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Comparative evaluation of fracture resistance among three fiber post systems restoring endodontically treated teeth - An *in vitro* study

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Abstract:
Restoration of endodontically treated teeth requires reinforcement to optimize long-term fracture resistance. Therefore, it is of interest to evaluate the fracture resistance of sixty maxillary anterior teeth restored using three distinct fiber post systems (Coltene Tenax, Angelus Reforpost and Dentapreg PIN). Statistically significant differences were identified among the experimental cohorts using one way ANOVA and post hoc bonferroni screening ($p < 0.05$). The Dentapreg PIN configuration exhibited the highest mean structural resistance (408.53 ± 88.24 N), followed closely by Coltene Tenax (334.67 ± 17.51 N) and Angelus Reforpost (270.78 ± 30.80 N). Thus, superior fracture outcomes for the multiple-pin design are attributed to enhanced localized stress distribution and root canal dentin preservation.

Keywords: Endodontically treated teeth (ETT), fiber post, fracture resistance, Dentapreg PIN

Background:
Teeth that have undergone endodontic treatment frequently show a considerable loss of tooth structure, which lowers mechanical strength and increases fracture susceptibility. In order to provide retention for the final coronal restoration and to strengthen the remaining tooth structure, post and core restorations are essential **[1]**. The predictable prognosis of endodontically treated teeth depends on an effective fluid-tight seal along with specialized post-endodontic restorations **[2]**. When a tooth has undergone endodontic treatment and has since lost its structure and vitality, the standard course of treatment is to place a post-and-core build-up **[3]**. Endodontically treated teeth are commonly restored using a post–core and crown system, where the post material and its modulus of elasticity significantly influence retention and fracture resistance. Posts are classified as metallic or tooth-colored, with tooth-colored posts further divided into prefabricated and custom-made types. Among prefabricated options, fiber posts are preferred because they are easy to use, have a modulus of elasticity similar to dentin, promote favorable stress distribution and reduce the risk of root fracture **[4]**. By offering favorable alternative to metal posts, fibre posts transformed the field of aesthetic dentistry. Fibre posts have an elasticity modulus (20 GPa) that is significantly closer to dentin (18 GPa) than metal posts, which increases the tooth's resistance to fracture comparable to biological dentin post **[5,16]**. Because a post's ability to adapt to canal walls varies depending on its shape and surface characteristics, post configuration affects retention .When compared to tapered forms, parallel-sided and tapered designs typically improve retention **[6]**.Tenax Fibre Trans, a high end, translucent fibre resin post system from Coltène, is intended to reduce root fractures, it has a cylindro-conical design with flexural strength (≈ 1577 MPa) and flexural modulus (≈ 26 GPa) that closely resemble natural dentin **[7]**. Angelus Reforpost Glass Fibre posts have parallel; radiopaque design improves retention and makes retrieval easier **[8]**. To address these issues and improve post-adaptation in the canal, a new strategy utilising multiple-pin posts has been presented. Innovative pin posts for tooth reconstruction following endodontic procedures were created by Dentapreg® (Dentapreg; ADM, Brno, Czech Republic). These posts are innovative, quick, safe and minimally intrusive. Because of their flexibility, they can precisely follow the root's natural contour without the need for extra equipment. This adaptable design approach lowers the risk of root fracture by maintaining the tooth's original biomechanics **[9]**. Although the type of luting cement had no significant effect on the fracture resistance of primary maxillary central incisors restored with fiber posts. However, certain cements having self-adhesive properties and ease of handling, improve the fracture resistance of fiber post cementation in endodontically treated primary maxillary central incisors **[10]**. Apart from this, tooth preparation design significantly influenced both the fracture resistance and marginal fit of advanced zirconia-reinforced lithium disilicate glass-ceramic (ALD) overlays **[11].** Certain other procedures contribute to improved fracture resistance such as Cervical margin relocation demonstrated higher fracture resistance than crown lengthening with complete ferrule and partial ferrule, used in combination with different post-and-core systems **[12].** Fracture resistance is also enhanced when obturation is done with root canal sealers such as AH plus sealers as shown in certain studies **[13].** The use of fiber-reinforced composites in place of conventional hybrid composites enhances the fracture resistance of endodontically treated teeth **[14].** Fiber-based posts exhibited more favorable stress distribution and better biomechanical compatibility with dentin, indicating the potential for improved clinical outcomes **[15, 16].** Therefore, it is of interest to evaluate the best fiber post system amongst the available that enhances the longevity and

prognosis of endodontically treated teeth by improving its fracture resistance taking decisions based on evidence will increase the longevity and success of restorations

Methodology:

The protocol was formally reviewed and authorized by the Institutional Ethics Committee, Maharishi Markandeshwar Institute of Medical Sciences and Research (Project No: MMIMSR-2963; 24-04-24) conforming to the 1975 Helsinki Declaration guidelines.

Specimen preparation and endodontic protocol:

A power analysis (G*Power v3.1.9) established that a minimum sample size of 52 specimens was required to achieve a large effect size (f = 0.40), with α = 0.05 and power (1–β) = 80%. To prevent specimen loss artifacts, 60 intact human maxillary anterior teeth were selected based on anatomical homogeneity. The specimens were decoronated 1.5–2.0 mm coronal to the cementoenamel junction using a high-speed diamond disk. Pulp tissue extirpation was performed and canal working lengths were standardly established using #10 K-file. Canal instrumentation was completed utilizing the ProTaper Universal rotary system up to an F4 master apical file size. Canals were continuously rinsed with 5.25% NaOCl and standard saline between successive instrument exchanges. Smear layer elimination was achieved with a final rinse sequence of 5.25% NaOCl, saline and 17% EDTA before paper point drying. Obturation was performed with matched gutta-percha cones and AH Plus sealer using cold lateral condensation.

Post insertion and core build-up:

Specimens were divided uniformly into three test groups (n=20):

[1] Group A: Coltene Tenax Fiber Posts Translucent
[2] Group B: Angelus Reforpost Glass Fiber Posts
[3] Group C: Dentapreg PIN Post System

Gutta-percha was removed from the coronal two-thirds of the canal using Peeso reamers #1 and #2 to standardize post spaces to a depth of 10 mm. All fiber post systems were conditioned with a silane coupling agent for 60 seconds and luted inside the canal spaces using dual cure resin cement. Core foundations were built up using hybrid composite resins before final finishing. Periodontal ligaments were simulated by coating root surfaces with a thin layer of wax and light-body impression material. Specimens were then cast vertically inside rigid acrylic resin mounting blocks.

Sample testing:

Assembled acrylic blocks were locked at a 45°C inclination within a Universal Testing Machine. A progressive static compressive load was applied to the composite core utilizing a crosshead speed of 1 mm/min until structural failure occurred measured in Newtons (N).

Results:

Primary testing datasets were tabulated inside Microsoft Excel and processed via IBM SPSS Statistics v25.0. Variations in mean fracture resistance across test groups were evaluated using a one-way Analysis of Variance (ANOVA), followed by a post-hoc Bonferroni multiple comparisons assessment (α = 0.05). The one-way ANOVA indicated highly significant differences in ultimate fracture resistance between the cohorts (F = 30.97, p = 0.000) **(Table 1)** and **(Figure 1).** Pairwise post-hoc Bonferroni testing confirmed that Group C (Dentapreg PIN) achieved significantly higher load thresholds compared to Group A (p < 0.01) and Group B (p < 0.001). Group A displayed moderate mechanical values that were significantly superior to the values noted for Group B (p < 0.05) **(Table 2).**

Table 1: Comparison of fracture resistance between specimens of group A, group B and Group C using ANOVA test

Groups	Number of Study Specimens	M (Newton) SD	F-test	P-value
Group A (Coltene Tenax Fiber Posts)	20	334.6685±17.5069	30.978	.000*
Group B (Angelus Reforpost)	20	270.779±30.8032		
Group C ((Dentapreg PIN Post system)	20	408.527±88.2380		

*** P-value <0.05 is considered statistically significant*

Table 2: Multiple comparison of fracture resistance between specimens of Group A, Group B and Group C using Post-hoc Bonferroni test

Groups		P-value
Group A	**Group B**	.002*
	Group C	.000*
Group B	**Group A**	.002*
	Group C	.000*
Group C	**Group A**	.000*
	Group B	.000*

** P-value <0.05 is considered statistically significant*

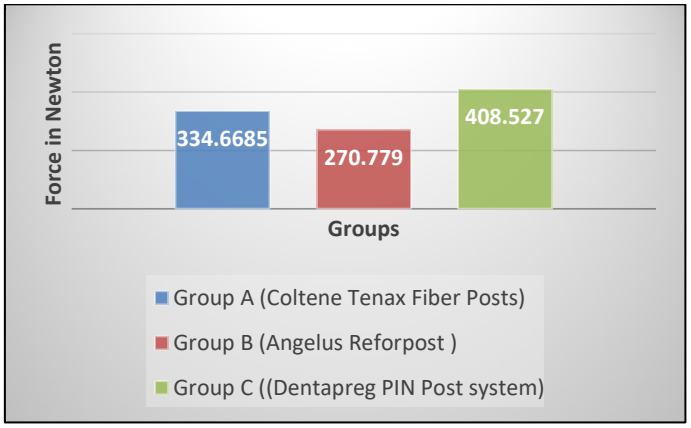


Figure 1: Comparison of Mean values of Fracture resistance between specimens of Group A, Group B and Group C

Discussion:

Teeth with substantial coronal destruction that have undergone endodontic treatment are usually restored using a post and core, then a prosthetic crown. Although cast post and core systems have historically been used because of their strength and fit, they can cause fractures because of increased stress concentration and variations in the Young's modulus between metal and dentin. With improved biomechanical stability and a lower risk of fracture, prefabricated glass fibre posts have become a popular substitute **[11]**. In the current study, Intergroup evaluations between the available prefabricared glass fiber posts are done which confirmed that post design significantly influences ultimate fracture limits ($p < 0.05$) as shown by de Assis *et al.* **[6]** The Dentapreg PIN system yielded the highest mean structural resistance (408.53 ±88.24), confirming its efficient stress dissipation pathways due to the multiple thin pin elements expand the available micromechanical binding surface area without requiring aggressive canal enlargement. However, its high standard deviation suggests high technique sensitivity during manual pin adaptation as shown by Falahchai *et al.* **[12]**. The Coltene Tenax posts showed intermediate load performance (334.67 ±17.51N). Their tapered cylindroconical architecture preserves radical dentin structure apically, while their high light transmission optimizes the polymerization chemistry of resin cements as shown by Gahana *et al.* **[7]**. The Angelus Reforpost system exhibited the lowest overall resistance values (270.78 ±30.80 N), which is likely due to stress distribution limits inherent to parallel-sided post structures as shown by Krishnarayan and Gehlot although its load thresholds remain safely within normal anterior functional limits **[8]**.

Conclusion:

Fiber post system architecture directly dictates the ultimate fracture resistance of endodontically treated teeth. The Dentapreg PIN post system achieved superior structural reinforcement through a minimally invasive, multiple-pin layout. Selecting post systems requires balancing basic material strength with dentin preservation and anatomical geometry.

Limitations:

[1] *In vitro* configurations cannot completely replicate the complex thermodynamic variations and cyclic fatigue of the oral cavity.
[2] The radiolucent composition of Dentapreg PIN structures complicates post-operative radiographic positioning checks.
[3] Increased manufacturing costs and limited retail availability may constrain widespread clinical adoption.

Conflict of interest: None

Source of Funding: None

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