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Original Article

Influence of Access Cavity Design on Canal Shaping Outcomes in Mandibular Molars: A CBCT-Based Study

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ABSTRACT

The purpose of this research was to evaluate how differing endodontic access cavity geometries influence canal transportation (CT) and centering ability (CA) in mandibular molars when employing the Bondent Platinum File System, as assessed via cone-beam computed tomography (CBCT). 30 extracted human permanent mandibular molars that satisfied the inclusion criteria were randomly assigned to one of three groups: Group 1 (TEC): Traditional endodontic access cavity (control), Group 2 (CEC): Conservative endodontic access cavity, and Group 3 (TrEC): Truss endodontic access cavity. The specimens underwent initial CBCT scanning before being randomly allocated into the three groups. Mechanical preparation of the root canals was performed with the Bondent platinum file system, using a #25.06 file in the mesiobuccal and mesiolingual canals and a #30.06 file in the distal canal. Post-instrumentation CBCT imaging was performed to measure CT and CA at apical distances of 3, 5, and 7 mm. The data were evaluated through one-way analysis of variance followed by Tukey's post hoc test. Statistically significant differences ($P < 0.01$) in both mean CT and CA were recorded when comparing Group 1 (TEC) against Groups 2 (CEC) and 3 (TrEC). Dentin removal peaked at 3 mm, decreased at 5 mm, and was lowest at 7 mm. The distal canal suffered the most pronounced dentin loss relative to the remaining canals. Minimally invasive access cavity configurations (CEC and TrEC) were associated with lower CT and superior CA compared to the traditional design (TEC). The authors acknowledged study limitations, noting that conservative access geometries yield reduced deviation (CT) and enhanced centering of instrumented canals compared with the traditional technique (TEC). These outcomes suggest the potential benefits of integrating less-invasive access cavity designs into clinical endodontics to improve therapeutic outcomes.

Keywords: Bondent platinum, Canal transportation and centering ability, Truss access, CBCT

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Introduction

Preparing the endodontic access cavity (EAC) is a vital component of root canal treatment [1], providing an unobstructed, straight-line path to the canal orifice. The traditional endodontic access cavity (TEC) fulfills this by unroofing the pulp chamber to identify canal orifices and facilitate a direct pathway for enhanced instrumentation. This step sacrifices a meaningful volume of dental hard tissue, notably the pericervical dentin (PCD) [2], thereby magnifying stress on both crown and root surfaces and predisposing root canal-treated teeth to fracture. Clark and Khademi [3] defined PCD as the region spanning 4 mm both coronally and apically from the crestal bone, and removal of dentin here during access opening and biomechanical preparation may heighten fracture risk. Consequently, appreciating the value of dentin preservation—which underpins minimally invasive access strategies such as the Truss endodontic access cavity (TrEC) and orifice-oriented designs—is essential for promoting the long-term survival of endodontically treated teeth.

Conservative endodontic access cavity (CEC) preparation generally commences at the central fossa of the occlusal table. It is enlarged solely as needed, leaving substantial portions of the pulp chamber roof intact [4]. TrEC retains a dentinal bridge interposed between two or more small cavities cut to reach the canal orifices within each root of multi-rooted teeth [5]. Özyürek *et al*. [6] determined that the CAC design did not improve fracture resistance when measured against TEC, while Vorster *et al*. [2] concluded that CAC preparation conferred greater fracture resistance to endodontically treated teeth compared to the TEC group.

A newly introduced engine-driven system, the Platinum V.EU file [7] (Bondent, UDG), is fabricated from heat-treated nickel–titanium (NiTi) alloy and features a flat surface, a noncutting tip with selective side cutting, and an S-shaped cross-section to promote optimal debris evacuation and drastically curtail the screw-in effect [8]. The performance of any rotary NiTi system can be gauged by its proficiency in remaining centered within the canal, in addition to the degree of canal transportation (CT) at various levels. In the present study, TEC was contrasted with CEC and TrEC, used together with the Platinum V.EU system, and analyzed using CBCT imaging. CBCT provides a three-dimensional, nondestructive means of evaluating canal shaping, enabling precise assessment of canal morphology and the effectiveness of shaping techniques [9].

Materials and Methods

Approval for this in vitro work was granted by the institute's research ethics committee (ethical approval number: 2023-24/1614). A total of thirty intact permanent mandibular molar teeth, all exhibiting Vertucci Class 1 root canal configuration and completely developed apices, formed the study sample. To be included, teeth needed to demonstrate patent root canals, an absence of carious lesions, mandibular first and second molar status with two roots housing three canals (MB, ML, and D), and a curvature ranging from 0° to 10° when measured by Schneider's method. Teeth were excluded if any of the following were present: external/internal/apical root resorption, developmental irregularities, calcified canals, fractures or cracks, the lack of any canals beyond the MB, ML, and D trio, or a history of endodontic intervention.

The requisite sample size was derived from earlier research published by Wang *et al*. [1]. Specimens were positioned within self-cure acrylic resin blocks measuring 2 cm × 2 cm, given individual numbers, and then assigned through a lottery-based draw (simple random sampling) by three independent evaluators into the three experimental arms:

- Group 1 – Traditional access cavity (TEC) (n = 10) (serving as the control)
- Group 2 – Conservative access cavity (CAC) (n = 10)
- Group 3 – Truss access cavity (TrEC) (n = 10)

Preinstrumentation cone-beam computed tomography

Baseline imaging was captured using the MyRay software package at 90 kV, 12 mA, a voxel size of 0.100, and an axial slice thickness of 0.125 mm. To guard against measurement bias, assigned evaluators documented root dentin thickness along both buccolingual and mesiodistal axes.

Sample preparation

A single clinician prepared all access cavities using a size 2 endo access bur (Dentsply Maillefer, Swiss-made).

- Group 1 – Traditional access (TEC) (control): The bur entered at the mesial boundary of the central fossa and progressed apically and distally until the pulp chamber roof had been completely taken down, yielding an unobstructed straight-line pathway
- Group 2 – Conservative access (CAC): Instrumentation was initiated from the central fossa, and enlargement was kept to the absolute minimum required, thereby conserving pericervical dentin along with the roof of the pulp chamber, in keeping with the guidance laid out by Clark and Khademi [3].
- Group 3 – Truss access (TrEC): The spans from the marginal ridges down to the floor of the pulp chamber were gauged first. The mesial and distal external surfaces were then oriented with the bur at right angles to the occlusal plane to pinpoint canal orifices. Two distinct access openings—one for the mesial canals and one for the distal canal—were fashioned and left bridged by a strut of dentin and enamel, consistent with the description of Saberi *et al*. [8].

Biomechanical preparation

Canal patency was first secured with a #10K file (Mani, Utsunomiya, Tochigi, Japan). The working length was then fixed at 0.5 mm short of the apical foramen. Shaping was accomplished with the rotary Platinum V.EU file system, calibrated to 350 rpm and 2.2 torque; 25.06 files were used in the mesiobuccal and mesiolingual canals, whereas a 30.06 file was used in the distal canal. Every tooth received a brand-new file set. The irrigation regimen for all specimens consisted of 5 mL of 3% sodium hypochlorite followed by a 5 mL saline rinse.

Postinstrumentation cone-beam computed tomography
Once instrumentation was complete, the same operators assigned to each group rescanned the teeth using MyRay software, focusing on axial-plane views.

Measurement and analysis
• The extent of CT was determined through the equation ([a1 − a2]−[b1 − b2]), where a1 and b1 stand for the shortest mesial and distal root edge distances to the canal before preparation, and a2 and b2 represent those same distances after preparation. An outcome of "0" signals no transportation whatsoever; any figure diverging from zero confirms its occurrence
• The CA metric relied on the ratio (a1 − a2)/(b1 − b2) or its inverse (b1 − b2)/(a1 − a2), under the rule that a final reading of "1" equates to ideal centering
• What remained of the dentin thickness was obtained by deducting post-preparation canal measurements from their pre-preparation counterparts.

Statistical analysis
SPSS version 23 (IBM Corp., Armonk, New York, United States) was used for all computations. Group differences were probed with a one-way analysis of variance, supplemented by Tukey's post hoc multiple-comparison testing, with P < 0.05 as the threshold for statistical significance.

Results and Discussion

When mean CT and CA values were compared, highly significant differences (P < 0.01) were observed between Group 1 (TEC) and Group 2 (CAC), and between Group 1 (TEC) and Group 3 (TrEC). The pattern of dentin removal revealed that Group 1 (TEC) shed the most tissue at the 3 mm level, with progressively diminishing amounts at 5 mm and 7 mm. Breaking this down further, Group 1 (TEC) reached peak CT at 3 mm within the mesiobuccal and mesiolingual canals, while the distal canal hit its maximum at 5 mm. Across all three experimental groups, centering ability was superior at the 5 mm mark, with 7 mm next, in both the distal and mesial canals. Tukey's post hoc analysis confirmed that Group 1 (TEC) differed significantly from Groups 2 (CAC) and 3 (TrEC) for CT at 3 mm, 5 mm, and 7 mm throughout the distal, mesiobuccal, and mesiolingual canals. Significant disparities in centering ability were likewise found at 5 mm within the distal and mesiobuccal canals, and at 7 mm within the distal, mesiobuccal, and mesiolingual canals. These findings are represented visually in **Figures 1 and 2**.

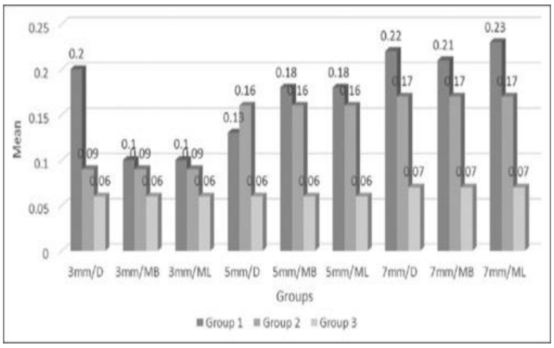

Figure 1. Intergroup comparison of canal transportation assessed at the 3 mm, 5 mm, and 7 mm levels.

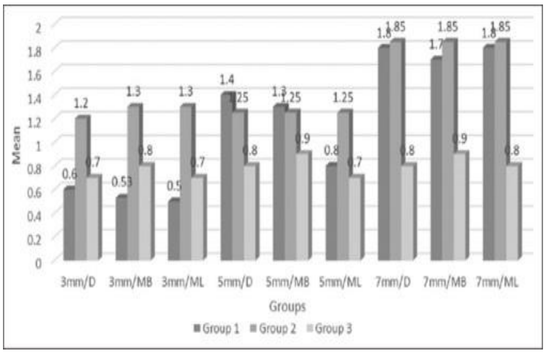

Figure 2. Intergroup comparison of centering ability assessed at the 3 mm, 5 mm, and 7 mm levels. Both graphs collectively underscore that the style of access cavity preparation significantly affects canal transportation and centering ability during root canal instrumentation, with the minimally invasive strategies (CAC and TrEC) outperforming the traditional design (TEC) at all three measured levels: 3 mm, 5 mm, and 7 mm.

The EAC represents a fundamental opening phase in nonsurgical root canal therapy, with the dual objectives of establishing an unobstructed path to the canal orifices and conserving as much sound tooth substance as possible [1].
Mandibular molars, which count among the earliest permanent teeth to emerge and are highly susceptible to caries and pulpal pathology, commonly necessitate root canal intervention [10]. Yet, when clinicians search for supplementary canals in these teeth, there is a risk of unnecessarily sacrificing healthy dentin, which may compromise the tooth's structural integrity and increase the likelihood of vertical fracture. The literature contains only a limited number of investigations employing mandibular molars as the test model. For this reason, the current work chose mandibular molars featuring straight canals as the

experimental substrate, departing from the curved-canal model utilized in the original publication by Wang *et al*. [1].

Preserving tooth structure is one of the principal determinants of the long-term success of endodontically treated teeth [11]. Jiang *et al*. [12] highlighted the crucial role of the intact pulp chamber roof in distributing occlusal loads. When this anatomical structure is lost—whether through iatrogenic or noniatrogenic causes—the functional dispersal of stress may be disrupted. Prompted by these issues, the present study set out to compare the impact of dentin conservation using newer, minimally invasive access configurations (conservative access cavity [CAC] and truss access cavity [TrEC]) against the conventional method (traditional access cavity [TEC]) on canal centering and transportation behavior in mandibular molars.

CT describes the propensity of endodontic instruments to stray from their intended trajectory during mechanical preparation. This phenomenon can create ledges or perforations, most notably within the apical half of the canal. CA quantifies an instrument's capacity to hold a central position inside the canal throughout the shaping procedure. Clark and Khademi [3], together with Abou-Elnaga *et al*. [13], have stressed that the depletion of tooth structure constitutes the primary factor behind the heightened fracture susceptibility observed in root canal-treated teeth [14]. The results of this investigation led to the rejection of the null hypothesis, revealing that both CAC and TrEC conserved significantly more dentin than TEC. The volume of dentin removed did not differ meaningfully between CAC and TrEC, a finding consistent with earlier reports indicating that minimally invasive strategies are associated with reduced dentin sacrifice, particularly within the middle and apical thirds of the root canal. In the present work, the Platinum V.EU rotary file system produced greater CT at 7 mm, followed by 5 mm and 3 mm, whereas superior CA was recorded at 7 mm, then at 5 mm and 3 mm. Such behavior may stem from the file's proprietary 360° cross-sectional geometry, its more pliable flat design, and its clockwise spirals, all of which facilitate debris clearance and lessen instrument constraint [9]. That said, inconsistencies at the file tips and micro-surface irregularities can introduce variability in performance, as documented by earlier investigators. Martins *et al.* [9] noted that flat-sided rotary files were outperformed by reciprocating counterparts in terms of cyclic fatigue resistance, peak torque, and flexibility, a discrepancy attributed to manufacturing variations.

When individual canals were compared, the distal canal experienced the greatest degree of CT, with the mesiolingual and mesiobuccal canals following in descending order. Correspondingly, CA was most pronounced in the distal canal, then in the mesiobuccal canal, and finally in the mesiolingual canal. These observations underscore the considerable influence that canal morphology exerts on instrument behavior.

Multiple-comparison testing revealed a significant difference in TEC between CT at the cervical, middle, and coronal thirds. For CA, TEC displayed a significant divergence at the middle and apical thirds. Cross-referencing with studies conducted by Rover *et al*. [15], who employed reciprocating instruments, and Moore *et al*. [16], who trialed different rotary systems, reveals disparate CT and CA outcomes. Such discrepancies likely arise from variations in root curvature, intricacies of file design (encompassing tip configuration, flute pattern, cutting edge geometry, and taper), metallurgical characteristics, and the practitioner's level of experience—each of which can sway procedural results [15-18]. Martins *et al.* [9] remarked that Platinum V.EU files exhibit more pronounced surface micro-irregularities and greater dimensional variability at their tips. These design attributes may partly account for their diminished performance and the inconsistencies observed during canal preparation.

To summarize, the present study reinforces the advantages of CAC and TrEC over TEC for dentin preservation. This property may, in turn, enhance the durability and structural soundness of endodontically treated teeth. Selecting an appropriate access cavity design, together with a compatible instrumentation system, is pivotal for achieving optimal canal shaping outcomes and requires careful judgment tailored to each tooth's unique anatomy and the dictates of the clinical situation. Additional studies are needed to explore the long-term clinical outcomes and patient-centered measures associated with varying access cavity designs and instrumentation systems across a range of clinical contexts.

Limitations

1. The observations drawn from this investigation pertain solely to straight canals; outcomes could diverge when curved canals are involved. Future studies ought to examine curved canal anatomies to build a more complete picture of how access cavity design influences CT and CA under those conditions
2. More extensive evaluation of the Bondent platinum file system is justified to gauge its overall instrument effectiveness. Moreover, the application of high-

resolution imaging modalities, such as micro-computed tomography, could yield finer detail on the subtleties of canal instrumentation and the performance characteristics of different file systems.

Conclusion

The current study revealed that both the truss access cavity (TrEC) and conservative access cavity (CEC) configurations preserved greater amounts of dentin at the 5 mm and 3 mm levels than traditional access cavities (TEC). At the 7 mm level, no significant differences were detected among the three groups. In addition, CT and CA did not differ significantly between TrEC and CEC, suggesting equivalent performance of these minimally invasive access cavity designs.

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