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Comparative evaluation of fracture resistance of glass fiber reinforced, carbon, and quartz post in endodontically treated teeth: An *in-vitro* study

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Abstract

Aim and Objectives:

Use of posts improves the physical properties of endodontically-treated teeth. Different post types are developed such as metal, custom-made, carbon, and quartz. The present study was conducted to evaluate the fracture resistance of glass fiber-reinforced, carbon, and quartz post in endodontically-treated teeth.

Materials and Methods:

Forty extracted human maxillary incisor teeth were decoronated and endodontically treated and equally divided into 4 groups; control, glass fiber-reinforced, carbon, and quartz posts. No post was used in the control group. Post space was prepared and cemented with different posts and subjected to universal testing machine to check fracture resistance. The data were statistically analyzed using *t*-test and analysis of variance to compare the mean difference between groups (SPSS version 20, IBM).

Results:

Quartz type of endodontic post showed good fracture resistance compared to carbon and resin-reinforced post. Least resistance was observed in the control group without post.

Conclusion:

Quartz, carbon, and glass fiber-reinforced posts show good resistance to fracture, and hence can be used in endodontically-treated teeth to enhance their strength.

Key words: *Carbon*, *compressive force*, *core*, *custom*, *fracture*, *post*, *quartz*, *resistance*

INTRODUCTION

Endodontically-treated teeth are often susceptible for crown fracture due to loss of crown structure, dehydration, and changes in the physical condition of pulpless teeth.[1,2,3] Hence, these teeth need to be restored with crown to resist fracture from occlusal load. Endodontically-treated teeth with loss of more than half of the coronal structures are usually restored using post and core with full coronal restoration.[1,2,4] Posts provide resistance and retention for core material whereas core provides stabilization to the coronoradicular part.[2] Endodontic post can be prefabricated or custom made and metallic or nonmetallic types. Conventional metal custom posts are time consuming and nonesthetic in nature; these were widely used in the earlier days. With increase in the demand for materials with improved esthetic and physical quality, various prefabricated tooth colored posts were developed with better strength and physical characters such as carbon, glass fiber-reinforced, composite, quartz, cerapost, and zirconia posts.[1,3] Bondability of posts increases retention and stress distribution and reinforces the tooth structure. It can be achieved with recent prefabricated posts such as carbon, glass, quartz, and reinforced posts, but not with cast posts. Cast post and core are prone to corrosion and their elasticity is different compared to natural tooth structure, resulting into stress and chances of tooth fracture.[2]

Raju *et al*. observed in their study that quartz fiber posts had higher flexural strength as compared to glass and composite-reinforced fiber posts. They also suggested that flexural properties of fiber posts are responsible for root fracture prevention.[4] Tortopidis *et al*. observed highly esthetic result with fiber-reinforced composite post with all ceramic crown.[5] Abduljawad *et al*. observed improved fracture resistance with glass fiber post in endodontically-treated teeth.[6]

Several researchers have observed that modulus of elasticity of metallic posts (220,000 MPa) are 20 times higher than that of dentine whereas glass fiber posts (54000 MPa) is nearer to that of dentine (20000 MPa), which reduces root fracture chances.[1,2,3] The present study was conducted to evaluate the fracture resistance of glass fiber-reinforced, carbon, and quartz post in endodontically-treated teeth via an *in-vitro* study.

MATERIALS AND METHODS

Forty human maxillary incisors teeth free from cracks, fracture, and caries were selected for the study and divided equally into 4 groups with 10 samples in each; (a) control, (b) carbon, (c) glass fiber reinforced and (d) quartz fiber post groups. Sample size was calculated with ± 0.5 of standard deviation with a minimum expected difference of 0.74 and 0.05 of significance at 90% statistical power. Informed consent was obtained from the patients for the use of extracted teeth for the experimental study. Ethical approval was obtained from the institutional review board. Test teeth were decoronated at cementoenamel junction using a diamond saw under water coolant and endodontically treated and obturated using gutta-percha by the lateral condensation technique. Post space was prepared by removing gutta-percha using peeso reamer and leaving 4 mm of apical gutta-percha.

In the control group, neither post-treatment nor post-placement was done. In other groups, after post space creation, cementation of respective posts was done using dual cure adhesive cement after treating post space with a chelating agent (Glyde, Germany). In all groups, core build up was done to a height of 4 mm using composite material.

All test samples were mounted on an acrylic block and subjected to a compressive force at 130° angle to the long axis of tooth with 1 mm diameter using Universal testing Machine (Asian test equipments, Ghaziyabad, India). The compressive force was applied until visible or audible evidence of fracture was observed. The fracture force was measured in MPa. The data were tabulated and subjected to statistical analysis using *t*-test and analysis of variance to compare the mean difference between groups (Statistical Package for the Social Sciences version 20, IBM, Chicago, USA).

RESULTS

Quartz type endodontic post showed good fracture resistance (1318.1 MPa) compared to carbon and resin reinforced post. Least resistance was observed in the control group (632.1 MPa) without post [Table 1]. There was a statistically significant difference ($P > 0.001$) in fracture resistance between control (group a) with other tested post groups and carbon (group b) over glass fiber-reinforced posts (group c), whereas quartz post (group d) had higher fracture resistance compared to the other tested posts [Table 2].

DISCUSSION

Successful endodontic treatment depends on three-dimensional obturation and maintaining the tooth in a nonpathological and functional state. Structural, esthetic, and functional rehabilitation of endodontically-treated pulpless teeth is challenging to the dentist.[3] Fracture resistance of endodontically-treated teeth with loss of crown structure can be enhanced using post and core with full coronal crown restoration.[1] Use of prefabricated posts reduces laboratory and chair-side time. Prefabricated posts are available as metallic and nonmetallic types. Nonmetallic posts are esthetically acceptable and have been observed by many studies to possess good physical properties.[1,2] Glass fiber posts were introduced in 1992 as esthetic endodontic posts.[1] Glass fiber reinforced and quartz fiber posts are composed of glass fibers embedded in an epoxy resin matrix, which distributes stress in a broader surface area, and thus reduces root fracture which provides more esthetic result and transmits light.[1,2] Carbon fiber posts are composed of pyramidal carbon fibers embedded in an epoxy resin matrix, and are fatigue and corrosion resistant with good biocompatibility, however, they have the disadvantage of being dark in color. Fiber posts made up of unidirectional glass fiber in an epoxy resin matrix.[2]

In the present study, quartz type endodontic post showed good fracture resistance (1318.1 MPa) compared to carbon (1275.3 Mpa) and resin reinforced post (1282.6 Mpa). Least resistance was observed in the control group (632.1 MPa) without post after application of compressive force for fracture [Table 1]. Between the groups, fracture resistance was statistically significant [Table 2]. In the present study, human maxillary incisors were selected to check fracture resistance because these teeth are more susceptible to fracture and receive more angular forces.

In our study there was statistically significant difference ($P > 0.001$) in fracture resistance between the control (group a) with other tested post groups, that is, carbon (group b) over glass fiber reinforced posts (group c), whereas quartz post (group d) had higher fracture resistance compared to the other tested posts [Table 2].

Torabi *et al*. found that 50% of teeth restored with carbon post showed irreparable root fracture and lower failure with quartz post, which is similar to our study.[2] Akkayan *et al*. concluded that root fracture resistance is more with quartz group compared to glass fiber post, as observed in the present study.[7]

Our study indicates improved fractured resistance with preformed carbon, glass fiber reinforced and quartz posts whereas the lowest fracture resistance was observed in the control group without post [Table 1]. This is in agreement with the study by Sonakeri *et al*.[1] Similar to our results, Makade *et al*. observed least fracture resistance in group without post and highest fracture resistance in stainless steel post groups. They observed better fracture resistance with glass fiber post compared to metal posts, and also observed cervical and middle third fracture with cast post, whereas only core fracture with glass fiber posts.[3] Good clinical success was observed with carbon and glass fiber posts by several researchers.[8] Kaur *et al*. found higher fracture with cast post compared to glass fiber and composite post.[9]

It was observed by researchers that ferrule incorporation helps in stress distribution in post-treated teeth.[10] Maximum biting force of 100–193 MPa was recorded by Anusavice *et al*.[11] In oral cavity, these forces are higher and affect dental restorations under normal physiologic conditions.[3] This should be taken into consideration for post and core restoration.

Raju *et al*. observed higher flexural strength with quartz fiber ($P < 0.001$) than carbon fiber and glass fiber posts, which is in accordance to our results.[4] Padmanabhan concluded that pre-fabricated stainless steel post had a greater fracture resistance at compared to carbon fiber and the ceramic post.[12] Fráter *et al*. concluded that, fracture pattern not influenced by the elasticity of the post and use of multiple post helps in fracture resistance.[13] Türker *et al*. concluded from their study that there was no significant difference between parallel-sided or tapered posts in terms of fracture resistance, except zirconia post ($P > 0.05$), and no relationship between the bond strength and fracture resistance of the post systems ($r = -0.015$, $P > 0.700$).[14] Braga *et al*. observed the highest fracture strength on premolars when restored with polyfiber post (Spirapost) ($P < 0.05$), similar to sound teeth.[15] Cagidiaco *et al*. observed 90% success with prefabricated post over custom post for only 76% of the patients after 3 years of clinical follow-up of endodontically-treated teeth.[16] Glazer concluded that carbon fiber-reinforced epoxy resin posts in the upper anterior teeth are associated with a higher success rate and longer life than those placed in premolars, especially lower premolars.[17] Cagidiaco *et al*. observed 4.3% deboning with fiber post in 2 year follow-up study.[18]

The present study indicated least fracture resistance in teeth without post compared to carbon, glass reinforced, and quartz post. These esthetic prefabricated posts have a good modulus of elasticity and fracture resistance. Hence, they can be safely used in endodontically-treated teeth with improvement in retention and resistance.

Limitations of the study

This *in-vitro* study may not accurately reflect *in-vivo* situation in determining stress distribution. However, glass fiber and quartz post have very good modulus of elasticity closer to dentin, which helps in improving the fracture resistance of endodontically-treated teeth. Further long-term clinical research is required to assess clinical performance and acceptability.

CONCLUSION

Quartz, carbon, and glass fiber-reinforced posts show good resistance to fracture, and hence can be used in endodontically-treated teeth to enhance their strength.

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Conflicts of interest

There are no conflicts of interest.

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Figures and Tables

Table 1

Group	Sample	Mean	Median	SD
Group a	10	632.1	642.8	72.1
Group b	10	1275.3	1279.4	123.5
Group c	10	1282.6	1285.2	145.3
Group d	10	1318.1	1324.6	152.8

Tests: Analysis of variance, $P<0.01$ nonsignificant, SD=Standard deviation

Mean and standard deviations values for fracture resistance (MPa)

Table 2

Group comparison	*t*-test result	*P*
Group a v/s Group b	13.65	0.001
Group a v/s Group c	14.67	0.001
Group a v/s Group d	18.45	0.001
Group b v/s Group c	11.43	0.001
Group b v/s Group d	17.87	0.001
Group c v/s Group d	0.8975	0.3753

$P>0.001$ significant, t-test

Intra-group comparison of fracture strength