STM JOURNALS

Journal of
Polymer & Composites

ISSN: 2321-2810 (Online)
ISSN: 2321-8525 (Print)
Volume 13, Issue 3, 2025
DOI (Journal): 10.37591/JoPC

https://journals.stmjournals.com/JOPC/

Research JoPC

Comparative Evaluation of Fiber-Reinforced Composite and Elastic Fiber Posts in Reinforcing Peri-Cervical Dentin: an In-Vitro Study

Indukuri. Sai Lakshmi Durga[1,*], Madhu Varma.K[2], Girija.S.Sajjan[3], Satish.RK[4], Praveen.G[5], Durga Prasad Naik. K[6]

Abstract

Aim: This study evaluates the fracture resistance of short-fiber reinforced composite and elastic fiber posts compared to conventional hybrid composites in reinforcing peri-cervical dentin of endodontically treated teeth. Methods: The crowns of thirty single-canal mandibular premolars were resected to achieve a dimension of 4mm from 1mm below the highest point of the proximal cervical line. In Group 1, teeth underwent endodontic treatment with gutta-percha filled up to the cement-enamel junction (CEJ) and restored with conventional hybrid composite. Groups 2 and 3 involved obturation up to 5 mm below the CEJ and restoration with short fiber-reinforced composite and elastic fiber posts, respectively. Fracture resistance was evaluated using a Universal testing machine. Statistical Analysis: The collected data were tabulated and assessed using one-way analysis of variance (ANOVA), and Tukey's post hoc test for pair-wise comparisons. Results: The short fiber-reinforced composite resin exhibited a significantly higher mean fracture resistance compared to other groups. The mean fracture resistance values (in newtons) were Group 2 (1238.07± 64.09 N) > Group 3 (988.12 ± 78.51 N)> Group 1(553.838 ± 78.76 N), with results between each group being statistically significant (P < 0.05).Conclusion: Within the limitations of this study, reinforcing PCD with a short fiber-reinforced composite significantly increased fracture resistance compared to using an elastic fiber post and conventional hybrid composite resin.

Keywords: Conventional hybrid composite, elastic fiber post, fracture resistance, peri-cervical dentin, short fiber-reinforced composite

***Author for Correspondence**
Indukuri. Sai Lakshmi Durga
E-mail: lakshmiindukuri111@gmail.com

[1,6]Assistant Professor, Department of Conservative Dentistry and Endodontics, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India
[2,3,4]Professor, Department of Conservative Dentistry and Endodontics, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India
[5]Associate Professor, Department of Public Health Dentistry, ESIC Dental College, Kalaburagi, Karnataka, India

Received Date: December 14, 2024
Accepted Date: April 15, 2025
Published Date: April 30, 2025

Citation: Indukuri. Sai Lakshmi Durga, Madhu Varma.K, Girija.S.Sajjan, Satish.RK, Praveen.G Durga Prasad Naik. K. Comparative Evaluation of Fiber-Reinforced Composite and Elastic Fiber Posts in Reinforcing Peri-Cervical Dentin: An In-Vitro Study. Journal of Polymer & Composites. 2025; 13 (3): 143–149p.

INTRODUCTION

Teeth that have undergone root canal treatment are considered weaker and more susceptible to fractures compared to vital teeth [1]. Studies showed that eleven to thirteen percent of extracted teeth having a history of endodontic therapy are with vertical root fractures [2,3], making it the second most frequent reason for the loss of endodontically treated teeth [4]. Among the causes of vertical root fractures, dentin loss either iatrogenic or non-iatrogenic renders teeth more vulnerable to mechanical failure [5], compromising their resistance to fracture [6]. Peri-cervical dentin (PCD) is of particular importance in this context, extending 4mm above and below the crestal bone level [7,8]. It is considered a critical area of the tooth because dentin loss in this zone is irreplaceable, while apical third of root can be resected and coronal third of the clinical crown can be replaced prosthetically. The pretreatment residual PCD serves as one of the deciding factors in the overall treatment plan and outcome [9]. PCD loss weakens the tooth and heightens the propensity of root fracture in endodontically treated teeth [10,11]. Foregoing information indicates that PCD reinforcement ought to be one of the main objectives of endodontic therapy.

Recent advancements in dentistry have seen a shift towards using bonded restorative procedures to enhance the longevity of root-filled teeth [6]. Research has shown that intra-canal and intra-coronal adhesive restorative materials enhance the fracture resistance of root canal-treated teeth [8,12]. Short fiber-reinforced composite (SFC) resin, such as everX Posterior, has emerged as a promising restorative material for use in high stress-bearing areas [13,14], particularly noted for its ability to provide isotropic-multi directional reinforcement [15]. Although studies have demonstrated its effectiveness in various applications as onlays, and core build-up materials, there remains limited literature on its specific impact in reinforcing PCD [1,16].

In cases where the residual tooth structure of root-filled teeth is insufficient in retaining the restoration, posts are often used. The GC everStick post, a flexible, unpolymerized elastic glass fiber post, conforms to the unique anatomy of root canals before polymerization, offering high strength once light-cured. Its design allows for the adaptation to atypical canal shapes, such as curved or oval canals, reducing the risk of root fracture by preserving the canal's natural contours [17]. This study aims to evaluate and compare the impact of SFC and elastic fiber post (EFP) in reinforcing PCD. The null hypothesis posited that these materials would not significantly reinforce PCD.

MATERIALS AND METHODOLOGY

Approval to conduct the experimental study was obtained from the ethical committee of the institutional review board. Each group in the study consisted of ten teeth, with the analysis at 80% power and a 5% significance level. Thirty freshly extracted, intact human mandibular premolars with single canals, free of caries, restorations, or pulpal aberrations, were selected for the study. Anatomic crowns (7±1 mm mesiodistal, 8±1 mm buccolingual) were measured with a caliper for standardization. Teeth with prior root canal therapy, developmental anomalies, root caries, or canal curvatures exceeding 15° were excluded. Teeth were examined at 10x magnification under a dental operating microscope (Carl Zeiss, Germany) to confirm the absence of pre-existing fractures. Teeth were cleaned with an ultrasonic scaler and stored in distilled water at room temperature. The crowns of all samples were sectioned to achieve a coronal dimension of 5mm from the proximal cervical line [7]. Endodontic access was prepared with an Endo access and an ENDO-Z bur (Dentsply, Maillefer, U.S.A.) using airotar (NSK Pana Air, Japan). Working length was determined using a 15K file (Mani, Japan) by subtracting 1mm from the measured length at which it reached the apical foramen. The working length was verified radiographically. The root canals were shaped with rotary Protaper files (Dentsply, Maillefer, U.S.A.) ranging from Sx to F3 sizes in a crown-down manner and irrigated with 2 ml of 5.25% sodium hypochlorite (NaOCl- Prime Dental Products, Thane) after each instrumentation. Final irrigation was performed with 5 ml of 17% ethylenediaminetetraacetic acid (EDTA) (Prime Dental Products, Thane) and 10 ml of distilled water used to neutralize any extended effects of EDTA. The canals were then dried using sterile absorbent paper points. Teeth were randomly allocated to three groups (n=10/each group). Description of materials used in the study are presented in Table 1.

Table 1. Description of materials used in the study.

Type of material	Trade name	Composition
Short fiber reinforced composite	everX Posterior ™: GC, Europe	Bis-GMA (Bisphenylglycidyldimethacrylate), PMMA (polymethyl methacrylate), TEGDMA (triethylene glycol dimethacrylate), Semi interpenetrating polymer network(semi-IPN), short E-glass fibre filler, barium borosilicate glass
Elastic fiber post	everStick post, GC	Silanized E-glass unidirectional fibre impregnated with PMMA and Bis-GMA.
Conventional hybrid composite	TeEconom Plus: Ivoclar, Vivadent	Urethane dimethacrylate, TEGDMA, Barium glass, ytterbium trifluoride, silicondioxide.

Group 1-Conventional Hybrid Composite (CHC) Group

Conventional hybrid composites are restorative materials designed to combine the strength and durability of larger filler particles (macrofillers) with the superior polishability of smaller particles (microfillers). This blend offers an optimal balance between mechanical performance and esthetic appeal, making them suitable for a wide range of dental restorations. In the present study, the hybrid composite used is Te-Econom Plus (Ivoclar Vivadent, Liechtenstein), which features a combination of coarse hybrid fillers (approximately 3–5 µm) and fine hybrid fillers (approximately 1.5–2 µm). For all teeth in the CHC group, obturation was done with Gutta-percha cones and a resin-based sealer (AH Plus, Dentsply) up to the CEJ. The canals were then cleaned with micro-brushes moistened with 70% alcohol to remove sealer remnants. A 37% Phosphoric acid gel (Eco Etch, Ivoclar Vivadent) was applied to the canal space for 15 seconds, followed by rinsing and blot drying. An Adhesive resin (Te-Econom bond, IvoclarVivadent) was applied with a microbrush by actively scrubbing for 20 seconds, air-dried for 10 seconds to volatilize the solvent, and light cured. Finally, the teeth were restored with an A2 shade conventional hybrid composite (Te-Econom Plus, IvoclarVivadent) in 2mm increments, with each increment being light-cured for 20 seconds. Samples in groups 2 (SFC Group) & 3(EFP Group) were obturated with Gutta-percha and resin-based sealer (AH Plus, Dentsply) to a depth of 5 mm from the cervical line. The canals were then cleaned with micro-brushes moistened with 70% alcohol to remove sealer remnants and restored as follows:

Group 2- SFC Group

A 37% Phosphoric acid gel (Eco Etch, Ivoclar Vivadent) was applied to the canal space for 15 seconds, rinsed with water and blot dried. An Adhesive resin (Tetric N-Bond, IvoclarVivadent) was applied with a microbrush by actively scrubbing for 20 seconds, air-dried for 10 seconds to volatilize the solvent, and light cured. The teeth were then restored with short fiber-reinforced composite (ever X Posterior, GC Europe) in 4mm increments, with each increment being light-cured for 20 seconds. A 1.5mm layer of nanohybrid composite resin (Tetric N Ceram, IvoclarVivadent) was placed on the occlusal surface and light-cured for 20 seconds. In both the SFC and EFP groups, a 1.5 mm occlusal layer of nano-hybrid composite resin (Tetric N-Ceram, Ivoclar Vivadent) was applied to simulate clinical conditions typical of post-endodontic restorations. This layer served to protect the underlying structures by preventing exposure of the fibers in the SFC group and the posts in the EFP group to the oral environment. Nanocomposites contains nano-filled materials formed by combining nanometric particles and nano clusters in a conventional resin matrix through nanotechnology. Nanotechnology is the production of functional materials and structures in the range of 0.1 -100 nanometres by various physical and chemical methods. The nano-hybrid composite used in the current study is a methacrylate based nano-hybrid composite resin (Tetric N Ceram, IvoclarVivadent). The combination of nanohybrid with the prepolymer technology, as the one used in this methacrylate-based composite provides restorative resin with lower shrinkage, better compressive strength, and high polish retention.

Group 3- EFP Group

A 20-size hand K-file (Mani, Utsunomiya, Japan) was used to measure the length of the canal. EverStick fiber (everStick Post™, GC Corporation, Tokyo, Japan, size 1.2 mm) was cut 1.5 mm shorter than the measured length, along with its silicone cover to prevent premature light exposure. A 37% phosphoric acid gel (Eco Etch, Ivoclar Vivadent) was applied to the canal space for 15 seconds, followed by rinsing and blot drying. An adhesive resin (Tetric N-Bond, Ivoclar Vivadent) was applied with a micro-brush, air-dried for 10 seconds to volatilize the solvent, and light cured. Low-viscosity dual-cure resin cement (Paracore; Coltene; Whaledent; USA) was injected into the canal, and the preselected everStick fiber was inserted. A spreader was used to insert additional posts into the root canal using the lateral condensation technique. Stick resin (GC, Europe) was used to attach each additional post to the main post. After filling the canal with everStick fibers, it was light-cured for 40 seconds and restored with nanohybrid composite resin (Tetric N Ceram, IvoclarVivadent), like Group 2. The samples were subjected to 500 thermocycling cycles between 5°C and 55°C, each lasting 30 seconds. Teeth were kept at 37°C and 100% humidity for 24 hours. Roots were covered with aluminum foil, mounted in acrylic resin 1 mm apical to the CEJ, and injected with light-body silicone after foil removal to simulate the periodontal ligament. The prepared specimens were placed on a holder slot that was fixed to the lower arm of the universal testing machine (Instron 8801, U.K.). A compressive load was applied with a metal indenter fixed to the upper arm of the universal testing machine positioned parallel to the long axis of the teeth until it slightly contacts the occlusal surface of the restoration, as shown in Figure 1. The vertical load was applied at a 1 mm/min speed until fracture (25% force drop) as shown in Figure 2. Fracture of each test specimen was confirmed by visual examination with the help of a 5X magnifying glass (Carl Zeiss, Germany). The force required to fracture each specimen was recorded in Newtons(N). The data thus obtained was tabulated and subjected to statistical evaluation.

RESULTS

The data were analyzed using SPSS (Version 21.0, Armonk, NY: IBM Corp.). Normality was confirmed with the Kolmogorov-Smirnov Z test. Mean fracture resistance values were compared using one-way ANOVA and Tukey's post hoc test for intergroup analysis. A P-value < 0.05 was considered statistically significant. Group 2 (SFC) demonstrated the highest mean fracture resistance (1238.07 N), significantly higher than other groups ($P<0.05$). Results are detailed in Table 2. Group 1 (CHC group) had the lowest fracture resistance at 553.838 N, while Group 3 (EFP group) had a mean fracture resistance of 988.12 N. All pairwise comparisons were statistically significant with a P value <0.05 (Table 3).

Figure 1. Compressive load application on tooth sample using universal testing machine.

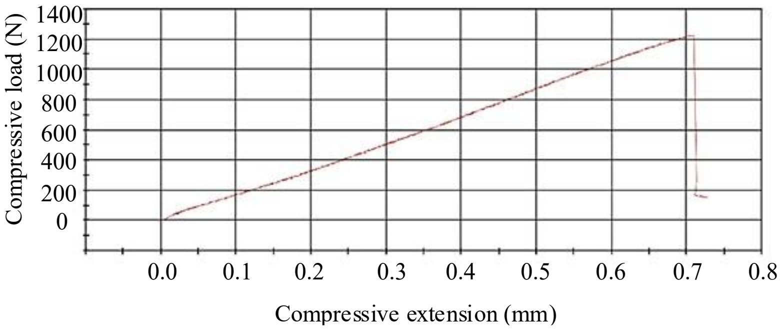

Figure 2. Graph showing increasing loads until 25% drop in applied force.

Table 2. Comparison of mean fracture resistance using one way ANOVA.

Groups	N	Mean	Std. deviation	F value	P value
Group-1 (CHC group)	10	553.83	78.76	218.261	.000*
Group-2 (SFC group)	10	1238.07	64.09		
Group-3 (EFP group)	10	988.12	78.51		

Table 3. Pair-wise comparison of fracture resistance using Tukey's test

Pair-wise comparison between groups		Mean difference (I-J)	Standard error	Significance	95% Confidence interval	
					Lower bound	***Upper bound***
CHC Group	SFC Group	-684.23*	33.14	.000*	-766.4073	-602.0567
CHC Group	EFP Group	-434.28*	33.14	.000*	-516.4603	-352.1097
SFC Group	EFP Group	249.94*	33.14	.000*	167.7717	332.1223

DISCUSSION

The prevalence of post-treatment tooth loss due to vertical root fracture (VRF) imposes a significant societal burden. Occlusal stresses tend to focus more on the cervical region when restored teeth experience compressive loads. Preservation and reinforcement of PCD is crucial, as it helps in the efficient distribution of masticatory forces, reducing stress on the root structure [18]. PCD restored with composite resin redirects micro-strain away from the apical root dentin, thereby minimizing apical flexing and lowering the risk of VRF.

Given the significance of PCD in root integrity, this study focused on its reinforcement. Single-rooted teeth were chosen due to the higher stress concentrations in their cervical region, caused by angular forces and limited surface area for force dissipation. The results demonstrated that short fiber-reinforced composite (SFC) was significantly more effective in reinforcing PCD than the Elastic fiber post (EFP). This superiority may be attributed to several factors, including the pre-incorporation of SFC fibers with resin, unlike other materials where fibers are added with resin only during placement, potentially creating voids due to oxygen-inhibited areas and reducing flexural resistance [19]. The differences in reinforcement effectiveness can be explained by fundamental biomaterial principles, including load distribution, fiber orientation, stress transfer, and material adhesive properties.

Material Structure & Load Distribution

SFC comprises randomly oriented short fibres that create an interlocking network, allowing multi-directional stress dissipation, reducing stress peaks in the peri-cervical region. The mechanism behind this improvement lies in stress transfer from the resin matrix to the fibres. In contrast, EFP consists of continuous, unidirectional fibres that primarily reinforce along their long axis, leading to higher stress concentration at the post-dentin interface, particularly in the cervical region.

Fracture Resistance & Crack Deflection

SFC improves fracture toughness by preventing crack propagation through fiber bridging, which requires more energy for failure. The critical fiber length of the E-glass fibres in the bisphenol A glycol dimethacrylate matrix is 3mm, surpassing the minimum length needed to optimize the material's mechanical properties [20,21]. In contrast, while EFP exhibits strong tensile strength along its length, it provides limited resistance to transverse forces, making cracks more likely to propagate along the resin-dentin interface.

Adhesion & Peri-Cervical Dentin Reinforcement:

SFC bonds chemically and micromechanically with the dentin, ensuring stress absorption and homogeneous reinforcement of the peri-cervical region. In contrast, EFP requires resin cement for bonding, which can introduce stress at the post-cement-dentin interface, increasing the risk of debonding and localized stress concentration.

The lower fracture resistance of EFP may be due to its placement in the central part of the tooth, where stress levels are minimal, limiting its reinforcement effect. Research suggests that reinforcement is more effective when applied away from the neutral axis, as seen in natural teeth, which are naturally hollow in the centre [22]. This complements the purpose of a post, which actually is to retain a core instead of reinforcing the tooth. EverStick Posts, despite their axial strength, concentrate stress at the post-dentin interface, making them less effective in reinforcing the peri-cervical region. In this study, Group 1 (CHC) exhibited significantly lower fracture resistance (553.838 ± 78.76 N) compared to all other groups ($P < 0.05$). This may be due to the low elastic modulus of root-filling materials like gutta-percha (77 MPa), which is much lower than dentin's modulus (16 GPa), limiting its ability to reinforce the root [23, 24].

Despite efforts to ensure accuracy, certain limitations of this in-vitro study remain. Factors such as oral temperature variations and the effect of saliva on restorations were not considered. Therefore, long-term clinical trials are necessary to validate these findings in a real-world clinical setting.

CONCLUSION

Within the limitations of this study, short fiber-reinforced composite resin exhibited significantly greater reinforcement of endodontically treated teeth compared to elastic fiber posts and conventional hybrid composite resin. This is likely due to its unique fiber structure and multi-directional fiber orientation, which enhances stress distribution and resists crack propagation in the critical peri-cervical region. EFPs, despite their axial strength, offer limited reinforcement due to their unidirectional fibers and reliance on resin cement, leading to stress concentration at the post-dentin interface. The CHC group showed the lowest fracture resistance, likely due to the inadequate mechanical support of gutta-percha and the absence of internal reinforcement. Strengthening the Peri-cervical region proved essential in improving overall fracture resistance, highlighting the importance of material selection in post-endodontic restorations.

Clinical Relevance

The strategic use of short fiber-reinforced composite resin in restoring endodontically treated teeth presents a clinically viable and biomechanically favorable approach to enhancing fracture resistance, reinforcing peri-cervical dentin, and ultimately improving long-term treatment outcomes.

Acknowledgments

This article has not received any external financial support.

REFERENCES

1. Eapen AM, Amirtharaj LV, Sanjeev K, Mahalaxmi S. Fracture resistance of endodontically treated teeth restored with 2 different fiber-reinforced composite and 2 conventional composite resin core buildup materials: an in vitro study. J Endod 2017;43(9):1499-504.
2. Fuss Z, Lustig J, Tamse A. Prevalence of vertical root fractures in extracted endodontically treated teeth. Int Endod J 1999;32:283–6.
3. Vire DE. Failure of endodontically treated teeth: classification and evaluation. J Endod 1991;17:338–42.
4. Caplan DJ, Weintraub JA. Factors related to loss of root canal filled teeth. J Public Health Dent 1997;57:31–9.
5. Kishen A. Mechanisms and risk factors for fracture predilection in endodontically treated teeth. Endod Topics 2006;13:57–83.
6. Soares PV, Santos-Filho PC, Queiroz EC, et al. Fracture resistance and stress distribution in endodontically treated maxillary premolars restored with composite resin. J Prosthodont 2008;17:114–9
7. Clark D, Khademi J. Modern molar endodontic access and directed dentin conservation. Dent Clin North Am 2010; 54(2):249-73.
8. Arora V, Yadav M P, Singh S P, Arora P, Chowdary P. Effect of adhesive obturation and post obturation monoblock systems on reinforcement of peri-cervical dentin (PCD). Int J Bio Trends Tech 2015; 8:1-6.
9. Boveda C, Kishen A, Millan B, Camejo MV, Gomez-Sosa JF. Pericervical dentin metrics in mandibular first molars determined with digital periapical radiography and cone-beam computed tomography. J Endod 2024;50(5):637-43.

10. Huynh N, Li FC, Friedman S, Kishen A. Biomechanical effects of bonding peri-cervical dentin in maxillary premolars. J Endod 2018;41:1-6.
11. Ribeiro G, Martin V, Rodrigues C, Gomes P. Comparative Evaluation of the Canal Shaping Ability, PCD Preservation, and Smear Layer Removal of TruNatomy, WaveOne Gold, and ProTaper Ultimate-ExVivoStudy. J Endod 2023;49(12):1733-8.
12. Sharma M, Mathew T, Kaur G. Effect of bonding pericervical dentin with reinforcing materials on strength of root-filled mandibular single-canal premolars: An in vitro study. Endodontology 2024;36(2):120-4.
13. Garoushi S, Vallittu PK, Lassila LV. Short glass fiber reinforced restorative composite with semi-interpenetrating polymer network matrix. Dent Mater 2007;23:1356–62.
14. Garoushi S, Vallittu PK, Lassila LVJ. Fracture toughness, compressive strength and load-bearing capacity of short glass fiber reinforced composite resin. Chin J Dent Res 2011;14:15–19.
15. Garoushi S, Hatem M, Lassila LVJ, et al. The effect of short fiber composite base on microleakage and load-bearing capacity of posterior restorations. Acta Biomater Odontol Scand 2015;1:6–12.
16. Garoushi S, Mangoush E, Vallittu P, et al. Short fiber reinforced composite: a new alternative for direct onlay restorations. Open Dent J 2013;7:180–5.
17. Fokkinga WA , Le Bell AM, Kreulen C M, Lassila LV, Vallittu PK, C reugers NHJ: Ex vivo fracture resistance of direct resin composite complete crowns with and without posts on maxillary premolars. Int Endod J 2005;38:230-237.
18. Elumalai V. Impact of Pericervical Dentin on Fracture Resistance of Endodontically Treated Posterior Permanent Teeth: A Systematic Review and Meta-analysis. The Journal of Contemporary Dental Practice 2024;25(4):373.
19. Belli S, Erdemir A, Yildirim C. Reinforcement effect of polyethylene fiber in root-filled teeth: comparison of two restoration techniques. Int Endod J 2006;39:136–42.
20. Petersen RC. Discontinuous fiber-reinforced composites above critical length. J Dent Res 2005;84:365-370
21. Cheng TH, Jones FR, Wang D. Effect of fiber conditioning on the interfacial shear strength of glass-fiber composite. Compos Sci Technol 2003;48:89–96
22. Le Bell-RönnlöfM, LassilaLV, Kangasniemi, etal: Load-bearing capacity of human incisor restored with fiber-reinforced composite posts. Dent Mater 2011;27:107-115.
23. Baba SM, Grover SI, Tyagi V. Fracture resistance of teeth obturated with Gutta percha and Resilon: An in vitro study. J Conserv Dent 2010;13:61-4.
24. Williams C, Loushine RJ, Weller RN, Pashley DH, Tay FR. A comparison of cohesive strength and stiffness of Resilon and gutta-percha. J Endod 2006;32:553-5

