EVALUATION OF FRACTURE RESISTANCE OF ENDODONTICALLY TREATED MAXILLARY TEETH RESTORED WITH FIBER POST AND RIBBOND WITH DIFFERENT POST SPACE DIAMETERS – AN IN-VITRO STUDY

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Abstract:

Background: Root canal posts are placed in teeth that have lost extensive tooth structure due to decay, failed fillings, or tooth fractures. The maxillary incisors are the most impacted teeth due to their anterior placement and protrusion resulting from the eruptive process. Traditionally, endodontically treated teeth are restored with a post-core and crown foundation system. The design, material, and modulus of elasticity of the dental posts are very important because they help hold the coronal restoration in place and keep it from breaking.

Materials and Methods: A total of 30 samples were divided into two groups of 15 each. Group A consists of Fiber post and was subdivided into 3 subgroups based on post space preparation and the materials used are ParaCore(COLTENE) as core build-up, and ParaCore-SLOW(COLTENE) for luting of fiber post. Tenax(COLTENE) Fiber Post using 1.1mm, 1.3mm, 1.5mm diameter drills and their corresponding posts. Group B includes Ribbond which was subdivided based on post space preparation and materials used are Ribbond (Ribbond Inc., Seattle, WA, USA) 2mm width, wetting resin and securing composite. Peeso Reamers(MANI, Japan) No.#2,#3 are used for post-space preparation. Type I GIC(GC) was used for crown cementation. The fracture resistance was tested using an Instron Universal Testing Machine. The data was statistically analysed using one-way ANOVA and Post-Hoc Tukey's Test.

Results: The one-way ANOVA showed a statistically significant difference. The highest mean fracture resistance in the fiber group was recorded for post space 1.1mm (593.20±7.04) and in the ribbond group, no post space preparation (283.76±7.51) had the highest mean fracture resistance. The post-hoc Tukey test was done for intra-group comparison of fiber post and ribbond post systems, where post space preparation with 1.1mm vs post space preparation with 1.5mm(447.90) for fiber post group and in ribbond group, no post space preparation vs post space preparation with peeso#3(191.67) showed the highest mean fracture resistance.

Conclusion: This in-vitro study concluded that teeth restored with a 1.1mm fiber post exhibit greater fracture resistance compared to those restored with 1.3mm and 1.5mm posts and when comparing teeth restored using the Ribbond post system, those with no post space preparation demonstrated superior fracture resistance compared to those with minimal post space preparation, indicating that post space diameter influences the fracture resistance of endodontically treated maxillary teeth.

Key Words: Fracture resistance, Fiber post, Ribbond, ParaCore, Post space diameter

Introduction:

The root canal-treated tooth is mainly associated with the loss of coronal and radicular tooth structure from preexisting restorations, restorative failures, trauma, dental caries, and endodontic access preparation. The most affected teeth are the maxillary incisors due to their anterior position and protrusion caused by the eruptive process. (1) The remaining tooth structure is the most crucial factor for a good prognosis as they are devoid of mechanical properties including loss of strength, fragility as well as the liability to fracture. Endodontically treated teeth are traditionally restored with a post-core and crown foundation system, which depends mainly on the design, material and modulus of elasticity of dental posts as they play a major role in retention and fracture resistance of coronal restoration of endodontically treated teeth. (2) The post is a relatively rigid material extending approximately two-thirds of the length of the root canal of the pulpless teeth. The core may be the coronal extension of the dowel, which replaces the missing coronal tooth structure. (3) Posts are classified according to their material into metallic or tooth-colored posts. Tooth-colored posts are further classified into pre-fabricated and custom-made posts. Fiber posts contain either carbon fibers or quartz fibers, embedded in epoxy or methacrylate resin matrix. The fibers are parallel to the long axis of the post with a diameter ranging between 6 to 15 mm. While the number of fibers ranges between 25 and 35 per mm2 with respect to post type and cross-sectional surface. So as a result, 30–50% of the area is filled with fibers when a transverse section is seen. (2) Ribbond® (Ribbond Inc., Seattle, WA, USA), which is commercially available and was first introduced as a splint material. The material has a three-dimensional structure due to the leno weave or triaxial braid, and this provides mechanical interlocking with composite resin at different planes. (4) The alteration or any minute modification in post space preparation either in width or length, might alter the properties of glass-fiber post and zirconia post and core system, which might lead to changing the fracture resistance of the post or endodontically treated teeth themselves. Fracture resistance of post-core restoration depends on the design of the post, post diameter, post length, the type of adhesive cement used along with the material of the post and core system material that aids in dissipation of occlusal forces along the post to the remaining radicular root (5)

Thus, this study aimed to evaluate the fracture resistance of endodontically treated teeth, restored with fiber post and ribbond with different post space diameters.

Material And Methods:

For this study, 30 extracted human permanent maxillary anterior teeth with closed apices and straight and moderately curved roots were taken and stored in 0.1% thymol. The samples were divided into two groups of 15 each, which were further subdivided into 3 subgroups of 5 samples each.

Study Design: Invitro study

Study Location: Drs. Sudha & Nageswara Rao Siddhartha Institute of Dental Sciences

Study Duration: November 2023 to November 2024

Sample size: 30

Materials used:

- ParaCore (COLTENE) – as core build-up
- ParaCore SLOW (COLTENE) – for luting of post
- Fiber Post – Tenax (COLTENE) - 4% taper

- drills – 1.1mm, 1.3mm, 1.5mm diameter

- Ribbond (Ribbond Inc., Seattle, WA, USA - 2mm width
  - Wetting resin
  - Securing composite
- Peeso Reamers(MANI, Japan) – No.#2 #3
- Type I GIC(GC) – for crown cementation

Selection method:

The 30 extracted human permanent maxillary anterior teeth were divided equally into two groups of 15 each and subdivided into 3 subgroups of 5 samples each.

Group 1 (n=15): FIBER POST

Subgroup A: post space preparation – 1.1 mm

Subgroup B: post space preparation – 1.3 mm

Subgroup C: post space preparation – 1.5 mm

Group 2 (n=15): RIBBOND

Subgroup A: No post space preparation

Subgroup B: Minimal post space preparation with peeso reamer #2

Subgroup C: post space preparation with peeso reamer #3

Inclusion criteria:

1. Maxillary anterior teeth will be included.
2. Teeth with closed apices.
3. Teeth with straight or moderately curved roots.

Exclusion criteria:

1. Teeth with open apex.
2. Canals that are calcified.
3. Anatomic malformations.

Procedure methodology:

After access opening, root canal therapy was performed with the sectional obturation technique with 4mm of remaining apical gutta-percha. Access cavities are filled with a temporary filling material. Teeth are decoronated using a diamond disk, maintaining 2mm crown structure.

GROUP 1 – FIBER POST

1. Post Space Preparation: The post space was prepared using the corresponding special drill.
2. Post Space Cleaning & Cementation: Cleaning of the post space was done with EDTA. Fiber posts were coated with a silane coupling agent. Cementation was done using ParaCore Slow. (Fig.1 and Fig. 2)

Fig. 1: ParaCore (COLTENE)

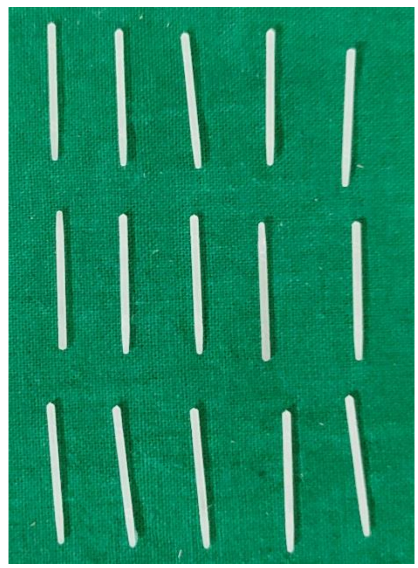

Fig. 2: Fiber Post – Tenax (COLTENE)

GROUP 2 – RIBBOND

1. Post Space Cleaning: Cleaning of the post space was done with EDTA.
2. Ribbond Placement: Placing of Ribbond in adhesive. Coating of adhesive to dentinal walls. (Fig. 3)
3. Ribbond Securing: A Ribbond securing composite was placed in the canal. Wetted Ribbond was inserted into the canal with free ends facing outward and cured.

Fig. 3: Ribbond (Ribbond Inc., Seattle, WA, USA - 2mm width, wetting resin, securing composite

Following this, for both the groups, core build-up was done with ParaCore. During the build-up, care was taken to provide a core length of approximately 8 mm. Tooth preparation was done. Impression was taken for fabrication of the metal crown with acrylic coping. The crown was cemented using GIC and a notch of about 3 mm below the incisal edge on the palatal surface was given.

Fracture resistance testing:

The fracture resistance was evaluated with a Universal Testing Machine with a constant load at a crosshead speed of 1 mm/min until fracture occurs. The jig was positioned such that the loading tip contacts the palatal surface of the samples 3 mm beneath the incisal edge, providing a 135° angle between the palatal surface and the loading tip. Load necessary to fracture the sample was recorded in Newtons.

Statistical analysis

The Excel software packages were used for data entry and analysis. Various statistical analysis tests such as One way ANOVA and Post-Hoc Tukey's Test was used. In all the above tests, a 'p' value of less than 0.05 was accepted as statistically significant.

Results

The ANOVA analysis revealed statistically significant differences in fracture resistance among the subgroups. (Table 1) The fiber post group with 1.1 mm post space exhibited the highest mean fracture resistance (593.20 ± 7.04 N), followed by 1.3 mm and 1.5 mm preparations. In the

Ribbond group, the highest resistance was noted in samples with no post space preparation (283.76 ± 7.51 N). The lowest mean fracture resistance was seen in the Ribbond group with Peeso #3 preparation (191.67 N).

Table 1: Comparative analysis of Mean fracture resistance among both groups

GROUPS		Mean±SD (N)	F value	p value
Fiber post group	post space prep with 1.1mm	593.20±7.04	321.197	<0.001*
	post space prep with 1.3mm	337.95±28.90		
	post space prep with 1.5mm	145.30±7.66		
Ribbond group	no post space prep group	283.76±7.51	2257.981	<0.001*
	post space prep with peeso #2	172.56±3.81		
	post space prep with peeso #3	92.09±3.32		

One way ANOVA test

*p≤0.05 is considered as statistically significant

Table 2: Pairwise comparison of fracture resistance using Post-Hoc Tukey's Test in the fiber post group

Comparison Groups	Mean difference	p Value
post space prep with 1.1mm Vs post space prep with 1.3mm	255.25	<0.001*
post space prep with 1.3mm Vs post space prep with 1.5mm	107.35	<0.001*
post space prep with 1.1mm Vs post space prep with 1.5mm	447.90	<0.001*

Post-hoc Tukey analysis showed significant intra-group differences. For fiber posts, 1.1 mm significantly outperformed 1.3 mm and 1.5 mm. (Table 2)

Table 3: Pairwise comparison of fracture resistance using Post-Hoc Tukey's Test in ribbond group

Comparison Groups	Mean difference	p Value
no post space prep group Vs post space prep with peeso #2	111.2	<0.001*
post space prep with peeso #2 Vs post space prep with peeso #3	80.47	<0.001*
no post space prep group Vs post space prep with peeso #3	191.67	<0.001*

In the Ribbond group, no post space preparation significantly outperformed both post space preparation with peeso #2 and #3. (Table 3)

Discussion:

When the remaining tooth structure of endodontically treated teeth cannot provide sufficient support and retention for restoration, remaining less than 50% of the tooth structure, a post and core is beneficial. (2) An ideal post-core foundation should have superior fracture resistance that is higher than mastication forces. Alshabib et al., summarised in their study, that a 2 mm margin of healthy tissue is considered adequate to provide the ferrule effect that protects the root. The length of the post must be equal to or greater than that of the crown, or two-thirds the length of the root, with a minimum of 4 mm apical seal. The larger the diameter, the lower the fracture resistance of the tooth. Self or dual-cure resin cements are recommended; such cements are not fully set just after cementation, even if light-polymerization is used. Therefore, a waiting period of 24 h before final tooth preparation is recommended to ensure maximum polymerization and post-retention. (6)

Previous studies suggested that the most appropriate post space diameter for maxillary central incisors should range from 1.3 mm to 1.7 mm or order to maintain post stability as well as not to weaken the residual radicular dentin. (6)

Also, it has been reported that the post diameter is more crucial than its length regarding its fracture resistance; the increase of post diameter can enhance its fracture resistance, but unfortunately, it reduces the sustaining resistance of the remaining tooth structure due to the excessive removal of sound dentinal root. (7)

The findings of the present study demonstrated that post space diameter significantly influences fracture resistance, with narrower post spaces yielding superior outcomes.

In the Fiber Post group, the highest mean fracture resistance was observed in samples with a 1.1 mm post space diameter (593.20 ± 7.04 N), suggesting that minimal removal of radicular dentin favors the structural integrity of the restored tooth. Larger diameters (1.3 mm and 1.5 mm) resulted in lower fracture resistance, possibly due to excessive dentin removal compromising the strength of the root. These findings align with those of previous studies, which have emphasized the importance of preserving radicular dentin to enhance post-endodontic fracture resistance. For instance, a study by Kuscar et al. indicated that increased post space preparation could lead to dentinal cracks, thereby reducing fracture resistance. (8) Also, in a study by Saad et al., showed no statistically significant difference among the four groups restored with two post-core systems in 1.3-mm (narrow) and 1.75-mm (wide) post space diameters. (2)

Within the Ribbond group, the highest fracture resistance was observed in samples without post space preparation (283.76 ± 7.51 N). Ribbond, a polyethylene fiber-reinforced material, adapts well to the canal anatomy without necessitating significant dentin removal. The improved performance in the absence of post space preparation highlights the advantage of using systems that conform to the natural root canal morphology and require minimal invasive intervention. This supports the hypothesis that the preservation of tooth structure is paramount to enhancing fracture resistance. This observation is corroborated by a study conducted by Aslan et al., which demonstrated that the use of polyethylene fiber without post space preparation resulted in higher fracture resistance compared to other techniques. (9)

The post-hoc Tukey analysis further validated intra-group differences. In the Fiber Post group, the 1.1 mm post space diameter significantly outperformed both 1.3 mm and 1.5 mm preparations. Similarly, in the Ribbond group, the no-preparation subgroup showed statistically superior fracture resistance compared to groups where Peeso reamers were used for post space enlargement. These results are consistent with the findings of a study by McLaren et al., which reported that increased post space preparation could compromise the structural integrity of the tooth, leading to decreased fracture resistance. (10)

This study indicated that the fracture resistance of all groups restored with fiber posts was higher than that of groups with ribbond. In a similar study done by Aggarwal et al., Batra et al., Jindal et al., Ozcopur et al., Thakur and Ramarao et al., and Ramesh et al., showed higher fracture resistance in the prefabricated fiber post group, which are similar to the present study results as in Table 1. However, according to Braga et al., and Kumar et al., showed higher fracture resistance in the Ribbond post group.

Conclusion and Future Directions:

Within the limitations of this in-vitro study, it can be concluded that the post space diameter significantly influences the fracture resistance of endodontically treated maxillary teeth. Teeth restored with Fiber Posts exhibited the highest fracture resistance when a minimal post space diameter of 1.1 mm was used. In the case of Ribbond, teeth restored without any post space preparation demonstrated superior fracture resistance compared to those with enlarged post spaces.

These findings highlight the importance of preserving radicular dentin during post space preparation and support the use of minimally invasive techniques. Both smaller diameter fiber posts and Ribbond without post space preparation can be considered favorable options for reinforcing endodontically treated teeth, particularly in clinical scenarios where structural preservation is critical.

Future clinical studies are recommended to validate these findings under dynamic loading conditions and over long-term periods to assess their practical relevance and longevity in clinical applications.

References:

[1]. Uthappa R, Mod D, Kharod P, Pavitra S, Ganiger K, Kharod H. Comparative evaluation of the metal post and fiber post in the restoration of the endodontically treated teeth. J Dent Res Rev 2015;2:73-7.

[2]. Saad KB, Bakry SI, AboElhassan RG. Fracture resistance of endodontically treated teeth, restored with two post-core systems in different post space diameters (in vitro study). BMC Oral Health. 2023 Dec 11;23(1):992-1004.

[3]. Elavarasu P, Karumaran CS, Indira R, Anilkumar R, Mani R, Natarajan R. An in vitro evaluation of fracture resistance of endodontically treated maxillary central incisor restored with custom-made cast post and core with uniform and nonuniform core ferrule heights. J Pharm Bioall Sci 2019;11:S407-12.

[4]. Ramesh P, Mathew S, Murthy SB, George JV, Hegde S, Premkumar R. Efficacy of Ribbond and a fibre post on the fracture resistance of reattached maxillary central incisors with two fracture patterns: a comparative in vitro study. Dent Traumatol. 2016 Apr;32(2):110-5.

[5]. Saritha MK, Paul U, Keswani K, Jhamb A, Mhatre SH, Sahoo PK. Comparative evaluation of fracture resistance of different post systems. J Int Soc Prev Commun Dent. 2017; 7:356–9.

[6]. Alshabib A, Abid Althaqafi K, AlMoharib HS, Mirah M, AlFawaz YF, Algamaiah H. Dental Fiber-Post Systems: An In-Depth Review of Their Evolution, Current Practice and Future Directions. Bioengineering (Basel). 2023 May 4;10(5):551-68.

[7]. Özarslan M, Büyükkaplan UŞ, Özarslan MM. Comparison of the fracture strength of endodontically treated teeth restored with polyether ether ketone, zirconia and glass-fibre post-core systems. Int J Clin Pract. 2021;75:e14440-50.

[8]. Kuşuçar AN, Kırıcı D. Evaluation of dentinal crack formation during post space preparation using different fiber post systems with micro-computed tomography. BMC Oral Health. 2025 Mar 27;25(1):443-53.

[9]. Aslan T, Sagsen B, Er Ö, Ustun Y, Cinar F. Evaluation of fracture resistance in root canal-treated teeth restored using different techniques. Niger J Clin Pract. 2018 Jun;21(6):795-800.

[10]. McLaren JD, McLaren CI, Yaman P, Bin-Shuwaish MS, Dennison JD, McDonald NJ. The effect of post type and length on the fracture resistance of endodontically treated teeth. J Prosthet Dent. 2009 Mar;101(3):174-82.