ORIGINAL ARTICLE

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To evaluate structural loss during selective re-treatment of mandibular incisors between conventional and static guided technique using customized re-treatment bur - an in vitro study

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Purpose: The present study aimed to compare and evaluate the extent of structural loss during selective endodontic retreatment of mandibular incisors using conventional burs versus customized retreatment burs.

Methods: Twenty-six extracted mandibular anterior teeth exhibiting two canals, confirmed through intraoral periapical radiographs in the mesiodistal dimension, were selected for the study. Access cavity preparation was selectively performed for buccal canal and lingual canal was intentionally missed. Biomechanical instrumentation and obturation was completed for buccal canal following copious irrigation with 5.25% sodium hypochlorite, 0.9% saline, and 17% EDTA. The lingual canals were intentionally left untreated. Access cavity was restored using composite resin. Preoperative cone-beam computed tomography (CBCT) scans were acquired for all samples. The specimens were then randomly allocated into two groups:

• Group A: Selective retreatment performed using a customized long-shank parallel round bur guided by a static 3D-printed template to locate the missed lingual canal.

• Group B: Selective retreatment carried out using a conventional small round bur (#1) under 10× magnification.

Following the retreatment procedures, postoperative CBCT scans were obtained. Volumetric substance loss was calculated using image analysis software by comparing pre- and postoperative scans.

Results: Group A exhibited significantly lower volumetric structural loss than Group B. The use of a customized guided bur enabled precise localization of the untreated canal with minimal removal of dentinal tissue.

Conclusion: Selective endodontic retreatment of mandibular anterior teeth with two canals, when performed using a guided endodontic approach with a customized bur, results in significantly reduced structural loss compared to the conventional technique. This method enhances accuracy and preserves tooth structure, offering a clinical advantage in retreatment cases.

Keywords: Mandibular anteriors with 2 canals; selective retreatment; static guided endodontics.

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Introduction

Guided Endodontics is an innovative technique that enhances accuracy and precision in root canal treatments by utilizing CBCT and 3D-printed guides. These guides assist clinicians in navigating access cavity preparation with minimal structural loss, improving treatment predictability and post-operative healing, which is particularly valuable in retreatment cases, as it reduces learning curve and increases success rates (1).

Mandibular anterior teeth present challenges in endodontic access due to their small size and high prevalence of two canals (2). Research indicates the occurrence of second canals in right central incisor (33.5%), left central incisor (30%), right lateral incisor (33.5%), and left lateral incisor (36.5%). Gender variations also exist, with second canals found in 15.2% of men and 20.4% of women. The most common canal configuration is Vertucci Type 1, followed by Types 3, 2, 5, and 4. Traditional lingual access, often preferred for aesthetic and restorative reasons, can make canal location more challenging, further emphasizing the benefits of guided techniques (3).

The most common un-treated canals in the mandible were observed in lateral incisors with a 33.3% prevalence (4). Selective root retreatment is emerging as a conservative alternative to full retreatment, targeting only the diseased root while preserving unaffected canals. Unlike the traditional "all-or-none" approach, this technique leverages CBCT to assess periapical pathosis and selectively retreat affected areas. By minimizing unnecessary removal of restorative and obturation materials, it helps preserve more natural tooth structure (5).

One challenge in guided endodontics is selecting effective bur. Standard burs often struggle to penetrate restorations efficiently, trap debris, or fracture due to heat buildup. Many have round tips and inadequate land areas, leading to debris entrapment and ineffective use within guided stents. Long-shank burs also experience tip displacement, reducing precision. While some clinicians use implant drills for better penetration, their large size makes them impractical for mandibular anterior teeth. To address these limitations, a specialized bur was used in a study to effectively and conservatively penetrate the coronal structure or restorative material while ensuring efficient debris removal during access cavity preparation (2).

Need for the study: There is a lack of literature in CBCT based guided endodontic retreatment of mandibular anterior teeth with customized bur to evaluate the substance loss of teeth during access cavity preparation.

Null hypothesis: There is no difference in structural loss between conventional retreatment technique and static guided retreatment technique using customized bur of selective retreatment.

Materials and Methods

The study is approved by the Manubhai Patel Dental College Ethics Committee (No: IEC/MPDC_242/CONS-46/22, Date: 22/09/2022) and conducted according to Declaration of Helsinki.

26 freshly extracted mandibular anterior teeth were collected from Oral Surgery Department of Manubhai Patel Dental College and Hospital. Teeth were stored in 0.9% sterile saline solution and disinfected using a 95% alcohol solu-

Table 1. Volumetric substance loss in group A and group B

	Group A		Group B	
Sample No:	Pre- intervention	Post- intervention	Pre- intervention	Post- intervention
1	5.95	8.92	26.32	29.52
2	21.62	7.234	35.82	39.62
3	10.02	7.734	10.28	12.38
4	8.613	4.734	6.25	14.86
5	12.47	2.91	13.69	12.25
6	10.77	14.46	10.77	15.56
7	12.43	16.54	8.988	21.56
8	14.82	7.246	14.81	22.06
9	25.92	15.99	10.84	18.06
10	30.9	15	14.92	14.42
11	16.67	7.443	23.68	18.96
12	17.79	8.25	18.15	17.87
13	22.62	10.42	20.89	22.21
Mean Value	16.20	9.76	16.57	19.95

tion. Based on an estimated 49% difference in substance loss between the two groups, a minimum of 13 teeth per group was selected to achieve 95% confidence and 80% statistical power (Table 1).

Formula for sample size calculation:

• n=Sample size per group

• Z_{1-a}=Z-score corresponding to the desired confidence level (e.g., 1.96 for 95%)

• $Z_{1-\beta}$=Z-score corresponding to the power of the test (e.g., 0.84 for 80% power)

• SD=Estimated standard deviation of the outcome variable

• d=Effect size (difference in means between groups)

Inclusion Criteria: Permanent mandibular anterior teeth with two canals, confirmed using IOPA in mesiodistal view. Only non-carious teeth with intact anatomy were selected to ensure standardized conditions for the study

Exclusion Criteria: Teeth with cracks or fractures, anatomical or morphological variations, or a single canal were excluded from the study. Additionally, grossly carious teeth and samples that did not exhibit two canals in the CBCT scan after RCT were also excluded.

In all 26 samples, access was performed using a #1 round bur (Mani, Japan). Root canal negotiation and apical patency were then achieved using a #10 K-file (Mani, Japan), but only in buccal canal, leaving the lingual canal untouched until the instrument tip appeared at apical foramen. Working length was set 1 mm short of this point (Fig. 1).

Root canal preparation was done using NeoEndo S rotary files (25/4) (Orikam Health India Pvt. Ltd.) with an ENDO MATE DT Endomotor and 16:1 contra-angle, as per manufacturer's instructions. Reaming and filing were combined with copious irrigation. Canals were irrigated with 6 mL of 2.5% NaOCl, 6 mL of 17% EDTA (Biodinamica, Brazil), and again 6 mL of 2.5% NaOCl, each agitated ultrasonically (Irrisonic, Brazil) in three 20-second cycles. Final rinse was with 5 mL distilled water.

Following instrumentation, canals were dried with sterile paper points and master cone radiographs were taken. Only buccal canals were obturated using single cone technique with gutta-percha and AH Plus sealer, simulating missed lingual canals. Coronal sealing was done with flowable composite, followed by composite restoration, finishing, and polishing. Samples were embedded in clear cold-cure resin (4×3 cm) for CBCT scanning. Pre-intervention CBCT (Veraview Pox 3D R-200, J. Morita, Japan) confirmed buccal canal obturation. Samples were divided into Group A (static guided retreatment, n=13) and Group B (conventional retreatment, n=13). CBCT scans were stored as DICOM files for analysis.

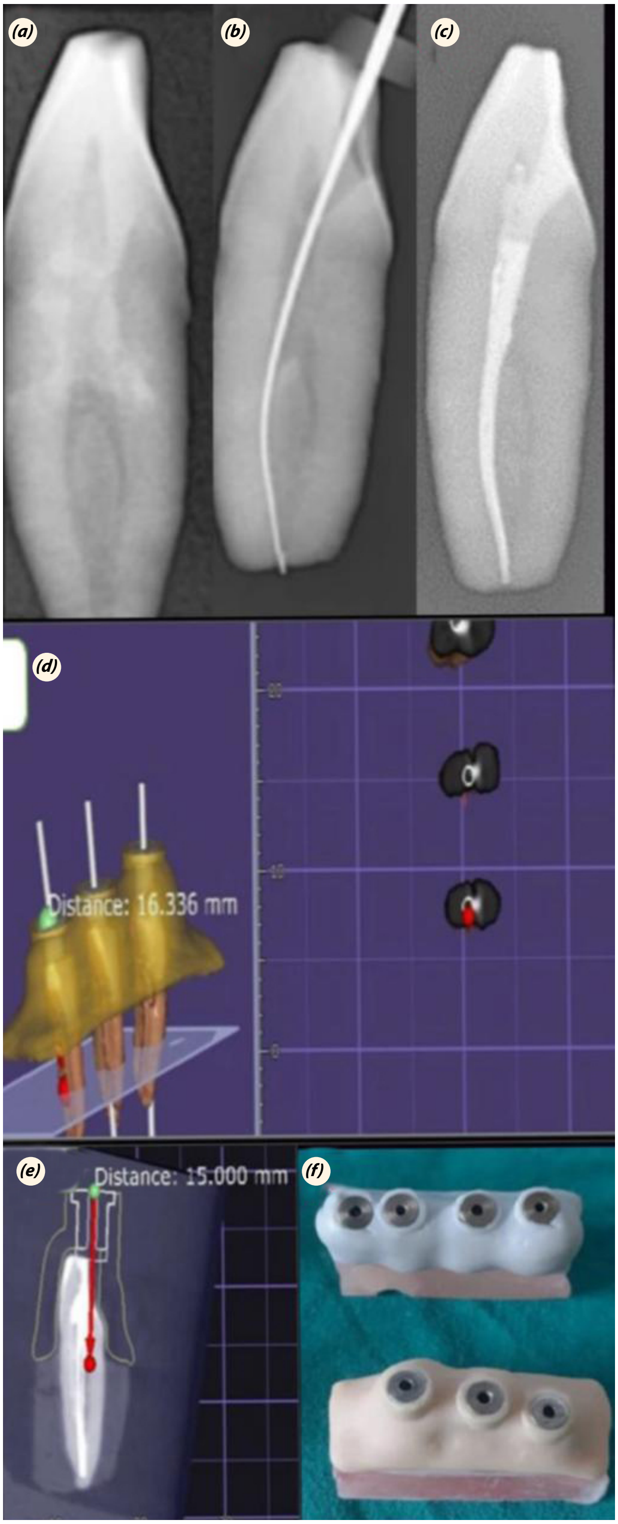

Fig. 1. **(a)** IOPA radiograph taken keeping the tooth in mesio-distal Position (showing 2 canals in mandibular incisors); **(b)** Working length into buccal canal; **(c)** Obturation of only buccal canal was carried out for all 26 sample teeth. **(d)** Virtual planning for static guided endodontic retreatment (Group A) **(e)** Virtual identification of lingual canal with customized bur length (Group A) **(f)**13 sample with static guided retreatment stent to locate the untreated canals (Group A).

Group A Methodology

Selective Retreatment with Guided Endodontics (N=13)

In this group (n=13), the previously untreated or missed lingual canal was accessed using a customized long-shank tungsten carbide bur (Design Patent No. 351977-001) guided through a static endodontic template (Fig. 2). The previously obturated teeth were embedded in acrylic blocks (dimensions: 4 cm×2 cm) to facilitate handling and stability. A pre-intervention cone-beam computed tomography scan was performed to confirm the presence of two canals in the mandibular anterior teeth and to aid in the virtual planning of static guided endodontic retreatment.

Digital impressions of both the tooth models and template site were captured using a 3D scanner (Shining 3D Autoscan DS-200, China). The corresponding STL and DICOM files were imported into the Exocad Dental CAD software (Exocad GmbH, Germany), where anatomical alignment of the scans was performed to ensure accuracy.

To guide access to the missed lingual canal, a virtual model of a customized bur (1 mm diameter) was integrated into the planning. Based on this, a surgical guide template was designed with a 1 mm diameter sleeve and 3D printed (Nextdent B.V., 3D Systems, Netherlands). Each operator was provided with the printed guide and corresponding bur. The procedures were then executed using the static guided technique to accurately localize and access the untreated lingual canal in each sample.

For Group A, a customized bur was fabricated to overcome the restricted access typically encountered at the orifice level of mandibular anterior teeth. This tungsten carbide bur was specially designed with a 31 mm long shank and a 1 mm diameter. It featured lateral flutes for effective debris evacuation and a round tip with an adequate land area to minimize iatrogenic damage. The bur design facilitated precise access through the 3D-printed guide while reducing heat generation during preparation.

Clinical procedures were conducted using this guided approach. When the previously untreated lingual canal was successfully located and negotiated, a periapical radiograph was obtained with a #10 K-file in place to confirm canal patency and treatment success. Subsequently, a post-intervention CBCT scan (4×4 cm field of view, 2.39 mGy, 90 kV, 5 mA; J. Morita Manufacturing Corp., Kyoto, Japan) was performed for all samples. The scans were evaluated by an experienced radiologist to assess and compare substance loss resulting from the intervention.

Group B Methodology

Selective Retreatment with Conventional Endodontics (N=13)

Using pre-intervention CBCT data, linear measurements were recorded from the lingual incisal edge to the point of canal bifurcation to guide re-entry and localization of the untreated lingual canal. Selective retreatment was then initiated by penetrating the coronal composite restoration with a small round bur (BR-45, Mani, Takenzawa, Japan), under 10× magnification (DNT Dental Microscope, Gurgaon, Haryana). This approach was meticulously guided by the preoperative CBCT measurements to enhance accuracy in locating the canal orifice.

Upon successful access and negotiation of the untreated lingual canal, a periapical radiograph was taken with a K-file in situ to confirm canal patency and treatment success. A post-intervention CBCT scan was subsequently performed on all samples to assess and compare substance loss following the procedure.

Volumetric Analysis (Group A + B)

Volumetric analysis of CBCT data was performed using Ez-3Di software (version 5.0.0.2, Vatech, South Korea). Measurements were obtained from the lingual access open-

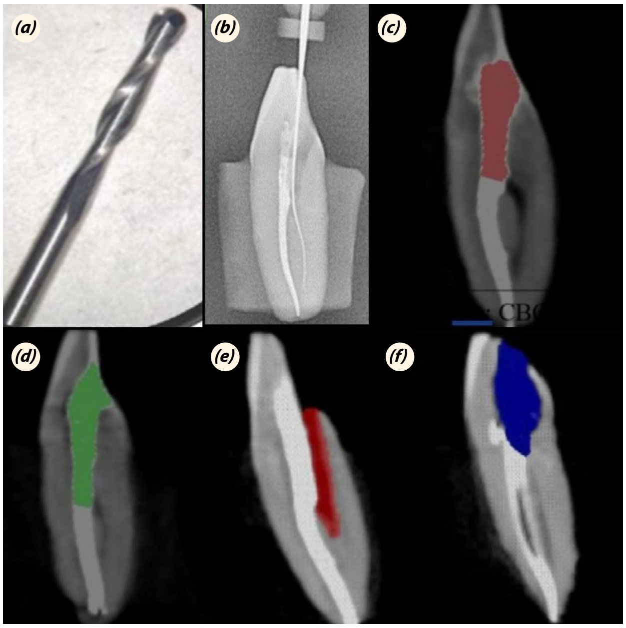

Fig. 2. **(a)** A customized Tungsten Carbide bur with a length of 31 mm and a diameter of 1.00 mm with lateral flutes and a round tip with the sufficient land area was used to facilitate the removal of debris during access preparation; **(b)** Untreated canal was negotiated with #10 k file and the length of the same was verified on IOPA. (Group A); **(c)** CBCT scans taken for volume analysis in Group A Calculated From the lingual access opening upto the level of bifurcation Group A (n=13); **(d)** CBCT scans taken for volume analysis in Group B Calculated From the lingual access opening upto the level of bifurcation Group B (n=13); **(e)** Volumetric loss of Group A (guided) While locating missed lingual canal Avg substance loss: 9.76 mm^3 **(f)** Volumetric Loss of Group B (conventional) while Locating missed lingual canal Avg substance Loss: 19.9 5mm^3

ing to the point of canal bifurcation in the mandibular anterior teeth across all 26 samples, where the buccal canal had been previously obturated. These initial volumes were used to standardize the comparison of substance loss between guided access preparations (Group A) and conventional techniques (Group B).

Following completion of the procedures, post-intervention CBCT scans were acquired for all models in both groups. Volumetric substance loss was again assessed using Ez-3Di software. All measurements were performed by a single calibrated observer to maintain consistency. The slice thickness and slice interval set to 0.1 mm. Measurements were conducted primarily in the sagittal plane, with corroborating data obtained from corresponding coronal and axial sections. The extent of tooth structure loss was quantified up to the canal orifice and extended to the level of exposed gutta-percha in both treatment groups.

Results

The statistical analysis was done using Statistical Package for Social Sciences (SPSS) software, version 20.0 (IBM, USA). Descriptive analysis was performed. Independent t-test was applied for comparison of substance loss in two groups. An independent t-test was performed to compare the means between two independent groups and determine whether the observed differences were statistically significant. Chi-square test was applied for comparison of the categorical variables and to determine whether the observed distribution differed significantly from what was expected by chance between the two groups.

Pre-operative CBCT volumes were similar between the groups: 16.20 mm^3 (Group A) and 16.57 mm^3 (Group B). Post-operatively, mean substance loss was significantly lower in Group A (9.76 mm^3) compared to Group B (19.95 mm^3), where treatment was performed under 10× magnification. The difference was statistically significant (t=4.186), indicating greater structural preservation with the static guided technique. An experienced radiologist conducted all CBCT volume assessments.

An independent t-test was conducted to compare the amount of substance loss between Group A (Conventional technique) and Group B (Static guided technique). The mean substance loss for Group A was 9.76±4.39, whereas Group B demonstrated a significantly higher mean substance loss of 19.95±7.59 (Table 2) The statistical analysis revealed a t-value of 4.186 with a p-value <0.001, indicating that the difference between the two groups was highly significant. This suggests that the static guided technique resulted in significantly less substance loss compared to the conventional technique. The findings highlight the choice of technique has a substantial impact on the extent of structural loss during the procedure.

Discussion

Endodontic and retreatment procedures can weaken tooth structure due to dentin dehydration and hard tissue removal, especially in patients with parafunctional habits. To improve the prognosis of retreated teeth, preserving remaining tooth structure is essential. Guided endodontics offers a minimally invasive solution by using 3D-printed guides to locate canals, previously used mainly for calcified cases (6,7). This in-vitro study applied the technique to detect missed lingual canals in mandibular anterior teeth. Compared to conventional methods, guided endodontics reduces unnecessary dentin loss and improves precision, even when magnification is used (8)

Modern restorative dentistry and endodontics emphasize preserving healthy tooth structure through minimally invasive techniques. While primary root canal therapy has a high success rate (86–98%), retreatment becomes more complex when it fails (9). A systematic review by Torabinejad et al. (10) found nonsurgical retreatment to be more successful (83%) than surgical approaches (71.8%) over 4–6 years. Success depends on proper shaping, disinfection, and three-dimensional obturation; failure in these steps increases the risk of treatment failure (11).

Several factors have been identified as contributors to endodontic failure, including persistent bacterial infection, inadequate obturation, and the presence of untreated or missed canals. Notably, missed canals have been reported to account for 12% to 42% of root canal treatment (RCT) failures across various populations (11). Mandibular permanent anterior teeth are known to exhibit significant anatomical variability. Approximately 15% of single-rooted mandibular anterior teeth possess two canals, and up to 5% may have two roots with separate canals (12). Retrospective CBCT studies further reveal that 30% to 40% of

Table 2. Comparison of substance loss between groups using independent t-test

Group	N	Mean	Std. Deviation	t-value	p-value
Group A	13	9.76	4.39		
Group B	13	19.95	7.59	4.186	<0.001

mandibular central and lateral incisors and canines exhibit two canals (13).

Accurate identification and treatment of all canals in mandibular anterior teeth are essential for a favorable prognosis. Missed canals may harbor persistent microorganisms, potentially leading to or sustaining apical periodontitis and thereby compromising treatment outcomes (11).

Conventional retreatment often leads to excessive tooth structure loss, weakening the tooth and increasing the risk of microcracks and thermal damage from high-speed rotary instruments (6). Studies by Lertchirakarn, Palamara, and others have shown that remaining dentin directly influences a tooth's resistance to lateral forces and fracture, highlighting the need to preserve root thickness. Elective retreatment of mandibular anterior teeth, supported by conservative methods like CBCT planning and 3D printing, offers a promising alternative to traditional techniques (14).

Static Guided Endodontic Retreatment (SGER) is an emerging solution for anatomically complex or small teeth, such as mandibular anteriors, where preserving tooth structure is critical to prognosis (15). It is particularly advantageous for abutment teeth under fixed prostheses, as it minimizes substance loss. Overall, SGER offers a conservative, time-efficient, and patient-friendly approach by preserving natural tooth structure and improving patient comfort (5).

The static guided endodontic technique requires CBCT confirmation of lesions, allowing for selective treatment and preservation of unaffected canals, thereby reducing unnecessary intervention. However, CBCT has limitations—beam hardening from gutta-percha can obscure anatomy, and its spatial resolution may be inadequate for visualizing fine canal structures, as noted by Buchgreitz et al. (16,17).

It's also emphasized that inaccuracies in CBCT settings—such as low image quality, excessive slice thickness (>1 mm), and improper threshold values—can impair the precision of guided endodontic planning, leading to deviations during treatment execution (18).

Static guided endodontics offers high precision and tissue conservation but involves added time, cost, and planning for CBCT imaging and guide fabrication, limiting its widespread use. Still, CBCT and 3D-guided techniques have improved retreatment accuracy and personalized care. 3D-printed guides allow anatomy-specific treatment. A systematic review found similar accuracy between static (98.5%) and dynamic (94.5%) navigation, though dynamic systems are more costly and complex (19).

In the present study, volumetric substance loss was compared between conventional access cavities and those created using static guided access techniques. As part of the selective endodontic approach, only the buccal canal—containing sealed gutta-percha—was targeted and accessed. The decision to selectively treat or retreat one or more roots should always be guided by comprehensive clinical and radiographic evaluation, including assessment of the tooth's structural integrity following access preparation (20).

Conventional long-shank burs present several limitations, including heat generation and debris accumulation at the working end, which reduce cutting efficiency. Moreover, due to their tapered design from shank to tip, these burs often exhibit instability or "wobble" when used through the guiding sleeve of a 3D-printed template (21). To address these issues, a customized bur was specifically engineered for guided endodontic applications. Fabricated from a tungsten carbide rod, the bur features a parallel shank and a rounded tip, enabling more precise and controlled removal of tooth structure during access cavity preparation. This design minimizes wobbling, enhances procedural accuracy, and ensures a centered path under lateral forces. The bur includes lateral cutting blades extending up to 10 mm from the tip, which facilitate efficient debris removal while maintaining alignment. This innovative bur, patented in India (Design Patent No. 351977-001), allows for a more effective and conservative access opening with minimal dentin loss (19).

Virtual planning for the static guided endodontic retreatment was carried out using a 3D scanner (Shining 3D Autoscan DS-200, China). The scan data (STL) and CBCT imaging files (DICOM) were imported into the Exocad Dental CAD software for 3D alignment and planning. The virtual guide was designed by positioning a virtual sleeve over the intended access path. Once alignment was verified, the STL file was finalized, and a surgical template with integrated guide sleeves was fabricated for clinical use (19).

Static Guided Endodontics (SGE) poses several intraoperative challenges, particularly related to thermal damage. Heat generated by friction at the bur tip can lead to the formation of microcracks on the tooth surface, and excessive temperatures may adversely affect the periodontal ligament (PDL) and adjacent alveolar bone. Therefore, continuous cooling via irrigation is essential to mitigate these risks during the procedure (22). In the present in-vitro study, three mandibular anterior tooth samples were excluded due to fractures caused by heat accumulation during guided access preparation. These were replaced by three additional samples selected using the same inclusion criteria.

A laboratory study by Zubizarreta-Macho et al. (18) compared two computer-aided navigation systems to traditional freehand methods for access cavity preparation, finding that static navigation provided superior accuracy despite a relatively high mean angular deviation of 10°. Similarly, Perez et al. (23) reported that static guided endodontics achieved apical gutta-percha access in 87.5% of cases, with root curvature being the main limitation. The technique was also more time-efficient than traditional methods using ultrasonic tips or long-stem drills.

Similarly, it's reported that static guided endodontics yielded faster and more satisfactory outcomes compared to traditional techniques such as post removal using milling devices and treatment under a dental operating microscope (24). It's also emphasized that static guidance is most effective in teeth with straight canals. As noted, rigid, non-deformable nature of drill restricts its use to straight segments of canal; attempting to navigate beyond canal curvature may lead to procedural errors or damage to surrounding structures (20).

A retrospective study by Galino Buniag et al. (25) remains the only one to date with a one-year follow-up, confirming that static guided endodontic treatment is clinically as effective as conventional methods. Connert et al. (26) reported that digital planning—including scanning, guide design, and 3D printing—averaged 9.4 minutes. In a later preclinical study, the same team showed that static guidance significantly reduced treatment time (11.3 min vs. 21.8 min for freehand methods). While planning may seem time-intensive initially, it becomes more efficient with experience and ultimately reduces chairside time, dentin loss, and iatrogenic risks (1).

To minimize iatrogenic errors in delicate teeth like mandibular anteriors, magnification tools are essential during retreatment. Precise treatment of missed canals requires advanced imaging such as CBCT, which helps identify untreated canals and provides accurate measurements to the bifurcation level, supporting effective planning and execution (21).

In this study, pre-intervention CBCT scans were utilized for all samples, focusing on teeth in which only the buccal canals had been obturated, leaving the lingual canals untreated. These scans confirmed that both Group A and B exhibited comparable baseline values, thereby establishing uniformity for valid comparative analysis of access cavity techniques. Volumetric analysis of substance loss was performed using CBCT measurements from the lingual incisal edge to the furcation area, specifically targeting the missed lingual canals.

In Group A, a customized bur designed for guided endodontic access was employed to locate and treat missed lingual canals. In contrast, Group B utilized a conventional small round bur. The results demonstrated that conventional technique caused significantly greater damage to internal tooth morphology and compromised fracture resistance when compared static guided approach. Post-intervention CBCT data were analyzed using Ez-3Di software (version 5.0.0.2, Vatech, South Korea). The findings revealed that volumetric substance loss was minimal in Group A but significantly higher in Group B. Statistical analysis using independent t-test confirmed that differences in post-intervention substance loss between two groups were statistically significant.

These findings are consistent with those reported, who compared substance loss between conventional and guided retreatment techniques. In their study, mean volumetric loss in conventional retreatment group (Group 1) was 27.64 mm^3, whereas guided retreatment group demonstrated significantly less loss, averaging only 11.73 mm^3. The difference was statistically significant, with a t value of 4.591 and $P=0.001$ (19). The reduced substance loss observed in Group A of the present study can be attributed to the use of a customized bur, featuring a 1 mm diameter along its entire parallel working blade and a round cutting tip. This design facilitates highly controlled and conservative access cavity preparation, thereby preserving the internal tooth structure more effectively.

Based on these results, guided access preparation emerges as a promising technique for endodontic retreatment, especially in locating missed canals. The use of a static guide simplifies the clinician's task, shortens treatment time, and enhances accuracy while preserving natural tooth structure. This study supports guided endodontics as a conservative alternative to conventional methods, offering reduced substance loss and potentially improving the long-term prognosis of retreated teeth.

Limitations of the Study

Despite promising results, several limitations exist. Guided endodontics relies heavily on high-quality imaging and software, requiring precise patient positioning and stability. Treatment planning is more time-consuming and costly due to CBCT, intraoral scans, and guide fabrication, which may limit patient access. Anatomical variability of the second canal's location in mandibular anterior teeth affects volumetric data and leads to inconsistent results. Additionally, during retreatment, irrigants like 5.25% sodium hypochlorite used on missed canals may compromise the apical seal of previously treated canals. Finally, as an in-vitro study, the findings cannot be directly applied clinically, underscoring the need for in-vivo trials with larger populations to confirm these outcomes.

Future Scope

Looking ahead, Augmented Reality (AR) navigation holds great promise for enhancing guided endodontics. By overlaying radiographic images and navigation paths directly onto the operator's field of view via a head-up display or microscope, AR allows real-time visualization of both 3D guidance and the operative site without shifting focus. Though already applied in neurosurgery, AR has yet to be clinically adopted in endodontics. Further clinical trials are needed to validate its potential for improving precision and treatment outcomes.

Conclusion

Compared to freehand techniques, guided endodontic procedures significantly improve accuracy. Selective re-treatment using a customized long shank parallel round bur with static guided endodontics enabled precise access cavity preparation through 3D-printed templates aligned with CBCT and intraoral scans. This method effectively located missed lingual canals in mandibular anterior teeth while minimizing dentin loss. As such, it offers a highly precise, minimally invasive approach that preserves healthy tooth structure, making it a preferred option for conservative endodontic retreatment.

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Conflict of Interest: We declare that we have no conflict of interest related to this study.

Ethical Approval: The study is approved by the Manubhai Patel Dental College Ethics Committee (No: IEC/MPDC_242/CONS-46/22, Date: 22/09/2022)

Informed consent: Not applicable.

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