Attahadi Medical Journal
2026;3(3):393-398
https://doi.org/10.69667/amj.26319

OPEN ACCESS

Original article

Evaluation of Fracture Resistance in Endodontically Treated Teeth Using Biomimetic and Conventional Approaches: An In Vitro Analysis

Manal El-Forjani, Momen Bin Zayed*, Sari Al-Sarar, Muhammad El-Fitouri, Sanad Omar Al-Mukhtar, Rawan Alshebani

Department of Conservative, Faculty of Dentistry, Attahadi University, Tripoli, Libya
***Corresponding Email.** manal.alfarjani@attahadi.edu.ly*

***Keywords**:*
Biomimetic restoration, Endodontically treated teeth, Fiber post, Fracture resistance, Short fiber-reinforced composite, Ain Shams University, Attahadi University

ABSTRACT

This study evaluated the fracture resistance of endodontically treated molars restored using a biomimetic composite approach compared to a conventional fiber post and core system. Forty extracted human molars with deep carious lesions were endodontically treated and randomly assigned to two groups (n = 20): biomimetic restoration using short fiber-reinforced composite (EverX) and Ribbond, and fiber post with composite core. Specimens were subjected to compressive loading until fracture. The biomimetic group showed significantly higher fracture resistance (1128.34 ± 192.79 N) than the fiber post group (812.28 ± 129.02 N) (p = 0.0001). Within the limitations of this in vitro study, the biomimetic approach demonstrated superior mechanical performance and may serve as a conservative alternative for restoring endodontically treated posterior teeth.

Introduction

The quality of coronal restoration is a key determinant in the success of endodontic treatment (1). Extensive loss of coronal tooth structure remains a major cause of failure and extraction in endodontically treated teeth (2). Resin composites are widely used due to their favorable aesthetic and mechanical properties; however, their effectiveness is limited in cases of severe structural loss (3).

Polyethylene fiber (PWF), such as Ribbond, has been introduced to improve fracture resistance through enhanced stress distribution and adhesion to restorative materials (4–7). Additionally, bulk-fill resin composites allow placement in larger increments with reduced polymerization shrinkage, improving clinical efficiency and performance (8–12). More recently, short fiber-reinforced composite (SFRC) has been developed to act as a reinforcing substructure capable of arresting crack propagation and withstanding occlusal forces, showing promising mechanical properties (10,13,14).

Conventional restoration of endodontically treated teeth often involves fiber-reinforced posts and composite core build-up to enhance retention and distribute functional stresses (5–8,10–12). Despite their widespread use, limitations remain in reinforcing weakened tooth structure.

Therefore, this in vitro study aimed to evaluate and compare the fracture resistance of endodontically treated molars restored using a biomimetic approach versus a conventional fiber post and core system.

This study aimed to evaluate and compare the fracture resistance of endodontically treated molar teeth restored using a biomimetic restorative approach and a conventional fiber post and core system. Additionally, it assessed the influence of these approaches on stress distribution and their ability to preserve remaining tooth structure.

Methods

Study design and sample selection

This in vitro experimental study was conducted to evaluate the fracture resistance of endodontically treated posterior molars restored using two different restorative strategies. A total of 40 freshly extracted human molars with deep carious lesions were selected according to predefined inclusion criteria. Teeth were included if they were human molars with deep carious lesions and sufficient remaining structure for restoration. Teeth with cracks, previous restorations, root resorption, or previous endodontic treatment were excluded. After extraction, all specimens were stored in 0.1% thymol solution at room temperature to inhibit microbial growth, then transferred to distilled water before the experimental procedures to prevent dehydration and preserve dentin properties (1,2).

Endodontic Treatment

All specimens underwent standardized root canal treatment. Access cavities were prepared using high-speed diamond burs under water cooling, and canal instrumentation was performed using stainless steel K-files and rotary nickel-titanium files with a crown-down technique. During instrumentation, canals were irrigated with 5% sodium hypochlorite, followed by saline as a final rinse. The canals were dried with paper points and obturated using gutta-percha cones. Group A received a bioceramic sealer, while Group B received a resin-based sealer. The specimens were then stored at 37°C and 100% humidity for one week to allow complete sealer setting (3,4)

***Received**: 06-06-2026 - **Accepted**: 03-08-2026 - **Published**: 13-08-2026*

Attahadi Medical Journal
2026;3(3):393-398
https://doi.org/10.69667/amj.26319

Restorative Procedures
Following endodontic treatment, the specimens were divided into two groups (n = 20 each). Group A, the biomimetic group, was restored using a conservative adhesive approach with Ribbond polyethylene fiber, flowable composite, short fiber-reinforced composite as a dentin substitute, and nanohybrid composite as an enamel replacement. Enamel margins were selectively etched with 37% phosphoric acid, followed by application of a two-step self-etch adhesive system. Ribbond fiber was wetted with bonding agent and adapted over a thin layer of flowable composite along areas of high stress concentration, particularly the pulpal floor and axial walls. The restoration was completed using incremental placement of short fiber-reinforced composite and nanohybrid composite (5,6).
Group B, the fiber post group, was restored using fiber posts cemented with dual-cure resin cement, followed by composite core build-up. Post space preparation was performed by removing gutta-percha while maintaining a 4 mm apical seal. The canal was prepared using corresponding drills, followed by phosphoric acid etching, universal bonding, post cementation, and composite resin build-up to restore normal tooth morphology (7).

Fracture Resistance Testing and Statistical Analysis
To simulate periodontal ligament conditions, a thin elastomeric layer was applied around the root surfaces, and each specimen was embedded in acrylic resin blocks, leaving approximately 2 mm of root exposed below the cementoenamel junction. Fracture resistance testing was performed using a universal testing machine at the Faculty of Dentistry, Ain Shams University, Egypt. Each specimen was positioned vertically, and compressive load was applied at 90° to the long axis of the tooth at a crosshead speed of 1 mm/min until fracture occurred. The maximum load at failure was recorded in Newtons (N).

Material	***Type***	***Manufacturer***	***Country***	***Composition / Description***
EverX Posterior	*Fiber-reinforced composite*	*GC Corporation*	*Japan*	*Short E-glass fibers in resin matrix*
Clearfil SE Bond	*Adhesive system*	*Kuraray*	*Japan*	*MDP monomer, HEMA*
ES Flow	*Flowable composite*	*Spident*	*South Korea*	*Microhybrid fillers*
Shofu Composite	*Nanohybrid composite*	*Shofu Inc.*	*Japan*	*Nano/micro fillers*
ZipBond Universal	*Universal adhesive*	*SDI*	*Australia*	*MDP, HEMA*
Phosphoric Acid (37%)	*Etchant*	*Spident*	*South Korea*	*37% phosphoric acid*
Fiber Post	*Glass fiber post*	*Dental AAA*	*China*	*Fiber-reinforced epoxy*
All Cem	*Resin cement*	*FGM Dental*	*Brazil*	*Dual-cure resin cement*
Gutta-Percha	*Root filling*	*Endostar*	*Poland*	*Thermoplastic cones*
Bio-C Sealer	*Sealer*	*Angelus*	*Brazil*	*Calcium silicate*
NaOCl 5%	*Irrigant*	*Turkey*	*Turkey*	*Sodium hypochlorite*
Saline	*Irrigant*	*Egypt*	*Egypt*	*NaCl solution*
K-Files	*Hand files*	*China*	*China*	*Stainless steel*
Rotary Files	*NiTi system*	*Perfect T-Flex*	*China*	*NiTi rotary*
Paper Points	*Drying*	*Generic*	*—*	*Absorbent*
Conventional Sealer	*Sealer*	*Dentsply Sirona*	*Germany*	*Epoxyamine resin*

Results
The biomimetic group (Group A) demonstrated higher fracture resistance than the fiber post group (Group B). Group A showed a mean fracture resistance of 1128.34 ± 192.79 N, with values ranging from 929.60 N to 1741.18 N. In comparison, Group B showed a mean fracture resistance of 812.28 ± 129.02 N, with values ranging from 536.27 N to 1023.33 N.
The median fracture resistance was also higher in Group A (1065.17 N) compared with Group B (818.27 N), indicating an overall shift toward greater fracture-load values in the biomimetic group. Although Group A showed a wider range of values, its distribution remained higher than that of Group B, suggesting improved fracture resistance with the biomimetic restorative approach.

Received: *06-06-2026 -* ***Accepted:*** *03-08-2026 -* ***Published:*** *13-08-2026*

Attahadi Medical Journal
2026;3(3):393-398
https://doi.org/10.69667/amj.26319

OPEN ACCESS

Table 1. Results

	Group A	Group B
	1074.33838	**654.81293**
	1212.60901	**863.13629**
	1741.1842	**666.44141**
	1299.23206	**919.28021**
	929.59857	**696.38214**
	1078.56995	**1008.00122**
	998.112	**865.70428**
	1022.334	**837.09094**
	1018.06177	**799.45148**
	948.32159	**536.26593**
	996.231	**899.234**
	1234.556	**670.332**
	1112.345	**870.543**
	1334	**756.444**
	981.787	**913.112**
	1322.224	**714.932**
	1056	**1023.334**
	998.111	**971.112**
	997.443	**789.145**
	1211.767	**790.814**
Mean	**1128.34128**	**812.278442**
SD	**192.788585**	**129.02284**

Received: *06-06-2026 -* ***Accepted:*** *03-08-2026 -* ***Published:*** *13-08-2026*

Attahadi Medical Journal
2026;3(3):393-398
https://doi.org/10.69667/amj.26319

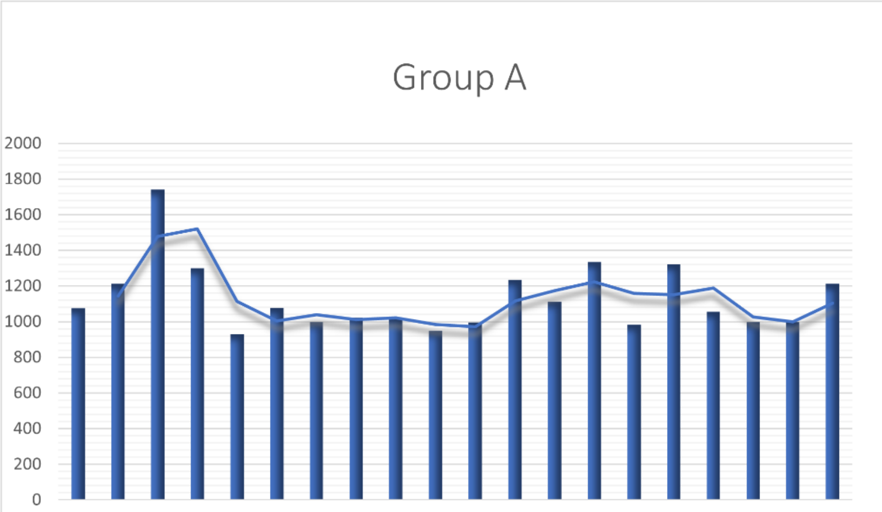

Figure 1. Representing results of EverX group

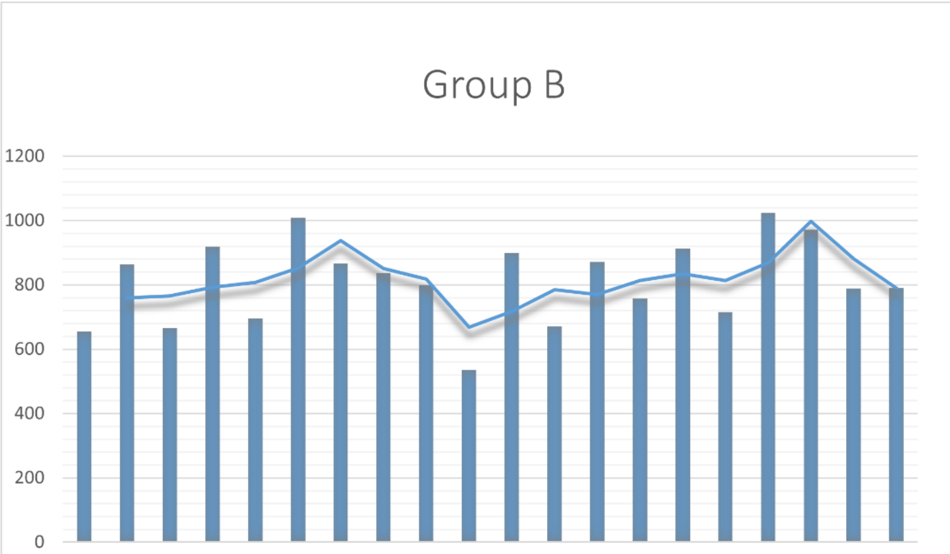

Figure 2. Representing results of Fiber Post group

Discussion

The present study showed that the biomimetic group (Group A) restored with EverX Posterior demonstrated higher fracture resistance than the conventional fiber post group (Group B). This difference was observed in both the mean fracture-load values and the overall distribution of results, indicating a more consistent load-bearing capacity in the biomimetic group.

This finding may be explained by the reinforcing effect of short fiber-reinforced composite. EverX Posterior contains short E-glass fibers within a resin matrix, which can improve stress distribution, transfer stresses away from crack tips, and limit crack propagation within the restoration (26,27). These properties are particularly important in endodontically treated posterior teeth, which are structurally weakened by loss of coronal dentin and root canal preparation and are exposed to high occlusal forces (24). The results of this study are consistent with previous reports showing that short fiber-reinforced composites can improve fracture resistance in structurally compromised teeth (26,27,30,33)

The superior performance of Group A may also be related to the biomimetic layering concept. In this approach, short fiber-reinforced composite is used as a dentin substitute, while conventional composite is applied as an enamel replacement. This bilayered structure more closely resembles natural tooth architecture and may contribute to improved stress distribution under functional loading (28,29). In addition, the conservative nature of the biomimetic technique helps preserve remaining tooth structure, which is a critical factor in the prognosis of endodontically treated teeth (31,32).

In contrast, the lower fracture resistance observed in the fiber post group does not indicate that fiber posts are ineffective, but rather that their primary role is retention rather than reinforcement. Although fiber posts have an elastic modulus closer to dentin than metallic posts, post-space preparation may remove additional radicular dentin and weaken the remaining root structure (29,30). Therefore, in cases where sufficient coronal tooth structure remains, a conservative biomimetic approach may provide better reinforcement without unnecessary removal of dentin.

***Received**: 06-06-2026 - **Accepted**: 03-08-2026 - **Published**: 13-08-2026*

Within the limitations of this in vitro study, the biomimetic EverX-based restoration demonstrated superior fracture resistance compared with the conventional fiber post and core approach. These findings support the use of conservative fiber-reinforced biomimetic restorations as a promising alternative for restoring endodontically treated posterior teeth.

Conclusion

Within the limitations of this in vitro study, the biomimetic EverX-based restoration provided higher fracture resistance than the conventional fiber post and core technique in endodontically treated molar teeth. The findings suggest that a short fiber-reinforced biomimetic approach may offer a more favorable mechanical outcome and a more conservative restorative option when compared with post-retained restoration. These results support the growing role of biomimetic dentistry in the management of structurally compromised posterior teeth.

Recommendations

1. Biomimetic short fiber-reinforced composite restorations may be recommended as a conservative option for restoring endodontically treated posterior teeth when sufficient sound tooth structure remains.
2. This approach may be particularly useful in molars with moderate structural loss, where dentin preservation is possible and the restoration can contribute to improved fracture resistance.
3. Fiber post and core systems should be considered when coronal tooth loss is extensive and additional retention is required.
4. Post placement should not be considered a guarantee of superior fracture resistance, as treatment success depends on remaining tooth structure, ferrule presence, root dimensions, and functional loading conditions.
5. A conservative biomimetic restoration may be preferred whenever the clinical situation allows preservation of coronal and radicular dentin.
6. Future in vitro studies should include cyclic loading, thermocycling, and fatigue simulation to better reproduce oral conditions.
7. Further studies are recommended to compare EverX with other biomimetic materials, assess different cavity designs, and evaluate fracture modes in greater detail.
8. Clinical trials are needed to determine whether the superior fracture resistance observed in vitro translates into improved survival and patient outcomes in vivo.
9. Future research should also evaluate the interaction between biomimetic composites and adhesive protocols, as bond quality directly affects the mechanical integrity of the restoration.

Author Contributions

O.A.: conceptualization, methodology, formal analysis, writing – original draft; H.E.: data curation, investigation, writing – review & editing; Y.A.: validation, supervision, writing – review & editing. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding or name the specific grant/institution and award number.

Conflicts of Interest

The authors declare no conflict of interest," or disclose any relevant financial or non-financial competing interests.

References

1. Rajaraman G, Senthil Eagappan AR, Bhavani S, Vijayaraghavan R, Harishma S, Jeyapreetha P. Comparative evaluation of fracture resistance of fiber-reinforced composite and alkasite restoration in Class I cavity. Contemp Clin Dent. 2022;13(1):56–60.
2. Dietschi D, Duc O, Krejci I, Sadan A. Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review. Quintessence Int. 2007;38(9):733–43.
3. Soares CJ, Pizi EC, Fonseca RB, Martins LR. Influence of restorative technique on fracture resistance of endodontically treated teeth. J Prosthet Dent. 2008;99(1):30–7.
4. Belli S, Erdemir A, Yildirim C. Reinforcement effect of polyethylene fiber in root-filled teeth. J Biomed Mater Res B Appl Biomater. 2006;76(2):354–9.
5. Albashaireh ZS, Ghazal M, Kern M. Effect of fiber-reinforced composite placement on fracture resistance of endodontically treated teeth. Clin Cosmet Investig Dent. 2019; 11:147–54.
6. Belli S, Eskitascioglu G. Biomechanical properties of polyethylene fiber-reinforced composite restorations. J Adhes Dent. 2006;8(4):239–45.
7. Garoushi S, Vallittu PK, Lassila L. Fiber-reinforced composite restorations: a review of the current literature. J Investig Clin Dent. 2018;9(3):e12330.
8. Ferracane JL. Resin composite—state of the art. Dent Mater. 2011;27(1):29–38.

***Received**: 06-06-2026 - **Accepted**: 03-08-2026 - **Published**: 13-08-2026*

9. Ilie N, Hickel R. Investigations on mechanical behavior of dental composites. Dent Mater. 2011;27(4):348–55.
10. Garoushi S, Lassila LV, Vallittu PK. Short fiber-reinforced composite resin with semi-IPN matrix. Dent Mater. 2007;23(10):1356–62.
11. Ilie N, Bucuta S, Draenert M. Bulk-fill resin-based composites: shrinkage behavior and curing depth. J Dent. 2013;41(10):909–17.
12. Jin X, Bertrand S, Hammesfahr P. New generation of bulk-fill composites: shrinkage stress evaluation. J Dent. 2009.
13. Garoushi S, Vallittu PK, Lassila L. Mechanical properties of short fiber-reinforced composites. Dent Mater. 2013.
14. Fráter M, Forster A, Jantyik Á, Braunitzer G, Nagy K. Fracture resistance of premolars restored with fiber-reinforced composite. J Dent. 2014;42(7):902–9.
15. Fokkinga WA, Kreulen CM, Bronkhorst EM, Creugers NH. Up to 17-year clinical study on post-retained restorations. Int Endod J. 2004;37(6):412–22.
16. Ferrari M, Vichi A, Garcia-Godoy F. Clinical evaluation of fiber-reinforced epoxy resin posts. Am J Dent. 2000;13:15B–18B.
17. Reeh and Douglas (1989) demonstrated that tooth stiffness is significantly reduced following the loss of structural integrity rather than dehydration of dentin, emphasizing the importance of preserving tooth structure (1).
18. Ferrari et al. (2000) investigated fiber post systems and reported improved stress distribution compared to metallic posts, attributing this to their dentin-like elasticity (4). However, they also highlighted that posts primarily serve a retentive function rather than reinforcing the tooth structure.
19. Fokkinga et al. (2004) evaluated the survival of post-retained restorations and concluded that fiber posts do not necessarily increase fracture resistance and may be associated with unfavorable fracture patterns (5).
20. Soares et al. (2008) reported that adhesive restorative techniques significantly influence the fracture resistance of endodontically treated teeth by improving stress distribution and reducing structural weaknesses (2).
21. Garoushi et al. (2007) demonstrated that fiber-reinforced composite restorations exhibit higher fracture resistance compared to conventional composites and produce more favorable fracture modes (7). In a later review, Garoushi et al. (2018) confirmed the effectiveness of short fiber-reinforced composites in reinforcing posterior restorations and preventing crack propagation (7).
22. Ausiello et al. (2011), using finite element analysis, showed that biomimetic restorations result in more favorable stress distribution compared to post and core systems, particularly in structurally compromised teeth (9).
23. Van Meerbeek et al. (2003) emphasized the role of adhesive systems in enhancing bonding to enamel and dentin, which contributes to improved mechanical behavior of restored teeth (8).
24. Reeh ES, Douglas WH. Reduction in tooth stiffness as a result of endodontic and restorative procedures. J Dent Res. 1989;68(4):625–7.
25. Ferrari M, Vichi A, Garcia-Godoy F. Clinical evaluation of fiber-reinforced epoxy resin posts. Am J Dent. 2000;13:15B–18B.
26. Fokkinga WA, Kreulen CM, Bronkhorst EM, Creugers NH. Up to 17-year clinical study on post-retained restorations. Int Endod J. 2004;37(6):412–22.
27. Soares CJ, Pizi EC, Fonseca RB, Martins LR. Influence of restorative technique on fracture resistance of endodontically treated teeth. J Prosthet Dent. 2008;99(1):30–7.
28. Garoushi S, Lassila LV, Vallittu PK. Short glass fiber-reinforced composite resin with semi-interpenetrating polymer network matrix. Dent Mater. 2007;23(10):1356–62.
29. Garoushi S, Vallittu PK, Lassila L. Short fiber-reinforced composite restorations: a review of the current literature. J Investig Clin Dent. 2018;9(3):e12330.
30. Ausiello P, Ciaramella S, De Benedictis A, Lanzotti A, Tribst JP, Watts DC. Stress distribution in restored teeth: a finite element analysis. Dent Mater. 2011;27(4):295–303.
31. Van Meerbeek B, De Munck J, Yoshida Y, Inoue S, Vargas M, Vijay P, et al. Adhesion to enamel and dentin: current status and future challenges. Oper Dent. 2003;28(3):215–35
32. Zafar MS, Amin F, Fareed MA, Ghabbani H, Riaz S, Khurshid Z, et al. Biomimetic aspects of restorative dentistry biomaterials. Biomimetics. 2020;5(3):34.
33. Fráter M, Forster A, Jantyik Á, Braunitzer G, Nagy K. Fracture resistance of premolars restored with fiber-reinforced composite. J Dent. 2014;42(7):902–9.

Received*: 06-06-2026 -* ***Accepted****: 03-08-2026 -* ***Published****: 13-08-2026*