizable with traditional access cavity (TAC) designs, regardless of whether an operative microscope was used, when contrasted with CAC. However, no statistically significant variation was noted when an operative microscope was utilized with ultrasonic troughing pertinent to these two designs [13]. Mendes et al. examined how CAC and TAC designs affected the visualization of middle mesial canals (MMCs) on extracted mandibular first molars, with an operating microscope, both with and without ultrasonic troughing [63]. The authors of the study concluded that access cavity design had no significant effect on the observation of MMCs from extracted mandibular first molars. Nonetheless, the utilization of an operating microscope improved MMC observation precision, especially when combined with ultrasonic troughing [63].

An inadequately prepared access cavity may compromise instrumentation, disinfection, and ultimately obturation, resulting in a poorer treatment prognosis. It has been recommended that obturation instruments enter the canal without contacting any portion of the access cavity, a requirement that may be difficult to achieve with conservative designs. In their assessment of how access cavity configuration influences the quality of root-canal filling, Lima et al. reported that CAC designs exhibited significantly more voids and a greater volume of residual filling material in the pulp chamber following obturation compared to TAC designs [35]. In contrast, Barbosa et al. and Rover et al. observed no significant difference in the percentage of filling voids between CAC and TAC approaches [38,39].

Conclusion

Although conservative access cavity designs do offer some benefits, such as the maintenance of tooth structure, such as pericervical dentin, which can increase the fracture strength of endodontically treated teeth, the effect of access cavity design on fracture resistance remains limited and controversial. Conservative access cavities can also include endodontics, especially when concerned with the size of chemomechanical preparation and the location of canals. Conservative access cavities can increase iatrogenic complications, including fracture of instruments and alterations to the original root of canal anatomy. Conservative access cavities can negatively affect the effectiveness of root canal obturation and prolong treatment time. It is strongly recommended to use advanced endodontic irrigation protocols, adjunct irrigation devices, as well as CBCT and magnification in cases where conservative access to cavities is considered.

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Conflicts of Interest

All authors declare no conflict of interest.

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