



ORIGINAL RESEARCH

IMPACT OF CONVENTIONAL VERSUS GUIDED FIBER-POST REMOVAL TECHNIQUES ON THE FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH: AN IN-VITRO STUDY

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Abstract

Background: Removing fiber posts during endodontic retreatment remains challenging due to their strong adhesive bonding to radicular dentin, which increases the risk of excessive dentin loss and structural compromise. Guided endodontic navigation has recently gained attention as a technique capable of enhancing precision and minimizing iatrogenic damage.

Aim: To compare and assess the fracture resistance of teeth following fiber-post removal using two techniques: conventional freehand removal and static guided endodontic navigation using two instrument systems: ultrasonic tips and Endo Tracer burs.

Materials and Methods: 36 human extracted mandibular premolars with standardized morphology were prepared using a rotary nickel–titanium system and root canal filled using the single obturation cone technique and AH Plus root canal sealer. Fiber posts (0.8 mm, 2% taper) were cemented using dual-cure resin cement. Teeth were mounted in custom U-shaped epoxy resin molds simulating the dental arch. Group I underwent conventional freehand post removal, while Group II used static guided navigation designed through the merging of CBCT and optical surface scans. Groups were further subdivided into two subgroups in accordance with the instrument type (ultrasonic tip ET18D or Endo Tracer bur). Fracture resistance was then measured with the use of an Instron Universal Testing device. Finally, data was analyzed using two-way ANOVA and independent t-test. Results: Guided navigation significantly increased fracture resistance compared to the conventional technique ($p < 0.001$). Ultrasonic instrumentation demonstrated higher fracture-resistance values than burs in both groups, with statistically significant differences within the guided technique ($p = 0.005$). No significant interaction was found between the technique and instrument type ($p = 0.366$).

Conclusion: Static guided endodontic navigation preserved radicular dentin and resulted in significantly higher fracture resistance than conventional freehand post removal. Ultrasonic instruments exhibited superior performance compared with burs. Guided navigation represents a safer and more conservative approach for fiber-post removal.

Keywords: Fiber post removal, guided endodontics, fracture resistance, ultrasonic tips, ET18D, Endo Tracer bur, static navigation.

INTRODUCTION

Fiber posts are known widely to be used in restoring previously endodontically treated teeth because of their favorable mechanical properties, esthetics, and bonding compatibility with restorative materials.¹ However, retreatment cases involving previously cemented fiber posts pose substantial clinical challenges.

Advances in adhesive technologies have increased the strength of the bond between posts and radicular dentin, complicating their

removal while also increasing risk of structural compromise. Conventional freehand post removal relies heavily on operator skill and visual-tactile feedback. This approach often leads to deviations from the original canal path, excessive dentin removal, and higher chances of perforation or weakening of the root. These complications may negatively affect long-term prognosis by reducing the fracture resistance of the tooth.²

Static guided endodontic navigation adapted from implantology, and microsurgery has emerged as a

technique capable of restricting instrument movement to a pre-planned digital path. This technique may allow more conservative preparation and greater preservation of radicular structure, with potential benefits including increased fracture resistance and procedural accuracy.^{3,4} Although guided endodontic systems have shown promising outcomes in preparation of access cavities, calcified canals location attempts, and degradation of fiber posts, limited evidence exists evaluating their influence on the mechanical performance of the tooth after post removal. Therefore, this study aimed to evaluate and compare the fracture resistance of these endodontic treated teeth following fiber-post removal using conventional freehand techniques versus static guided navigation, employing either ultrasonic tips or Endo Tracer burs.

MATERIAL AND METHODS

This study got approved by the Research Ethical Committee (REC) of the Faculty of Oral and Dental Medicine, Misr International University (MIU) (MIU-IRB-2223-243).

All patients who contributed extracted teeth provided informed consent for future scientific use.

Sample Size Calculation Power analysis was conducted to detect differences in fracture resistance. Using $\alpha = 0.05$, $\beta = 0.20$ (power = 80%), and effect size $f = 0.618$ (from prior research), the total required sample size was 36 teeth (18 per group, 9 per subgroup), calculated using G*Power 3.1.9.7.⁵

Sample Selection

Thirty-six extracted human mandibular premolars were included in accordance with: Inclusion Criteria (Intact crowns and roots, Mature apices, Type I canal configuration, and no previous root canal treatment), Exclusion Criteria (Root defects, caries, or cracks, Calcification or apical resorption, Multiple canals). Teeth were standardized in buccolingual and mesiodistal dimensions.

Teeth were cleaned with ultrasonic scaling, sterilized via autoclave at 121° C for 20 minutes, and kept in distilled water until use. Teeth after then were randomly allocated into two main groups depending on the technique utilized in fiber post removal, Group I – Conventional Technique (n=18), Group II – Guided Technique (n=18). Each group was further subdivided later into two subgroups according to

the instrument used in the removal of the fiber post, Subgroup A: Ultrasonic tip ET18D, while Subgroup B: Yellow-coated Endo Tracer bur.

Preparation of Samples

Teeth were decoronated to 14 mm root length using a diamond disk under coolant. (6) Root canal were prepared following the crown-down technique using the EDGE X7 rotary system reaching size 40/0.04. (7,8,9)

Irrigation was performed with 5.25% NaOCl^{10,11,17}, followed by drying and filling using a single obturation cone technique with AH Plus sealer.^{12,13,14}

Post spaces were prepared using a white-coated ENA drill matching the fiber post size (0.8 mm). Post spaces were conditioned with phosphoric acid, rinsed, and bonded with dual-cure adhesive. Posts were positioned and cemented with a dual-cure resin cement, light-cured for 40s, and trimmed at the orifice level.^{6,10,16,17} For materials settlement, teeth were stored in 100% humidity.

Mold Preparation

A 2-mm wax layer was applied around each tooth below the CEJ to act as a separating medium. The teeth were then fixed individually to a surveyor using sticky wax in a standardized U-shaped arch arrangement, with the distance between surveyor arms set at 1.5 cm. A custom U-shaped mold (5 cm in the diameter, and 1.2 cm in the height) was placed beneath the teeth.

Each tooth was lowered into the mold so that 3 mm of root surface below the CEJ was embedded, simulating biological width and allowing space for thermocouple placement. Transparent epoxy resin was poured slowly into the mold to the predetermined level. After 24 hours of setting, the mold was placed in a 60–70°

C water bath to melt the wax layer, enabling easy removal and repositioning of the teeth within the cured resin block.^{16,18,19}

CBCT and Digital Scanning

CBCT imaging was performed using a KODAC 9000 unit with a 5.0 × 5.0 cm as the field of view, and 150 μm voxel size, 90 kV, 12.5 mA, with 15.022-second exposure, and the images were saved as DICOM files.

Each mold was digitally scanned using an intraoral scanner following a standardized protocol: starting from the occluso-lingual surfaces on the right side, moving to the left, then scanning back from the buccal surfaces. The surface scans were exported as STL

files. The DICOM and STL data were subsequently overlaid using DDS-Pro software (version 2.22.0_2024), which was used for virtual planning and guide fabrication.

Fabrication of 3D-Printed Endodontic Guides

In the software, the DICOM and STL files were overlapped, and each post was identified to determine the appropriate sleeve path. A pre-existing implant tool was used to mark the drill path parallel to the post, with its length set to the full post depth and ending 5 mm from the root apex. A coronal guidance hole was then placed to mark the start of the post. The metal sleeve, prefabricated from brass using a desktop milling machine and designed with CAD software, had an inner diameter of 2 mm and an outer diameter of 3 mm. Two guides were designed for each subgroup, virtually exported as STL files, and printed using a DLP 3D

printer with transparent resin. After printing, the guides were rinsed with 99% isopropyl alcohol, cured with ultraviolet light, and finished using rubber polishing cups and sandpaper discs.

Post Removal Procedures

Group I – Conventional Freehand

Post removal was performed under 10× magnification. In Subgroup A: Ultrasonic ET18D tip with intermittent cutting and water cooling was used, while in Subgroup B: Endo Tracer bur used axially with saline irrigation. Removal was confirmed visually under magnification and radiographically. (20,27) (Fig 1)

A

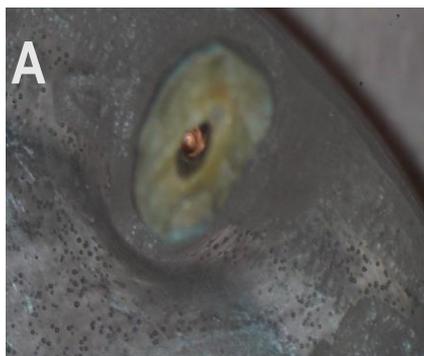


Figure (1): A) Photograph showing post degradation procedure under microscope, B) Photograph showing visualization of gutta percha apical to the fiber post after degradation.

Group II – Static Guided Navigation

Guides were fitted, and the same instruments were used through the guide sleeves following the digitally planned path. Post removal verification followed the same protocol. (Fig. 2)



Figure (2) photograph showing static guide on mold.

Evaluation of Fracture Resistance

Specimens were mounted on an Instron Universal Testing Machine (model 3345), Instron, Norwood, Massachusetts, USA. A steel rod applied an axial compressive load at 1 mm/min until the fracture happened. The maximum break load (N) was then recorded using BlueHill software. (22)

RESULTS

Values of mean and standard deviation were then calculated for each main group in each test. Data then were examined for normality through the Kolmogorov-Smirnov and Shapiro-Wilk tests, and the data manifested parametric (normal) distribution.

The two-way ANOVA test was utilized to find out the interactions present between the different variables. Independent sample t-tests were used to do the comparison in between two groups within non-related samples.

The level of the significance was set to $P \leq 0.05$. the statistical analysis was done using IBM® SPSS® Statistics Version 25.

Effect of subgroups:

Group I (Conventional Technique)

No statistical significant difference was found between the subgroups A(Ultrasonic), and B(Bur) ($p = 0.328$). Subgroup A showed a slightly higher mean value.

Group II (Guided Technique)

While a statistical significant difference was found between Subgroup A and Subgroup B ($p = 0.005$). With Subgroup A that demonstrates higher fracture resistance than Subgroup B.

Effect of groups:

Both in Subgroup A (Ultrasonic ET18D) and Sub group B (Endo Tracer Bur), Guided navigation resulted in the presence of significant higher fracture resistance values comparing it with the conventional technique ($p < 0.001$). (Table 1)

Table 1 Mean and, standard deviation (SD) values for the fracture resistance of the groups.

Variables	Fracture resistance				p-value
	Group I		Group II		
	Mean	SD	Mean	SD	
Subgroup A	81.33	6.69	108.77	4.97	<0.001*
Subgroup B	78.39	5.63	102.64	2.79	<0.001*
p-value	0.328ns		0.005*		

*, significant (p<0.05) ns; non-significant (p>0.05)

Effect among groups regardless of the subgroups:

Statistically significant difference was present t between (Group I) and (Group II) where (p<0.001). The highest mean value was noted in (Group II), in contrast with the lowest mean value that was noted in (Group I). (Table 2)

Table 2. Mean and, standard deviation (SD) values for the fracture resistance of among groups regardless of the subgroups.

Variables	Fracture resistance	
	Mean	SD
Group I	79.86	6.19
Group II	105.71	5.02
p-value	<0.001*	

*, significant (p<0.05)

Effect among subgroups regardless of the groups:

No statistically significant difference was noted between (Subgroup A) and (Subgroup B) where (p=0.347). The highest mean value noted was found in (Subgroup A), in contrast with the lowest mean value that was found in (Subgroup B).

Table 3. Mean and standard deviation (SD) values for the fracture resistance among groups regardless of the groups.

Variables	Fracture resistance	
	Mean	SD
Subgroup A	95.05	3.59
Subgroup B	90.52	3.11
p-value	0.347ns	

ns; non-significant (p>0).

DISCUSSION

In contrast, the conventional freehand technique depends solely on the operator's tactile sensation and visual magnification. Even under a dental microscope, it is difficult to differentiate between the resin matrix of the post, cement layer, and surrounding dentin, especially when anatomical variations or limited visibility are present. This increases the likelihood of iatrogenic dentin loss, external stripping, or internal notching all factors that reduce root strength and predispose to vertical root fractures. The significantly lower fracture resistance values observed in the conventional groups reflect these limitations.^{29,30}

Across both techniques, ultrasonic tips yielded higher fracture resistance values than Endo Tracer burs. Ultrasonic tips (ET18D) exhibit selective cutting efficiency, focusing more on the composite post material rather than aggressively removing dentin. (31) The fine diamond coating and slender design produce vibration-based abrasion that gradually degrades the post while enabling the operator to maintain controlled instrument contact. This selective removal reduces the risk of dentin over-preparation during post removal.

Endo Tracer burs, although precise and commonly used in endodontic retreatment, possess a higher cutting aggressiveness due to their rotary action and diamond-coated surfaces.³² When used freehand, this may lead to unintentional over-preparation of the apical extension or enlargement of the post space, especially in narrower or anatomically curved roots. This can weaken the remaining radicular dentin and consequently lower the fracture resistance.³²

However, the effect of instrument type was significant only within the guided technique. This indicates that when the instrument's path is tightly controlled as in guided navigation the intrinsic properties of the tool (e.g., abrasiveness, precision, vibration pattern) become more influential. In contrast, within the freehand technique, human variability and difficulty in maintaining an accurate trajectory overshadow the differences between instruments, leading to generally lower and more comparable fracture resistance values.^{33,34}

CONCLUSION

The results suggested that guided navigation plays a dominant role in structural preservation. Even the bur subgroup within the guided technique performed significantly better than both subgroups in the freehand technique. This underscores that precision of instrument path is more important than the instrument itself in determining mechanical outcomes.

Given that vertical root fractures are a leading cause of tooth loss in retreatment cases, the ability to maintain high fracture resistance is essential for long-term success. Thus, the results of this study carried significant clinical relevance regarding using Guided endodontics for fiber-post removal, especially in cases of deep posts, calcified canals, or thin roots. Also, the Ultrasonic tips may be preferred over burs, particularly when combined with guided navigation, to enhance precision and minimize radicular dentin loss.³⁰

DECLARATIONS .

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Competing Interests

The no competing interests .

REFERENCES

1. Ferrari M, Vichi A, Garcia-Godoy FR. Clinical evaluation of fiber-reinforced epoxy resin posts and cast post and cores. *American journal of dentistry*. 2000 May 1;13(Spec No):15B-8B.
2. Krastl G, Zehnder MS, Connert T, Weiger R, Kehl S. Guided endodontics: a novel treatment approach for teeth with pulp canal calcification and apical pathology. *Dental traumatology*. 2016 Jun;32(3):240-6.
3. Hildebrand H, Leontiev W, Krastl G, Weiger R, Dagassan-Berndt D, Birklein S, Connert T. Guided endodontics versus conventional access cavity preparation: an ex vivo comparative study of substance loss. *BMC Oral Health*. 2023 Oct 4;23(1):713.
4. Alfadda A, Alfadley A, Jamleh A. Fiber Post Removal Using a Conservative Fully Guided Approach: A Dental Technique. *Case Reports in Dentistry*. 2022 22;2022.
5. Faul F, Erdfelder E, Lang AG, Buchner A. G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior research methods*. 2007 May;39(2):175-91.
6. D' Arcangelo C, D' Amario M, De Angelis F, Zazzeroni S, Vadini M, Caputi S. Effect of application technique of luting agent on the retention of three types of fiber-reinforced post systems. *Journal of Endodontics*. 2007 1;33(11):1378-82.
7. Galal MM, Ismail AG, Omar N. Stress analysis of different experimental finite element models of rotary endodontic instruments. 2025; 49:22.
8. Hussein AA, Galal MM, Sabet NE. The influence of a thermomechanical treatment on the cutting efficiency of NiTi endodontic rotary file. 2025; 68:297.
9. Bakr MM, Mobarak AM, Abdallah AM. EVALUATION OF THE SHAPING ABILITY OF EDGEFILE X-7, XP-ENDO SHAPER AND TRUNATOMY ROTARY FILES IN MESIOBUCCAL CANALS OF LOWER MANDIBULAR MOLARS

USING CONE BEAM COMPUTED TOMOGRAPHY (IN-VITRO STUDY). Alexandria Dental Journal. 2023 Dec 1;48(3):132-7.

10. Hamdy TM, Alkabani YM, Ismail AG, et al. Impact of endodontic irrigants on surface roughness of various nickel-titanium rotary endodontic instruments. 2023; 23:517.

11. Ismail AG, Galal MM, Aly Y, Hassan SN, AlMoghazy HH. The Influence of different Disinfection and Hemostatic Procedures on Post-Operative Pain In Adult Pulpotomy: Clinical Study. (2025). Vascular and Endovascular Review, 8(9s), 1-7.

12. Galal MM, Ismail AG, Abdelnabi A, Mosallam O, Abdel Hamed KM. Evaluation of Postoperative Pain Following Adult Pulpotomy in Symptomatic Irreversible Pulpitis using MTA, Bioceramic Material, and Nanohydroxyapatite. (2025). Vascular and Endovascular Review, 8(8s), 365-371.

13. Galal MM, Ismail AG, Nashaat Y, Hamdy TM. Evaluation of the cytotoxicity, apoptotic effects, and remineralization potential of recent bioceramic-based root canal sealers. 2025; 15:4.

14. Hamdy TM, Galal MM, Ismail AG, et al. Physicochemical properties of AH Plus bioceramic sealer, Bio-C Sealer, and ADseal root canal sealer. 2024; 20:2.

15. Abella Sans F, Alatiya ZT, Val GG, Nagendrababu V, Dummer PM, Durón- Sindreu Terol F, Olivieri JG. A laboratory study comparing the static navigation technique using a bur with a conventional freehand technique using ultrasonic tips for the removal of fibre posts. International Endodontic Journal. 2024 Mar;57(3):355-68.

16. Ibrahim BH, Beleidy ME, Hamdy AM, Abdel Sadek HM. The effect of different materials and lengths of custom made post and core on the fracture resistance of endodontically treated teeth. Ain Shams Dental Journal. 2025 Mar 1;37(1):132-40.

17. Vano M, Cury AH, Goracci C, Chieffi N, Gabriele M, Tay FR, Ferrari M. The effect of immediate versus delayed cementation on the retention of different types of fiber post in canals obturated using a eugenol sealer. Journal of Endodontics. 2006 Sep 1;32(9):882-5.

18. Salman NR, AlSwafeeri H. Evaluation of shear bond strength of band cementation with different cementation materials. Egyptian Dental Journal. 2025 Oct 1;71(4):2827-34.

19. Batalocco G, Lee H, Ercoli C, Feng C, Malmstrom H. Fracture resistance of composite resin restorations and porcelain veneers in relation to residual tooth structure in fractured incisors. Dental Traumatology. 2012 Feb;28(1):75-80.

20. Galal MM, Ismail AG, Aly Y, AlMoghazy HH, Elbattawy EA. Examining Accuracy of New Apex Locators in Working Length Determination in Human

Teeth: An In Vivo Study. (2025). Vascular and Endovascular Review, (8s), 411-415.

21. Buchgreitz J, Buchgreitz M, Mortensen D, Bjørndal L. Guided access cavity preparation using cone-beam computed tomography and optical surface scans— an ex vivo study. International endodontic journal. 2016 Aug;49(8):790-5.

22. Krishnarayan PP, Gehlot PM. Influence of glass fiber post design and luting cements on ease of post removal and fracture strength of endodontically retreated teeth: An in vitro study. Journal of International Society of Preventive & Community Dentistry. 2022 Mar;12(2):199.

23. Kulinkovych-Levchuk K, Pecci-Lloret MP, Castelo-Baz P, Pecci-Lloret MR, Ocate-Sánchez RE. Guided endodontics: A literature review. International journal of environmental research and public health. 2022 Oct 26;19(21):13900.

24. Dianat O, Naseri M, Safi Y, Modaberi A, Zargar N, Peters OA, Farajollahi M. Accuracy comparison of single- and double-sleeve endodontic guides for fiber post removal. BMC Oral Health. 2024 Apr 27;24(1):497.

25. Krug R, Schwarz F, Dullin C, Leontiev W, Connert T, Krastl G, Haupt F. Removal of fiber posts using conventional versus guided endodontics: a comparative study of dentin loss and complications. Clinical Oral Investigations. 2024 Mar 4;28(3):192.

26. Zubizarreta-Macho B, de Pedro Mucoz A, Riad Deglow E, Agustín-Panadero R, Mena Blvarez J. Accuracy of computer-aided dynamic navigation compared to computer-aided static procedure for endodontic access cavities: an in vitro study. Journal of clinical medicine. 2020 Jan 2;9(1):129.

27. Farajollahi M, Dianat O, Gholami S, Saber Tahan S. Application of an endodontic static guide in fiber post removal from a compromised tooth. Case Reports in Dentistry. 2023;2023(1):7982368.

28. Ito R, Watanabe S, Satake K, Saito R, Okiji T. Accuracy and efficiency of the surgical-guide-assisted fiber post removal technique for anterior teeth: An ex vivo study. Dentistry Journal. 2024 Oct 18;12(10):333.

29. Jawed A, Alghmlas AS, Khurshid Z. Fiber post: Physics, chemistry, adhesive properties, and its implications on root canal retreatment. In Biomaterials in Endodontics 2022 Jan 1 (pp. 357-378). Woodhead Publishing.

30. Arukaslan G, Aydemir S. Comparison of the efficacies of two different fiber post-removal systems: A micro-computed tomography study. Microscopy research and technique. 2019 Apr;82(4):394-401.

31. Puri A, Abraham D, Gupta A, PURI A. Impact of Guided Endodontics on the Success of Endodontic Treatment: An Umbrella Review of Systematic Reviews and Meta-Analyses. Cureus. 2024 Sep 7;16(9).

32. Alsaeed A, Alfadley A, Jamleh A. The use of low-power ultrasonic technique in conservative fiber post removal: A report of three cases using a novel technique. Saudi Endodontic Journal. 2025 May 1;15(2):200-6.

33. Haupt F, Riggers I, Konietschke F, Rüdiger T. Effectiveness of different fiberpost removal techniques and their influence on dentinal microcrack formation. Clinical oral investigations. 2022 Apr 1:1-7.

34. Beraldo DZ, Pereira KF, Yoshinari FM, Pinto JO, de Abreu Mateus TH, Zafalon EJ. Temperature changes on external root surfaces with the use of several thermoplastic filling techniques. Journal of endodontics. 2016 Jul 1;42(7):1131-4.