

Fracture Resistance of Endodontically Treated Maxillary Premolars with a Longer Single Post and Shorter Double Posts of Different Sizes: An *In Vitro* Study

Arun Mayya¹, Rajaram Naik¹, Shreemathi S. Mayya², Maria P. Paul¹

¹Department of Conservative Dentistry and Endodontics, A.J. Institute of Dental Sciences, Mangalore, ²Department of Data Science, Prasanna School of Public Health, Manipal Academy of Higher Education, Manipal, Karnataka, India

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ABSTRACT

Aim: The aim of this study was to determine if there is any difference in fracture resistance between different post sizes and lengths when more than one post is involved. **Materials and Methods:** Thirty extracted maxillary first premolars were endodontically treated and divided into three groups: In Group 1 (control group), no post space preparation was conducted and access cavities were restored with composite; in Group 2 (single post), post space preparation of 10mm was carried out only in one of the canals; and in Group 3 (double post), post space preparation of 5 mm was conducted in both the canals. Appropriately sized glass fiber posts were cemented in Groups 2 and 3 followed by core buildup. The fracture resistance of the specimen was measured using a universal testing machine and the data analyzed. The mean fracture resistance values of the three groups were compared applying one-way analysis of variance (ANOVA) followed by *post hoc* Tukey's test. The data were analyzed using Statistical Package for the Social Sciences software program, version 15.0. South Asia, Bangalore. **Results:** The control group had a significantly lower fracture resistance value as compared to Groups 2 and 3. No statistically significant difference was observed in the fracture resistance between Groups 2 and 3. **Conclusions:** No significant difference was observed between the fracture resistance of endodontically treated maxillary first premolars restored with size 3 single post of longer length and size 1 double posts of shorter lengths.

KEYWORDS: Dental dowels, fiber posts, fracture resistance, fracture strength post and core

INTRODUCTION

One of the existing challenges in restorative dentistry is the restoration of endodontically treated teeth with extensive loss of coronal tooth structure.^[1] A standard method of restoring such teeth is the use of post and core, followed by the cementation of a full crown. The endodontically treated teeth show significantly different physical and mechanical properties compared to those of vital teeth. The quality and quantity of the remaining dental tissue directly influence the likelihood of a pulpless tooth surviving.^[2]

Absence of moisture content due to the extirpation of pulp, desiccation over time, and changes in collagen cross-linking results in decreased tooth resiliency and increase in susceptibility to fracture.^[3]

The fracture resistance of endodontically treated teeth can be improved by the use of posts for its rehabilitation.

Address for correspondence: Dr. Arun Mayya, Department of Conservative Dentistry and Endodontics, A.J. Institute of Dental Sciences, Kuntikana, Mangalore 575004, Karnataka, India. Email: mayya.arun@gmail.com

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They aid in the retention of the final restoration as well as the distribution of torquing forces within the radicular dentin along the length of the root.^[4] Tooth-colored posts such as zirconium-coated carbon fiber post, fiber-reinforced light post, and various glass fiber posts are available today.^[5] These posts are metal-free, physiochemically homogenous materials that have physical properties similar to those of dentin. The fiber-reinforced posts have shown a reduced root fracture probability as well as a significantly higher survival rate. Their low modulus of elasticity, which is similar to that of dentin (approximately 20 GPa) allows the post to absorb stress and prevent root fracture.^[6,7] The glass fiber posts provide a natural hue by integrally bonding to the composite, thereby improving the aesthetics without compromising much on the strength.^[8]

The choice of the posts is predestined to the dimension of the root canal and limited by the size of the root. Several independent factors, such as the design, surface texture, diameter, and length of the posts, determine the long-term clinical service of prefabricated posts.^[9]

A post length equal to the crown height or two-thirds of the root length while leaving at least 3–6 mm of gutta-percha at the apex has been suggested to facilitate stress distribution and provide resistance to occlusal forces.^[10-12] The other guidelines that have been previously recommended for metal posts include the following: The post should end halfway between crestal bone and root apex; the post should be half, two-third or four-fifth the root length; and the post should be as long as possible without disturbing the apical seal. However, the use of resin cement has enhanced the retention of fiber posts unlike the metal posts that have a high modulus of elasticity and depends on frictional retention to the canal wall.^[13]

Previously, an increased post length was suggested to improve the retention of the post.^[14] However, an increase in the post length could result in a decrease in root strength. Furthermore, the use of a longer post may not always be possible, mainly when the remaining root is short or curved.^[15]

The remaining bulk of tooth structure plays a vital role in terms of strength and resistance to root fracture.^[16] The preservation of tooth structure is an essential criterion while selecting the post diameter. It is suggested that the post diameter should not exceed one-third of the root diameter at any location with a minimum of 1 mm of sound dentin around the post.^[17] The post diameter is reported to be less effective than its length in retention. Small-diameter posts have shown adequate retention while minimizing the tooth structure removal from the root canal.^[18] Therefore, the purpose of this study was to determine if there is any

difference in fracture resistance between different post sizes and lengths when more than one post is involved.

MATERIALS AND METHODS

Thirty extracted maxillary first premolars with two roots of approximately similar lengths were used. The inclusion criteria of the study consisted of teeth free of caries, restoration, and cracks. The study was approved by the institutional ethical committee. Soft tissue and calculus were mechanically removed from these teeth. The teeth were stored in a saline solution at ambient temperature. The crown portions except for the control group were sliced at the cemento-enamel junction using a diamond disc in a slow-speed handpiece and cooled with air/water spray to create approximately 13-mm-long specimens.

All the teeth were endodontically treated and obturated using gutta-percha and AH Plus resin sealer (Dentsply DeTrey, Konstanz, Germany) with cold lateral condensation technique.

The specimens were then randomly divided into three groups, 10 in each group. The canals of the experimental groups were sealed with Cavit (3M ESPE, Seefeld, Germany) and stored for 36 h in distilled water at 37°C ($\pm 2^\circ\text{C}$).

Group 1 (control group): The access cavities were restored with Filtek bulk-fill composite resin (3M ESPE, St. Paul, Minnesota) followed by 2 mm of crown preparation from occlusal edge to the cervical region. A shoulder of 1 mm was prepared around the full circumference of tooth with cylindrical diamond bur.

Group 2 (single post): Post space preparation using size 5 peeso reamers (Mani, Tochigi-ken, Japan) was conducted in one of the canals to accommodate a single size 3 glass fiber post (Reforpost, Angelus, Londrina, Brazil) of diameter 1.5 mm and length 10 mm from the cervical end to the apex.

Group 3 (double post): Post space preparation using size 3 peeso reamers (Mani, Tochigi-ken, Japan) was conducted in both the canals to accommodate two size 1 glass fiber posts (Reforpost, Angelus, Londrina, Brazil) of diameter 1.1 mm and length 5 mm from the cervical end to the apex, one each in the buccal and the palatal canal.

In both the experimental groups, 3 mm of the post extended above the cemento-enamel junction. After preparation of each post space, a radiograph was taken to evaluate the length of prepared post space and remaining apical seal in the canal. The posts were cleaned and dried with air free of water and oil. The teeth were etched with 37% phosphoric acid (3M ESPE Dental Products, St. Paul, Minnesota, USA) for 20 s and then washed and dried with paper points. Prior to the cementation, posts

were coated with silane using a disposable applicator, left for 1 min and then gently air-dried. Base and catalyst of the adhesive resin cement (Maxcem Elite Kerr Self cure, Kerr, Orange, California) were mixed, and the posts were luted generously and inserted in the canals. The posts were pressured for 5–10s and light-cured for 40s. Excess cement was removed, and a core of 5mm height was built up with core buildup material (LuxaCore Z, DMG, Hamburg, Germany) using a size 3 core former (PDP Rhos Core, Mumbai, India).

The 30 teeth were mounted vertically parallel to the long axis of the tooth in acrylic resin blocks of dimensions 2cm × 2cm × 2cm. To simulate the biological width, the margin 2mm apical to the crown was not covered with acrylic. After observing the first signs of polymerization, the acrylic blocks were removed from the molds used to create them. All the 30 specimens were mounted on a universal testing machine. A compressive load of 0.5 mm/min at 90° was applied in a direction parallel to the long axis of the tooth until fracture occurred. The fracture resistance was measured, and the data were analyzed.

STATISTICAL METHOD

The mean fracture resistance values of the three groups were compared applying one-way analysis of variance (ANOVA) followed by *post hoc* Tukey's test. The Shapiro–Wilk test was used to confirm normality of the data. The significance level for the study was set to 5% for all the tests. The data were analyzed using the Statistical Package for the Social Sciences software program, version 15.0.

RESULTS

The Shapiro–Wilk test confirmed that fracture resistance values of all the three groups followed normal distribution (control group: $P = 0.847$; single post; $P = 0.727$; double post: $P = 0.068$).

One-way ANOVA indicated significant difference in mean fracture resistance between the three groups ($F_{[2,27]} = 78.753$, $P < 0.001$). Control group had the least fracture resistance [Table 1]. *Post hoc* Tukey's honestly significant difference test showed no significant difference between single and double post groups. Control group had significantly less fracture resistance compared to single and double post groups ($P < 0.001$) [Table 2].

DISCUSSION

An intracanal post is often required for the restoration of endodontically treated teeth. The decrease in fracture resistance of endodontically treated teeth is attributable to various factors. They include extensive loss of tooth structure due to dental caries, previous restorations or fracture, loss of water from the dentinal tubules, age changes in the dentine, the effect of endodontic irrigants and medicaments, and the effect of bacterial interaction with the dentine. Thus, maintaining the structural integrity of postendodontically restored teeth by conserving the bulk of dentine has been advocated. A post system should ideally show a fracture resistance higher than the average masticatory forces. Post material and fracture of roots also have a definite link.^[2]

The mechanical behavior of these teeth may vary according to the features of the posts, such as their manufacturing material.^[19] Various studies have shown that teeth restored with metallic posts show a higher prevalence of catastrophic fracture patterns.^[19,20] On the contrary, a repairable pattern of fracture was observed in roots restored with fiber posts, especially glass fiber.^[8,21,22] The glass fiber posts possess an edge over the previously used posts because of factors such as better aesthetics, fewer clinical steps, and a modulus of elasticity similar to dentine.^[19] Only glass fiber posts

Table 1: One-way analysis of variance comparing mean fracture resistance values (N)

Group	N	Mean load (N)	SD	$F_{(2,27)}$	P value*
Control	10	589.45	129.96		
Single post	10	1689.99	234.22	78.753	<0.001
Double post	10	1749.26	301.30		

SD = standard deviation

* $P < 0.05$ indicates statistically significant difference in the group means at 5% level of significance

Table 2: Pairwise group comparison of fracture resistance values (N)

Comparison	Mean difference	P value*	95% confidence interval	
			Lower bound	Upper bound
Control—single post	-1100.54	<0.001	-1358.63	-842.45
Control—double post	-1159.81	<0.001	-1417.90	-901.73
Single—double	-59.27	0.837	-317.36	198.82

**Post hoc* Tukey's test, $P < 0.05$ is statistically significant

were used in this study considering the superior nature of this post system compared to the others.

The aspects of fiber post retention, which have been studied previously include the influence of cement curing mode, cement type, post surface treatment, length, and post pattern.^[23-25] Factors that are still controversial concerning the use of fiber posts are the influence of size and number of posts that can be used. Previous studies have evaluated the effect of intraradicular multiple fiber posts on the fracture resistance of endodontically treated teeth. However, this is the first study where the fracture resistance between a larger diameter and longer post was compared with two smaller diameter shorter posts in endodontically treated teeth.

The studies evaluating the fracture resistance of multiple fiber posts have consistently shown a higher fracture resistance of the multipost technique compared to the use of a single fiber post as shown by Haralur *et al.*^[17] and Frater *et al.*^[26] These studies used accessory posts for the multipost technique with the post space preparation length being the same in the single and multipost groups.

Studies have shown that post space preparation results in weakening of the tooth structure and increase the probability of tooth fracture due to the formation of cracks and defects that can cause stress concentration.^[27,28] Thus, the post-insertion should not be accomplished at the cost of sacrificing radicular dentin.^[16] In this study, the post space preparation in the double post group (Group 3) was limited to 5 mm in order to preserve the remaining dentin thickness. The absence of a significant difference between the single and double post groups is attributable to the reduced post space preparation in the double post group, with the length and thickness of the posts being diminished. This allowed the preservation of more tooth structure, which is a critical factor influencing the mechanical behavior of an endodontically treated tooth.^[26,29] The similarity of the mechanical behavior of roots restored with glass fiber posts of different sizes as shown here may also be related to the adhesion after luting, which favors retention. In contrast to the cast metal posts, where the mechanical factors promote retention, the glass fiber posts show adhesion through the bond between resin cement and dentinal walls, which ensures adequate retention even when shorter posts are used.^[19] The use of an adhesive resin cement allows the formation of a significant chemical bond between the dentin and post itself.^[30] Bonding between the fiber post and the root dentin creates a “monobloc” another factor that could contribute to a better distribution of stress on the tooth.^[31] The effectiveness of retention

may also be altered by the shape of the post as well as the thickness of the cement.^[32]

A balance between the intraradicular post length and the coronal extension is ideally required. Laboratory studies have revealed that a more favorable stress distribution along the post and an increase in retention is obtained when the length of the post within the root canal is increased.^[15,33] However, Chuang *et al.*^[34] have shown that increasing the length of the post can result in decreased root strength. The importance of the remaining bulk of tooth structure has been confirmed by several *in vitro* studies.^[35-37] The fracture resistance of the endodontically treated tooth does not increase with an increase in the diameter of the post.^[31] Nevertheless, this can increase the stiffness of the post at the expense of the remaining dentin and the resistance of the root to fracture. Therefore, the radicular dentin must be preserved by controlling the post diameter in order to reduce the risk of perforation and permit the tooth to resist fracture. Although there was no difference in fracture resistance between the two experimental groups, the importance of preserving the sound dentine while restoring these teeth should not be overlooked as the mechanical resistance of the tooth improves with increased remaining healthy tissue. This further affirms that the use of multiple shorter and thinner posts instead of a single longer and broader post would be beneficial in improving the fracture resistance of an endodontically treated tooth.

The design of the post also has a significant role in avoiding fracture of endodontically treated teeth. In this study, a parallel-sided serrated post was used. Parallel posts resist tensile, shear, and torquing forces better than tapered posts and distribute stress more uniformly along their length during function.^[16,38] The parallel-sided serrated posts also show better retention compared to tapered posts and double tapered posts.^[39]

A crown ferrule plays a crucial role in improving the fracture resistance and clinical prognosis of teeth with posts and cores.^[40,41] However, in this study, crown ferrules and crowns were eliminated from the methodology in order to avoid more variables that could complicate interpretation of the results.

Another critical factor that can influence the fracture resistance of an endodontically treated tooth is the type of core material used.^[42] In this study, LuxaCore Z (DMG, Hamburg), a dual-cured core buildup material was used in the experimental groups. The dual-cure composite core material was selected because of its ability to bond to both the glass fiber post and tooth structure, and still be cured

with the post where light activation within the root was not possible. A previous study showed that the microtensile bond strength of low-viscosity core material to fiber-reinforced composite post is higher than conventional composites using the incremental technique.^[43] The use of such flowable composites minimizes the occurrence of bubbles and voids within the core or the core/post interface due to better integration with the fiber post.^[44] The low consistency of the core material makes it easier to lute the surface of the post, with less air contamination and superior bond strength.^[42]

It has been reported that the materials used to simulate periodontal ligament does not affect the fracture or bond strength of the teeth restored with fiber posts and cores.^[45,46] Consequently, in this study artificial periodontal ligament was not used to simulate clinical conditions. This study could not replicate the oral conditions accurately; however, the *in vitro* evaluation of the fracture resistance of single and double posts of different lengths and diameters provides information that can be of use in post system selection.

The limitations of the study included the following: The samples were tested under static load, unlike masticatory forces in the mouth. The samples were not subjected to ageing, thermal cycling, and fatigue loading. Further *in vitro* studies including various post combinations with thermal cycling and fatigue loading can be carried out in the future.

CONCLUSION

Within the limitations of this *in vitro* study, there was no significant difference between the fracture resistance of endodontically treated maxillary first premolars restored with size 3 single post of longer length and size 1 double posts of shorter lengths. Two shorter and thinner posts can be considered as an alternative to the use of a broader and longer post in teeth with shorter and curved root as well as to preserve more tooth structure.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHOR CONTRIBUTIONS

Arun Mayya and Rajaram Naik: Study conception, data collection, data interpretation, manuscript

writing, manuscript review. Shreemathi S. Mayya: Data analysis, Interpretation and writing of results. Maria Priya Paul: Literature search, manuscript preparation, manuscript editing. All the authors approved the final version of the manuscript for publication.

ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT

Institutional ethics committee A J Institute of Medical Sciences & Research Centre approved this study. (AJEC/REV/224/2017, Dated 21/11/2017).

PATIENT DECLARATION OF CONSENT

Not applicable as it is an Invitro Study

DATA AVAILABILITY STATEMENT

The data is available on request from the corresponding author.

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