"Evaluation of fracture strength of teeth restored with different types of posts luted with different luting cements": An *in vitro* study

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Abstract

Aims: The aim was to evaluate the incidence of root fracture of endodontically treated teeth reinforced with glass-fiber posts and metal posts luted with different luting cements.

Materials and Methods: Forty maxillary central incisors were sectioned at 1 mm of the cementoenamel junction and endodontically treated. The teeth were divided into four groups (n = 10) and restored with prefabricated metal posts and glass-fiber posts luted with resin-based luting cement and glass ionomer cement. Core built up was done using composite resin. The fracture strength was evaluated using an Instron universal testing machine (Model 4206, Instron Corp., Canton, MA). The results were recorded.

Statistical Analysis Used: The Kruskal–Wallis test analysis test was used to analyze the data.

Results: Prefabricated metal post was statistically superior to the glass-fiber posts. Posts luted with resin-based luting cement were superior in fracture strength than glass ionomer cement.

Conclusions: Teeth restored with prefabricated metal posts present higher fracture strength than those reinforced with glass-fiber posts. Posts luted with resin-based luting cement showed higher fracture strength than glass ionomer cement.

Key words: Fracture resistance, glass-fiber post, prefabricated metal post, resin cement

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Introduction

"To Save is Divine and to Extract is Human"

Endodontic treatment is an attempt to save and preserve the tooth with damaged pulp in function. Success of endodontic therapy depends upon a combination of a three dimension fluid tight obturation along with adequate postendodontic restoration to make the pulpless teeth to function as an integral part of the dental arch.[1]

Coronally deficient teeth with sound root are often critical to restore. Coronal tooth structure loss requires utilization of the radicular dentin for support of core.[2]

Posts are often used to retain a core in endodontically treated teeth that have minimal remaining tooth structure.[3]

Post and core equally distributes torqueing forces to radicular dentin to supporting tissues and thus protect and strengthen the tooth against intraoral forces. It disperse forces along the root and provide retention for the core which has replaced the lost coronal tooth structure.[2]

Endodontically treated anterior teeth are traditionally being restored with cast metal post and cores. These metallic

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posts have a much higher modulus of elasticity than the supporting dentin.[4] This mismatch in modulus could lead to stress concentration and leads to failure; inferior esthetics as they do not allow light transmission; might corrode due to gingival and tooth discoloration. This disadvantages of the metal post have lead to search for a plastic based material that has modulus closer to that of dentin.[5]

Tooth-colored posts have increased in popularity since they were introduced in 1997. Prefabricated postsystems have become more popular because they can provide satisfactory results while saving chair time and reducing costs. Tooth-colored fiber-reinforced posts have esthetic advantages, including increased transmission of light through the root and the overlying gingival tissues.[4]

Moreover, fiber-reinforced posts eliminate the problems of corrosive reactions that can occur with metal alloy prefabricated posts. Fiber-reinforced posts can be easily removed if any retreatment is required. An important characteristic of fiber-reinforced posts is their elastic modulus, which is similar to that of dentin, resin cements, and resin core materials.[4]

Many studies have investigated various factors affecting fracture resistance includes length of the post, design of post, surface treatment of post, dentinal surface preparation, dentin bonding agents, luting cements, and polymerization method. The resin cement significantly increases the retention of the posts, and it also increases fracture resistance of the teeth when compared to other cements.[6]

Hence, the aim of this study was to evaluate the incidence of root fracture of endodontically treated teeth restored with two different types of posts: Prefabricated metal post, glass-fiber-reinforced postluted with two different types of cements: Glass ionomer cement, resin cement and composite core system.

The null hypothesis stated that there was no significant difference in fracture resistance of teeth restored with the above-mentioned postsystems luted with above-mentioned luting cements.

Materials and Methods

Forty freshly extracted maxillary central incisors were selected for the purpose of the study had specific dimensions, that is, lengths ranging from 14 to 16 mm and bucco-lingual diameters ranging from 6 to 8 mm. This was done in order to eliminate the dimension variation factor, Table 1, respectively, represents the significance value (based on ANOVA test) of lengths and bucco-lingual diameters of all the specimens belonging to different groups.

Table 1: Significance value (based on ANOVA test) of lengths and bucco-lingual diameters of all the specimens

	For length	For bucco-lingual diameter
F	0.288	0.102
Significance value	0.885	0.981

Significance value >0.05 suggests no significance difference among groups. ANOVA=Analysis Of Variance

All teeth were thoroughly cleaned with an ultrasonic scaler and stored in 10% neutral buffered formalin solution for <1-week at room temperature as this will aid in disinfection of freshly extracted teeth and it will not alter the cutting characteristics of teeth.[7,8]

All the teeth selected had mature root apex, extracted on periodontal and orthodontic ground, no caries, no restorations, no previous endodontic treatment, and no cracks that might affect fracture resistance to experimental compressive loading.

All the teeth were decoronated 1 mm above the cementoenamel junction. The sectioned surfaces were flattened and smoothed with 2 mm grit abrasive paper. The roots were mounted individually in modeling wax, such that the apex of the root was retained on the hard surface.

The roots were endodontically instrumented 1 mm short of the apex with the step-back technique using K-files (Dentsply, Maillefer). Enlarged canals were irrigated with a 2.5% sodium hypochlorite solution, rinsed with saline, dried with paper points (Dentsply), and obturated with thermoplasticized gutta-percha (E and Q master, Meta Biomed, Korea) and a resin sealer (AH26; Dentsply DeTrey, Konstanz, Germany).

After completion of endodontic treatment, the coronal root canal openings were restored with a temporary restorative material (GC Fuji II, GC Dental Products Corp., Tokyo, Japan) and teeth were kept in gauze soaked in saline to maintain moistness.

Specimen preparation

After 24 h, postspace preparation was done with Peeso reamer no. 3 (Mani, Japan) leaving 5 mm gutta-percha in the apices, to preserve the apical seal.

The teeth were then assigned experimental groups ($n = 10$) [Table 2].

Fiber postpreparation

Fiber posts were cleaned with alcohol and dried with air. Salinization was done with silane agent (Monobond-S, Ivoclar Vivadent, US). Bonding agent (Prime and Bond NT, Dentsply DeTrey GmbH, Germany) was applied, and light cured (Mini LED, Setelac, France).

Table 2: Experimental group distribution for the study

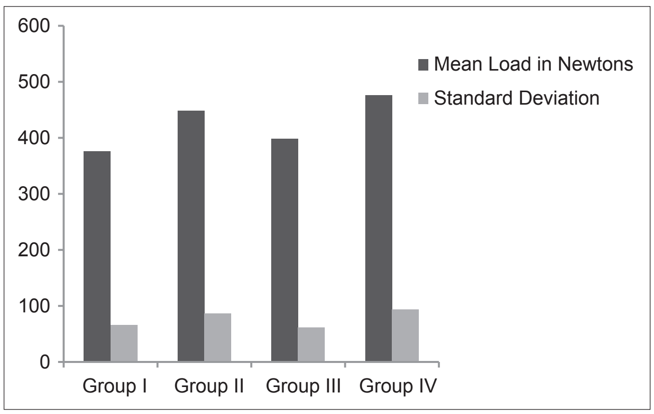
Group	Post	Luting cement	Core built up material
I	Glass-fiber posts (number 1, Reforpost, Angelus)	GC Fuji I (GC Corp., Japan)	Filtek Z 350 (3M ESPE)
II	Glass-fiber posts (number 1, Reforpost, Angelus)	Calibra esthetic resin cement (Dentsply DeTrey GmbH, Germany)	Filtek Z 350 (3M ESPE)
III	Prefabricated metal post (number 3L, Mani, Japan)	GC Fuji I (GC Corp., Japan)	Filtek Z 350 (3M ESPE)
IV	Prefabricated metal post (number 3L, Mani, Japan)	Calibra esthetic resin cement (Dentsply DeTrey GmbH, Germany)	Filtek Z 350 (3M ESPE)

ESPE=3m espe is a company name . so no expansion is there.

Table 3: Mean and SD (in newtons) from the results of kruskal-wallis test

Group	*n*	Mean	SD	*H*	*P*
I	10	377.5	65.70	8.475	0.037 S
II	10	449.7	86.85		
III	10	399.1	62.54		
IV	10	477.1	93.53		

SD=Standard deviation



Graph 1: Fracture loads of teeth in four groups: Mean and standard deviation

Canal preparation

Root canals for group II and IV were etched with 37% Phosphoric acid for 15 s. Bonding agent (Prime and Bond NT, Dentsply DeTrey GmbH, Germany) was applied and light cured (Mini LED, Setelac, France).

Core buildup was completed to the final core height of 6 mm and bucco-lingual and mesio-distal dimensions corresponding to that of the tooth, with the help of composite finishing kit (Shofu, Japan).

The teeth were then removed from modeling wax and mounted individually in addition silicone putty (Affinis, Coltene Whaledent, USA). Each root was mounted vertically, such that the apex of the root was retained on the hard surface.

Load application

All the specimens were placed individually on the testing platform of an Instron universal testing machine (Model 4206, Instron Corp., Canton, MA). Direct vertical load was applied to the long axis of the tooth, at a crosshead speed of 1 mm/min until failure occurred. Reading for individual tooth was recorded.

Results

In all the tested specimens fractured, group IV exhibited the maximum fracture resistance while group I exhibited the least fracture resistance among the four groups. The Kruskal–Wallis statistical test revealed that while comparing the four groups, it was found to be significant at $P < 0.05$ [Table 3 and Graph 1].

Discussion

Posts should have the ability to allow force and stress transfer and distribution to prevent root fracture. This study compared the fracture resistance of natural teeth restored with two different types of postsystems: Glass-fiber post and prefabricated metal post and two different luting cements: Glass ionomer cement and resin cement. Results showed statistically significant difference between teeth restored with prefabricated metal postluted with resin cement and glass-fiber postluted with glass ionomer cement. Thus, we reject our hypothesis.

The aim of postendodontic restoration is to achieve normal form and function and to prevent the fracture of residual root. Caries prevention, esthetics and retention of the final restoration are the other considerations.[9]

To simulate the clinical conditions, natural teeth were used in the study as artificial teeth do not simulate dentin and post will not adhere to the artificial teeth.[5]

This study simulates a realistic condition with a reduced amount of tooth structure which has 1 mm of remaining coronal dentin. Hence, the post and core bears the compressive load.[10]

The aim of this study was to evaluate the fracture strength of two different prefabricated posts like metal post and glass-fiber post when luted with two different cements like glass ionomer cement and resin cement in endodontically treated teeth.

If the postmaterial is having the same modulus of elasticity as the root dentin, applied forces are evenly distributed along the length of the post and the root.[11] If the modulus of elasticity is significantly greater than dentin, it will create stresses at the tooth-cement-postinterface. Hence, it has chances of postseparation and failure.

Glass-fiber post is having modulus of elasticity approximately (9–50 GPa) which is similar to that of dentin which may allow postflexion to mimic tooth flexion. Hence, the glass-fiber post will absorb and distribute the stresses and thus reduced stress transmission to the root.[12]

In contrast, the modulus of elasticity of the metal post is 8–9 times than that of dentin. Hence, the metal posts are stiff and does not absorb stresses. It also concentrates stresses produced by occlusal and lateral forces so it can cause unfavorable root fracture.[13]

Some researchers adopted the idea that stiffer the post the more even the stress distribution.[14] Others have opposed this idea.[15]

In the present study, the results of the fracture pattern revealed that unfavorable fractures in prefabricated metal post group III and group IV were three and five, glass-fiber group I and group II were one and two. Thus, the results concluded that when glass-fiber postsystems were used, less damage to the tooth structure occurred at a failure load. This result supports the results of a study by Dean, in his study out of ten samples, unfavorable fractures in stainless steel posts were five and carbon fiber post was one.[15]

So from the result of the present study, glass-fiber postperformed superiorly if fracture mode was taken as a parameter than fracture resistance.

Cylindrical posts with parallel sides were selected for this study because a study performed by Sorensen states that tapered posts which increases the fracture strength, but it can result in unrestorable complicated fracture upon loading. It occurs because the tapered posts adapts well to residual root.[16]

Some studies similar to the present study have used several type of cements including zinc phosphate cement,[17] Panavia – Ex,[18] Kuraray Dental [GmbH] dual polymerizing adhesive resin cement.[19] Adhesive resin cement has ability to bond to radicular dentin and postallowing conservative postinsertion techniques and reducing potential stress.[20]

Composite has good bond strength, controlled and quick setting, good esthetics, and adequate compressive strength.[21] Composite have higher fracture strength than amalgam and glass ionomer materials.[22]

An ideal postsystem should have fracture strength more than that of physiologic masticatory forces, but it should not be very high to cause catastrophic root fracture. Fracture strength is more important than the retention because recementation of dislodged post can be done but if root fractures, the tooth is lost recementation of postcant be done.[23] Postdiameter, postdesign, postlength, remaining dentin, cement, cementation technique, core material, biocompatibility of postmaterial are the factors which affect fracture treated teeth.[24]

Universal testing machine (4206, Instron Corp., Canton, MA) was used to check the fracture strength. Clinically, the velocity of mandibular movement varies considerably, the compressive load at a crosshead speed of 1 mm/min was maintained because it is considered as an acceptable value.[25]

In the present study, group IV exhibited the maximum fracture resistance while group I exhibited the least fracture resistance among the four groups. Group IV exhibited higher mean fracture resistance followed by group II, group III, and group II, showing that the metal posts were slightly superior. Studies by Sidoli,[25] Purton and Payne,[26] Purton and Love[11] and Gallo *et al*.[12] showed similar results when these two postsystems were compared.

The teeth were mounted in a material for load testing which has limited the resiliency when compared to the periodontal ligament and alveolar bone. Universal testing machine applies single unidirectional load which does not duplicate multidirectional characteristics of masticatory forces.[24] So from these two points, it is very clear that this type of *in vitro* study does not represent the complete *in vivo* situation.

Conclusions

From the findings and within the limitations of this study, it can be concluded that:

- Teeth restored with the prefabricated stainless steel postluted demonstrated significantly higher fracture resistance when compared with the glass-fiber post
- Posts luted with resin cement are having significantly higher fracture resistance when compared with glass ionomer cement.

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