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Comparison of fracture resistance of primary incisor teeth restored with glass fiber post and reversed-oriented metal post – An *in vitro* study

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ABSTRACT

Background: This *in vitro* study aimed to compare the fracture resistance of fiber post and reversed-oriented metal post in the restoration of severely decayed primary incisors.

Materials and Methods: In this *in vitro* study**,** forty extracted human primary incisors were sectioned horizontally 1 mm above the CEJ and randomly divided into four groups – Group 1: Central incisors restored with reverse-oriented metal post, Group 2: Lateral incisors restored with reverse-oriented metal post, Group 3: Central incisors restored with fiber post, and Group 4: Lateral incisors restored with fiber post. The coronary portion of the teeth was then restored with nanohybrid universal composite. The fracture resistance was measured using universal testing machine. The type of fracture was determined by employing a stereomicroscope. Data were analyzed using two-way ANOVA test. The level of significance was considered at $P < 0.05$.

Results: The mean fracture resistance of glass fiber posts (208.00 ± 73.19) was higher than the reverse-oriented metal posts (190.37 ± 56.36); however, there was no significant difference between any of the groups ($P = 0.353$).

Conclusion: Within the limitations of this study, it can be concluded that both types of posts studied in the present research can be successfully used in the restoration of severely damaged primary incisors**.**

Key Words: Fracture resistance, glass fiber post, primary incisors, reversed-oriented prefabricated metal post

INTRODUCTION

Dental caries is the most common chronic disease of childhood. Dental caries in very young children, known as early childhood caries, shows a clinically distinct pattern.[1] The teeth most often involved are the maxillary central incisors, lateral incisors, and the maxillary and mandibular first molars. The maxillary incisors are most severity affected, with deep carious lesions usually involving the pulp. In extreme cases, early childhood caries can even lead to loss of the crown structure.[2] Loss of primary anterior teeth leads to mastication problems, speech disorders

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such as difficulty in pronunciation, development of parafunctional habits, hesitation to play among the peer groups due to esthetic concerns and also reduction in vertical facial height. Such children usually have self-esteem problems and they are often psychologically distressed.[3] Extensive restorative treatments of anterior primary teeth have always been a big challenge in pediatric dentistry. In severe decayed incisors where pulpectomy is carried out, intracanal retention is necessary for durability of the composite crown.[1] Metal posts, biologic posts, omega-shaped stainless steel orthodontic wires, polyethylene fiber posts, and glass fiber posts are routinely suggested retention techniques for primary teeth restoration.[4] Glass fiber posts are commonly used in pediatric dentistry. Glass fiber post composed of unidirectional glass fiber embedded in a resin matrix that strengthens the dowels without compromising the modulus of elasticity. Another advantage of glass fibers is that they distribute stresses over a broad surface area, increasing the load threshold.[5] Recently, Eshghi *et al*.[6] introduced a new method for the reconstruction of severely damaged primary anterior teeth in 2011. This method advocated the use of reversed-orientated (upside-down) metal posts for intracanal retention in the restoration of severely decayed primary anterior teeth. Based on the findings of a clinical study, this technique presents advantages over traditional methods of restoration due to ease of use, lower cost of treatment, the lack of rotation inside the canal, the lack of need for core preparation to create the space needed for the restorative material, and the possibility of placing a greater volume of restorative material around the core which would lead to better color matching.

However, this new technique has been merely performed on severely damaged maxillary canines. Therefore, there is an urge to examine the efficiency of this restoration technique in primary incisors as well. In addition, although previous studies have compared the fracture resistance of various postretained restorations, no published research has been conducted to compare the fracture resistance of primary teeth restored with fiber post and reversed-oriented metal posts. Thus, the purpose of this experimental study was evaluation of fracture resistance of primary incisor teeth restored with fiber post and reversed-oriented metal posts.

MATERIALS AND METHODS

This *in vitro* study was approved by the Ethics committee of Shiraz University of Medical Sciences in Shiraz, Iran (IR.SUMS.REC.1397.897), and an informed consent has been obtained from all of the patients parents of everybody whose tooth/teeth used for this study. A total of 40 extracted primary incisors (23 lateral and 17 central incisors) with initial physiological resorption not more than two-thirds of the root were collected so the teeth with more than two-thirds of the roots resorbed were included. One of the most important factors is the orifice dimension. Hence, the teeth with the same orifice dimension were chosen (mesiodistal and buccolingual orifice dimension of central and lateral incisors were approximately [4 mm × 3.5 mm] and [3 mm × 3 mm] respectively. Teeth with any evidence of crack or fracture were excluded.

Preparation of samples

The samples were cleaned and stored in physiological saline solution until the preparation. The teeth were sectioned horizontally 1 mm above the cement-enamel junction with a diamond bur in a high-speed handpiece, and the root canals were prepared to size 40 by k-files (Mani INC, Utsunomiya Tochigi, Japan) 1-mm short of the apex. Then, the root canals were dried using paper points and were filled with zinc oxide eugenol (ZOE) paste (Kemdent, Swindon, UK). The apex of the roots was covered with red wax, and the apical parts of the roots (from 1 mm below the cementoenamel junction) were placed in the center of cold-cured acrylic resin (cylindric shape with a dimension of 2 cm × 2 cm × 2 cm). Then, the specimens were divided randomly into 2 groups of 20 and restored with either glass fiber post or reverse-oriented metal post. Twelve lateral incisors and eight central incisors were selected for glass fiber restoration. In glass fiber postgroup, 4 mm of the canal was coronally depleted of any trace of ZOE on the canal walls by 1.1 mm diameter postspace preparation bur. The most apical part of the prepared space (1 mm) was filled with glass ionomer cement (GC, GC Corporation, Tokyo, Japan) to avoid any composite setting impairment by ZOE cement. The length of the glass fiber post in the canal was 3 mm, and the adjusted post (Reforpost, Angelus, Brazil) was placed in the canal for length confirmation. Before cementation, the post was cleaned with ethanol and thoroughly air-dried. Afterward, the primer and adhesive (Adper, Single Bond 2, 3M ESPE, USA) were applied for the entire postspace and cured for 20 s. The postspace was filled with flowable light cure composite (Filtek Z350 XT,3M ESPE, USA), the glass

fiber post was inserted and cured for 60 s.[4] Eleven lateral incisors and nine central incisors were selected for metal postrestoration. In reversed-orientated metal postgroup, the postspace was prepared using fissure bur to match the quadrangle head of the metal post. A short, prefabricated, gold-plated metal screw post (gold plated anchorage post; Directa, Sweden) which was fitted to the coronal segment of the root was selected. The fit of the posthead in the quadrangle preparation and correct placement of the post was checked before cementation. Adequate incisal space for the composite resin restoration was secured by adjusting the length of the post. 3 mm of the metal post was cemented into the canal in reversed orientation (upside-down) with glass ionomer cement (GC, GC Corporation, Tokyo, Japan). After cementation, the post was cut in such way that 3 mm of the post (the threaded part) remained outside of the canal[4,6] to restore the crown of the teeth in both groups, the remaining tooth substance was etched with 37% phosphoric acid gel (Scotchbond, 3M ESPE, USA) and rinsed. The primer and adhesive (Adper, Single Bond 2, 3M ESPE, USA) were applied to the etched tooth structure and the threaded part of the metal post and were light-cured for 40 s. A thin layer of universal opaque flowable composite resin (Filtek Z350 XT, 3M ESPE, USA) was placed over the metal post to prevent the metal postshade shining through the restoration and cured for 20 s. The coronal restoration was incrementally placed using nanohybrid universal dental composite (Filtek Z250 XT, 3M ESPE, USA).

Fracture resistance measurement

All the specimens were stored in distilled water at 37°C for 7 days and then thermo cycled 5000 times between water baths held at 5°C and 55°C with 60s of dwell time. The fracture resistance was measured using universal testing machine (Zwick-Roell, Zwick, and Ulm, Germany). The dislodging force was applied with a speed of 1 mm/min with an angle of 135° relative to the longitudinal axis of the teeth using 1000 Newton load cell, which exerted a load ranging from 0.1 g to 10 kg. The obtained values were recorded in Newtons. The type of fracture was also recorded as adhesive failure (at the interface of composite and tooth structure), cohesive failure (inside the composite restoration), or mixed failure (a combination of adhesive and cohesive failures). The type of fracture was determined visually where possible or by means of a stereomicroscope [Figure 1].

Statistical analysis

For data analysis, the mean and standard deviation (SD) values of all groups were obtained using SPSS version 15.0 (Microsoft, IL, USA). The average and (SD were used for data description. Furthermore, two-way ANOVA was used for the comparison of mean fracture resistances between two restorative methods. A $P < 0.05$ was considered to be statistical.

RESULTS

Mean and SD of fracture resistance values of different experimental groups are presented in Table 1. The results of two-way ANOVA revealed that there was no interaction effect between type of teeth and type of post in terms of fracture resistance.

As shown in Table 1, the highest fracture resistance was observed for central incisors which were restored with glass fiber post (222.87 ± 85.65 N). The lowest fracture resistance was detected in lateral incisors which were restored using reverse-oriented metal posts (183.54 ± 44.81 N).

Table 1: Mean and standard deviation of fracture resistance values of different experimental groups (*n*)

Type of post	Type of teeth		Total
	Central incisor	Lateral incisor	
Reverse-oriented metal post	198.71±69.95 (*n*)	183.54±44.81 (*n*)	190.37±56.36 (*n*)
Glass fiber post	222.87±85.65 (*n*)	198.08±65.71 (*n*)	208.00±73.19 (*n*)

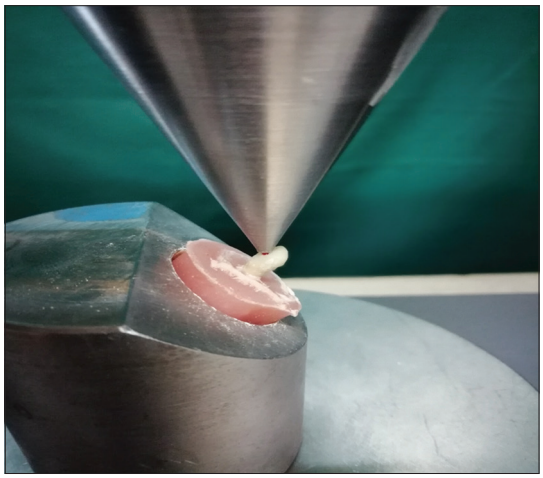

Figure 1: The dislodging force was applied with a speed of 1 mm/min with an angle of 135. Degrees relative to the longitudinal axis of the teeth.

In general, the mean fracture resistance of the groups restored with glass fiber post was higher than that of teeth restored with reverse-oriented metal posts regardless of type of teeth, however, the difference was not significant.

Furthermore, regardless of type of post, the mean fracture resistance of the central incisors was observed to be higher than that of lateral incisors; though the difference was not significant.

As the results of two-way ANOVA revealed, there was no interaction effect between type of teeth and type of post in terms of fracture resistance. The results of two-way ANOVA for comparison of mean fracture resistance between the groups are presented in Table 2.

As shown in Table 2, considering the type of tooth as the control variable, there was no significant difference between different types of posts in terms of fracture resistance ($P = 0.368$).

Moreover, by considering the type of post as the control variable, it was shown that there was no significant difference between different types of teeth in terms of fracture resistance ($P = 0.353$).

Considering both type of tooth and type of post as variables, no significant difference was observed between any of the experimental groups in terms of fracture resistance ($P = 0.822$).

As revealed in Table 3, among the central incisors restored with either metal post or fiber post, the distribution of cohesive and adhesive failure types was almost similar.

Among the lateral incisors, the adhesive failure was more dominant in the metal post restored groups, and the cohesive/combination failure modes were more prevailing in the fiber post restored groups. No combination failure type was reported in the groups restored with metal post.

Table 2: The results of two-way ANOVA for comparison of mean fracture resistance between the groups

Source	SS	df	MS	*F*	*P*
Post type	3650.089	1	3650.089	0.831	0.368
Tooth type	3890.761	1	3890.761	0.886	0.353
Post type×tooth type	225.805	1	225.805	0.051	0.822

SS: Sum of square; df: Degrees of freedom; MS: Mean square

Table 3: The frequency of fracture type in different experimental groups (%)

Groups	Failure type (%)			Total (%)
	Cohesive	Adhesive	Combination	
Metal post				
Central incisor	4 (44.4)	5 (55.6)	0	9 (100)
Lateral incisor	3 (27.3)	8 (72.7)	0	11 (100)
Fiber post				
Central incisor	4 (50.0)	3 (37.5)	1 (12.5)	8 (100)
Lateral incisor	5 (41.7)	2 (16.7)	5 (41.7)	12 (100)
Total	16 (40)	18 (45)	6 (15)	40 (100)

DISCUSSION

One of the most important mechanical properties of restorative materials is fracture resistance which determines the restorations durability. Presenting high fracture strength becomes particularly important during mastication.[7] Few studies in literature have been conducted to investigate fracture resistance of primary teeth restored with various posts; thus, there is insufficient data to substantiate the results of our study.

The use of postretained restorations in endodontically treated teeth increases the retention of definitive restorations, providing an esthetic, retentive, and functional restorative option in severely destroyed primary anterior teeth which noticeably endure masticatory forces.[8-10]

Different types of posts have been used in pediatric dentistry.

Glass fiber posts are another choice of intracanal posts, which are used in different diameters. This type of post offers chemical and mechanical adhesion to the restorative materials leading to long-lasting restorations with favorable esthetics.[11] *In vitro* studies have shown that this technique significantly increased the fracture resistance of teeth.[1,12,13] Therefore, these two types of posts were studied in our research.

In the present study, the glass fiber postgroup (208.00 ± 73.19 N) showed the highest fracture resistance and the reverse-oriented metal postgroup (190.37 ± 56.36 N) had the lowest fracture resistance; however, the difference between groups was not statistically significant. The slight difference observed in the fracture resistance of different posts may be due to high tensile strength and similar modulus of elasticity to dentin in glass fiber posts.[14]

In line with the findings of the present study, previous investigations on the fracture resistance of severely damaged primary anterior teeth restored

with different posts have shown that there is no significant difference between various types of posts in terms of fracture resistance. Recently, a study was conducted by Seraj *et al*.[1] to investigate the fracture resistance of three types of post, including composite resin, customized quartz fiber, and prefabricated glass fiber. The researchers showed that all three types of studied posts can be successfully used to restore severely damaged primary anterior teeth. Moreover, Hegde *et al*.[15] showed that the mean fracture strength of quartz fiber post (480.9 N) and glass fiber post (432.2 N) was not statistically significant. The higher fracture strength of glass fiber post in the study of Hegde *et al*.[15] compared to our research can be due to the difference in the post used in their study (Parapost, Coltene Whaledent, USA) with the one applied in the present research (Reforpost, Angelus, Brazil). Moreover, it could be due to the difference in the cement they applied (Rely X luting cement (3M ESPE, MN, USA) compared to the cement used in our study (Filtek Z350 XT, 3M ESPE, USA,). The selection of luting cement as well as postselection are important factors that affect the bond strength of postretention. Glass ionomer is bonded chemically whereas the flowable composite bonded micromechanically.[16] Similarly, in another *in vitro* study, the application of threaded posts, nickel chromium (Ni-Cr) posts with macroretentions, biologic posts, alpha-shaped orthodontic wire, and Ribbond were investigated as intracanal retainers in primary teeth and showed similar fracture resistance values when submitted to shear strength tests.[17]

Despite the findings of the present research which showed no significant improvement in fracture resistance of teeth restored by glass-fiber groups compared to reverse metal posts, some previous researches have reported the superiority of glass fiber posts over metal posts in permanent teeth. In a study conducted by Giovani *et al*. on permanent teeth, it was shown that the 10-mm-long glass-fiber restored teeth demonstrated significantly higher values of fracture resistance, representing a viable alternative to the cast metal post by increasing the resistance to fracture of endodontically treated canines. Posts with a modulus of elasticity similar to dentin such as the glass fiber post when submitted to a compressive load can better absorb the force which decreases the possibility of fracture. This is true about glass fiber post with larger mass volumes (10 mm) which absorb greater amount of stress which leads to transferring lower stress to dentin. In contrast, the concentration of stress in shorter post appears in smaller region with a greater probability of fracture.[18] Whereas in our study, shorter glass fiber post (<10 mm) was applied.

Very few studies have been conducted to assess the new method of reverse-oriented metal post. Only recently, in an *in vivo* study, Eshghi *et al*.[19] compared the retention of reverse metallic post with fiber post and composite post. It was shown that the retention did not change significantly after a 12-month follow-up and was 100, 90, and 98%, respectively.[19]

Furthermore, in the present study, the mean fracture resistance of the central incisors was observed to be higher than that of lateral incisors regardless of type of post, though the difference was not significant. The higher fracture strength of central incisors compared to lateral incisors can be attributed to larger teeth diameter with more enamel surface available for bond.

We had some adhesive and cohesive failures in all experimental groups [Table 3]; among the central incisors restored with either metal post or fiber post, the distribution of cohesive and adhesive failure types was almost similar. Among the lateral incisors, the adhesive failure was more dominant in the metal postrestored groups showing the low bond strength between the luting cement and the dentin. The cohesive/combination failure modes were more prevailing in the fiber postrestored groups indicating no gain in reinforcement of the core. As a result, the force loaded during testing in lateral incisors restored with fiber posts resulted in the fracture of the crown mostly at the cervical margin. This indicates the decreased chance of a positive clinical outcome of restoring severely destroyed primary lateral incisors with fiber posts.

One of the limitations of this *in vitro* study was its incapability in simulating the clinical conditions precisely. Multidirectional characteristics of masticatory forces in this test model with universal testing machine cannot be duplicated. Whereas only a single unidirectional load was used in our study. Post diameter, length, design and adaptability, amount of remaining root dentin are other factors that affect the fracture resistance of teeth treated with post.[20]

The results obtained from the current *in vitro* study do not necessarily validate those achieved *in vivo*. For this matter, there is a need for future clinical studies to verify these findings. The results of these

tests should be applied to the clinical situation only after being substantiated by *in vivo* evidence requiring long-term clinical studies.

CONCLUSION

According to the results and within the limitations of the present study, it can be concluded that there was no significant difference between fracture resistance of reverse-oriented metal posts and glass fiber posts. Hence, it is proposed that both types of studied posts can be successfully used in the restoration of severely damaged primary incisors.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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