Original Article

Comparative Evaluation of Fracture Resistance of Different Post Systems

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Abstract

Aim: The study was done to evaluate the fracture resistance of carbon, glass fiber, and zirconia posts.

Materials and Methods: Forty-five human premolars indicated for orthodontic extraction were subjected to root canal treatment and obturated with gutta-percha. All the teeth were decoronated and mounted in acrylic block. Then, teeth were equally divided into three groups: (a) carbon, (b) glass fiber, and (c) zirconia post group. Post space was prepared and particular post was cemented in post space. Core buildup was made with composite. A compressive load was applied using universal testing machine and fracture force was measured in MPa. The data were tabulated, and statistical evaluation was done using statistical software IBM SPSS Statistics for Windows, version 21.0., IBM Corp., Armonk, NY, USA, using one-way analysis of variance for analysis of difference and Bonferroni *post hoc* test.

Results: Zirconia endodontic post had good fracture resistance (489.2 MPa) when compared with carbon (258.4 MPa) and glass fiber-reinforced post (348.7 MPa). Fracture resistance was statistically significant between test groups $P>0.001$.

Conclusion: The present study concluded that zirconia had good fracture resistance compared to glass fiber and carbon posts.

Keywords: *Carbon post, fracture resistance, glass fiber post, zirconia post*

Introduction

Endodontically treated teeth often present with compromised crown structure, which need full-coronal restoration along with post and core restorations.[1,2] Endodontically treated teeth present with dehydration, altered esthetic, and change in physical characteristics. Hence, successful outcome of pulp-treated permanent teeth needs proper rehabilitation procedure. Post is required to restore radicular part of teeth and core to enhance coronal structure. The prime objectives of post and core procedure are to build missing coronal structure as well as to provide sufficient retention and resistance form to final restoration.[3,4] In earlier days, custom-made post and core restoration was one of the popular methods to restore endodontically treated teeth. Later on, prefabricated posts gain importance due to reduced time and feasibility.[1]

Today, various tooth-colored posts are gaining popularity such as glass fiber post, zirconia, and composite post. Use of fiber-reinforced post has reduced the risk of root fracture with higher survival rate and has biomechanical

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properties compatible to that of dentin.[5] Glass fiber post can bond to composite core and retain strength. Zirconia posts are newer development in esthetic prefabricated posts.[1,2,6] Previous studies observed that prefabricated steel post or custom post is nonesthetic and has higher failure rates due to internal stress.[3,7] Padmanabhan from his study concluded that prefabricated stainless steel post has significantly higher fracture resistance at failure compared to ceramic or carbon posts,[3] and similarly, Sadeghi from his study found that cast post has higher fracture resistance as compared to zirconia or fiber posts.[6]

Studies related to fracture strength of carbon, glass fiber, and zirconia posts are very less. Hence, the present study was done to evaluate the fracture resistance of different posts – carbon, glass fiber, and zirconia posts – in endodontically treated teeth.

Materials and Methods

Forty-five human premolars with straight roots indicated for orthodontic extraction and free from any caries, crack, and fracture were selected for the present study. The study was conducted during August 2015 to September 2016. Teeth were stored in normal saline after clearing any blood, stain, or calculus. Ethical approval (Ref No: CDCH-Res085/15) for the study was obtained from the Institutional Ethical Committee, and informed consent was obtained from the cases regarding the use of extracted teeth for the study. 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.

All the teeth were decoronated at cementoenamel junction using diamond saw under water coolant, and the length of all the teeth was adjusted to 14 mm. Then, teeth were endodontically treated and obturated with gutta-percha by lateral condensation method. Later, the teeth were randomly divided into three groups of 15 samples in each group: (a) carbon post group, (b) glass fiber-reinforced post group, and (c) zirconia post group.

Post space was created by removing gutta-percha using peeso reamer and leaving 4 mm of apical gutta-percha obturated material. Cementation of selected post (carbon, glass fiber, or zirconia) was done with dual-cure adhesive cement after treatment with chelating agent (Glyde, Germany). Core buildup was done for all the teeth to the height of 4 mm with composite material (3M ESPA).

All root canal filled teeth were stored in normal saline till the end of the study. Root surfaces were coated with melted wax to a depth of 0.2–0.3 mm, below the cervical margin, to create periodontal ligament space. Resin blacks were made using these prepared teeth. After removing the wax spacer, a thin layer of light-body condensation silicone impression material (Speedex, Colten, AG, Feldwiesenstrasse 20, CH-9450 Altstattea, Switzerland) was allowed to flow to simulate periodontal ligament space.

A compressive load at 130° angle was applied to the long axis of tooth with 1 mm diameter using universal testing machine (Veekay Industries, Karol Bagh, New Delhi, India) until visible or audible evidence of fracture was observed. The fracture force was measured in MPa. The data were tabulated, and statistical evaluation was done using statistical software IBM SPSS Statistics for Windows, version 21.0., IBM Corp., Armonk, NY, USA, using one-way analysis of variance for analysis of difference and Bonferroni *post hoc* test.

Results

Zirconia endodontic post had good fracture resistance (489.2 MPa) when compared with carbon (258.4 MPa) and glass fiber-reinforced post (348.7 MPa) ($P > 0.001$) [Table 1]. Fracture resistance was statistically significant between the groups (0.000). Carbon post had least fracture resistance. Carbon fiber has lesser fracture resistance compared to glass fiber and zirconia posts (84.34 and 242.89 MPa, respectively). Glass fiber has 84.34 MPa higher strength than carbon and 138.76 MPa lower strength than zirconia posts. Zirconia post has highest strength compared to carbon and glass fiber posts (242.89 and 138.76 MPA, respectively) [Table 2].

Discussion

We need to look for alternative esthetic posts due to increased esthetic demand and possible corrosion problem with custom metal posts. Post and core method

Table 1: Mean and standard deviation readings for fracture strength (MPa)

Group	Sample	Mean±SD
Group a	15	258.4±13.204
Group b	15	348.7±28.568
Group c	15	489.2±13.658

Test used analysis of variance, $P<0.001$. SD=Standard deviation

Tables 2: Intragroup comparison for fracture resistance

Group	Comparison	Mean difference	*P*
Carbon fiber post	Glass fiber post	−84.34	0.000
	Zirconia post	−242.89	0.000
Glass fiber post	Carbon post	84.34	0.000
	Zirconia post	−138.76	0.000
Zirconia post	Carbon post	242.89	0.000
	Glass fiber post	138.76	0.000

Test used *post hoc* Bonferroni, *P*=Significant (0.00)

is a method of choice where there is loss of most of the coronal structure.[7] Success of post and core treatment depends on case selection, type of post and core used, adhesive resin cement, and operator caliber. Post restoration depends on esthetic need, amount of remaining tooth structure, tooth position, and functional load on tooth.[1,8] Posts can be classified as custom made or prefabricated, metallic or nonmetallic, flexible or stiff, esthetic or nonesthetic types. Post and core interface is the most common site for tooth fractures.[1] Fracture resistance of restoration with post is directly related to post design, post length, post diameter, core material, and type of cement used.[3,7,9] It has been observed that core structure provides stress transmission from crown then to post core structure to remaining root dentin. Root fracture occurs when this stress transmission exceeds the withstanding resistance.[9] Physical properties differ from one post type to other. An ideal post system should have higher fracture resistance than average masticatory forces and should have physical properties such as modulus of elasticity, compressive strength, and coefficient of thermal expansion similar to those of dentin.[3,10] Fracture above the alveolar bone is considered favorable but below the alveolar bone is unfavorable. Posts with significantly greater modulus of elasticity than dentin may create stress at tooth–cement or tooth–post interfaces. Modulus of dentin is found to be around 14–18 MPa.[3] Carbon post has modulus of elasticity of 9–50 GPa. It absorbs and distributes the stress and thus reduces stress transmission.

It has been observed form previous studies that carbon posts are presents with lower failure load compared to glass and quartz posts. However, it has higher flexural strength compared to glass fiber posts.[1] Advancement in ceramic technology gave the introduction of zirconia post. Ceramic posts are rigid and transmit more stress to root canal, resulting into root damage. Ceramic has 170–213 GPa modulus of elasticity, which is around 14 times that of dentin.[3]

Post cementation material is important in its success. Mendoza in their study showed that cementation with PANAVIA has more fracture resistance than with zinc phosphate.[11] Gopal *et al.* also observed highest fracture resistance and bonding efficacy with self-adhesive cementation of posts.[12] do Valle *et al*. stated that longest posts have worst results, whereas shortest posts have best results; this is because longest posts may weaken the root considerably.[7]

The present study evaluates the fracture resistance of carbon, glass fiber, and zirconia post for success of postendodontic treatment. We have observed highest fracture resistance with zirconia post (489.2 MPa) followed by glass fiber and carbon post. Intragroup comparison among the post group was statistically significant ($P = 0.000$).

Vadavadagi *et al*. observed higher compressive strength in carbon post than quartz and glass fiber posts.[1] Ok *et al*. compared the fracture strength of cast post, positive control, negative control (NC), glass fiber post with resin core (GCR), and glass fiber post with rebilda core (GR) and found lowest resistance in NC and highest resistance in cast post group. They also observed cervical third fracture in the GCR and GR groups, but cast post group showed vertical, horizontal, or oblique fractures.[9]

Torbjörner *et al*. observed comparable flexural modulus to stainless steel post, whereas Isidor *et al*. concluded that carbon post has higher fracture strength than prefabricated titanium or metal posts.[13,14] Sharma *et al*. observed higher fracture resistance with quartz post over fiber and carbon posts.[2] Sonkesriya *et al*. observed higher fracture resistance with fiber-reinforced and carbon post compared to metal or custom posts.[4]

Zhou and Wang from metal analysis on fracture resistance of cast post over fiber post observed significantly higher fracture resistance with cast post compared to fiber post.[15] Kılınç *et al*. compared the oval root canal restored with oval and circular posts and found higher fracture resistance in oval post at 10-mm length compared to circular post.[16] Kurthukoti *et al*. on comparing the biologic, fiber, and zirconia posts found highest fracture resistance with biologic post followed by fiber-reinforced composite post and least with zirconia post in contrast to our results.[10] Panitiwat stated that fiber post with composite core improves the fracture threshold.[17]

In the present study, we found highest fracture resistance with zirconia post followed by glass fiber. These esthetic posts provide sufficient fracture resistance to withstand occlusal load. Carbon post is nonesthetic post with comparatively lower fracture resistance. These esthetic posts can be used in high stress-bearing areas such as in posterior teeth. Fracture strength of endodontically restored teeth can be enhanced with these posts.

We have found that carbon fiber has lesser fracture resistance compared to glass fiber and zirconia posts. Glass fiber has higher strength than carbon and lower strength than zirconia posts. Zirconia post has highest strength compared to carbon and glass fiber posts.

Limitation of the present study is lower sample size and thermal changes in oral environment, and masticatory forces were not applied and it was *in vitro* study. Further,

long-term *in vivo* studies are required to evaluate the fracture resistance of different metal and esthetic posts in oral environment for successful postendodontic procedures.

Conclusion

The present study indicated that zirconia post had good fracture resistance compared to glass fiber-reinforced and carbon posts.

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Conflicts of interest

There are no conflicts of interest.

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