Fracture resistance of endodontically treated teeth restored with glass fiber posts of different lengths

Érico Braga Franco, DDS, MSc, a Accacio Lins do Valle, DDS, PhD, b Ana Lúcia Pompéia Fraga de Almeida, DDS, MSc, PhD, c José Henrique Rubo, DDS, MSc, PhD, d and Jefferson Ricardo Pereira, DDS, MSc, PhD e
Bauru Dental School, University of São Paulo (USP), São Paulo, Brazil; Dental School, University of Southern Santa Catarina (UNISUL), Santa Catarina, Brazil

Statement of problem. Endodontically treated teeth are known to have reduced structural strength. Glass fiber posts may influence fracture resistance and should be evaluated.

Purpose. The purpose of this study was to evaluate the influence of glass fiber post length on the fracture resistance of endodontically treated teeth.

Material and methods. Forty intact human maxillary canines were selected and divided into 4 groups, the control group consisting of teeth restored with a custom gold cast post and core, with a length of two-thirds of the root. Other groups received prefabricated glass fiber posts in different lengths: group 1/3, removal of one-third of the sealing material (5 mm); group 1/2, removal of one-half of the sealing material (7.5 mm); and group 2/3, removal of two-thirds of the sealing material (10 mm). All the posts were cemented with resin cement, and the specimens with glass fiber posts received a composite resin core. All the specimens were restored with a metal crown and submitted to a compressive load until failure occurred. The results were evaluated by 1-way ANOVA, and the all pairwise multiple comparison procedures (Tukey honestly significantly difference test) (α = .05).

Results. The ANOVA showed significant differences among the groups (P < .002). The Tukey test showed that the control group presented significantly higher resistance to static load than the other groups (control group, 634.94 N; group 1/3, 200.01 N; group 1/2, 212.17 N; and group 2/3, 236.08 N). Although teeth restored with a cast post and core supported a higher compressive load, all of them fractured in a catastrophic manner. For teeth restored with glass fiber posts, the failure occurred at the junction between the composite resin core and the root.

Conclusion. The length of glass fiber posts did not influence fracture load, but cast post and cores that extended two-thirds of the root length had significantly greater fracture resistance than glass fiber posts. (J Prosthet Dent 2014;111:30-34)

Clinical Implications

The technique of using glass fiber posts and composite resin cores may be appropriate because no root fractures were detected even when one-third of the root length was used. Therefore, this method appears to protect tooth structure against fracture.

aPrivate practice, Bauru, SP, Brazil. Department of Prosthodontics, Bauru Dental School, University of São Paulo (USP).
bProfessor, Department of Prosthodontics, Bauru Dental School, University of São Paulo (USP).
cProfessor, Department of Prosthodontics, Bauru Dental School, University of São Paulo (USP).
dProfessor, Department of Prosthodontics, Bauru Dental School, University of São Paulo (USP).
eProfessor and Research Coordinator, Department of Prosthodontics, Dental School, University of Southern Santa Catarina (UNISUL).
Many dentists assume that endodontically treated teeth are fragile and more susceptible to fractures than vital teeth. However, failures tend to occur when remaining coronal walls are lost and the roots weakened.\(^1\) Issues such as the failure load and mode of fracture have been extensively studied.\(^2\) The most frequent types of failure are loss of post retention,\(^7\) root fracture,\(^3\) and loss of crown retention.\(^7\) Some studies have reported that increasing the post length resulted in a significant increase in root preparation, fracture resistance, and a decreased shear stress concentration.\(^8\) However, when the post is placed beyond two-thirds of the root depth, the level of stress in the apical region increases.\(^14\) The risk of perforation and the weakening of the root caused by decreasing the dentin volume in root preparation must be evaluated because of the compromised prognosis of the restored tooth.\(^15\) The presence of a ferrule is considered the most important feature for the fracture resistance of endodontically treated teeth.\(^1\)\(^,\)\(^15\)-\(^17\)

For many years, the restorative method of choice for endodontically treated teeth has been the cast post and core, with a high rate of success.\(^15\) However, new techniques and materials such as prefabricated posts and composite resin core materials have emerged as alternatives.\(^7\)\(^,\)\(^18\)\(^-\)\(^21\) More recently, an increase in the use of prefabricated post systems has been observed.\(^22\) The use of nonmetallic materials with physical properties similar to dentin is now preferred in restorative dentistry.\(^15\) Glass fiber posts have been reported as having a favorable indication, with their excellent biomechanical properties, esthetics, and clinical performance.\(^22\)\(^-\)\(^27\) However, other studies have shown that glass fiber posts had inferior results to other pre-fabricated posts.\(^26\)\(^-\)\(^30\)

Given the relationship between intra-radicular length and the success of restorations, the purpose of this study was to evaluate the influence of the length of glass fiber posts in the fracture resistance of endodontically treated teeth. The null hypotheses were that no significant difference would be found in the effect of post length on fracture resistance and that no significant difference would be found among the types of post.

**MATERIAL AND METHODS**

This study was approved by the ethics committee of Bauru Dental School, University of São Paulo. Forty extracted human maxillary canines were selected with similar anatomy and with root lengths between 16 and 18 mm. The teeth were cleaned and stored in an antifungal isotonic 0.9% sodium chloride that contained 0.1% solution thymol crystals during the experiment. The crowns were sectioned at the cementoenamel junction with a diamond disk under continuous coolant to standardize the remaining root length at 15 mm. After this procedure, the roots were prepared to a no. 40 file (Dentsply Maillefer), and obturation was done with endodontic cement (Sealapex; Sybron Endo).

The roots were fixed with acrylic resin in cylindrical tubes (20 mm × 20 mm) parallel to the long axis of the cylinder (Duralay; Reliance Dental Mfg Co) (3 mm between the cementoenamel junction and the acrylic resin was left without acrylic resin to represent in vivo distances). The specimens were then randomly divided, by drawing lots, into 4 groups (n=10). All the specimens were identified according to the group to which they belonged (Fig. 1).

The length of root canal preparation varied according to the post length: the control group and group 2/3 had 10 mm of endodontic filling material removed; group 1/3 had 5 mm of endodontic filling material removed, and group 1/2 had 7.5 mm of endodontic filling material removed. During and after the endodontic preparations, irrigation was performed with solutions of 2.5% sodium hypochlorite and 17% EDTA and saline solution to remove remnants of gutta percha and dentin.

Cast posts and cores were obtained from acrylic resin patterns of the root canals (Duralay; Reliance Dental). The core height (6.5 mm) and dimensions were standardized by using a core-forming matrix (TDV Dental). The patterns were cast in Type IV gold alloy (Stabilor G; Degussa Dental AG). After casting, they were adjusted and adapted to their respective post spaces.

The glass fiber posts used were Fibrekor no. 2 (diameter, 1.25 mm) (Jeneric/Pentron). The posts were inserted into the prepared post spaces to evaluate whether they achieved the desired length and crown extension of 4 mm. Marks were made, and the final length of the posts was achieved by cutting off the excess with a diamond disk under water cooling. Before cementation, the posts were cleaned with 70% ethanol and water, air-dried, and silanized (Clearfil SE Bond Primer and Porcelain Bond Activator; Kuraray Co Ltd).

The remaining root dentin of specimens from groups 1/3, 1/2, and 2/3 were etched with 37.5% phosphoric acid for 30 seconds, washed for 10 seconds, and partially dried with air jets and absorbing paper points, which left the dentin moist. The adhesive system (Excite; Ivoclar Vivadent) was applied to both the root surface and glass fiber post and was photopolymerized for 20 seconds with a polymerization unit (Ultradent 110 W; Dabi Atlanfe) used at a 450 MW/cm\(^2\) light intensity; then a composite resin core (Z100; 3M ESPE) was made.

All the posts were cemented with Panavia 21 (Kuraray) by following the manufacturer’s recommendations. The tooth was prepared with 1.5 mm of facial reduction with a chamfer finish line and 0.5 mm of chamfered lingual reduction to receive a complete metal crown. The waxing of the crowns to the shape of a canine tooth was performed directly on the teeth. On the lingual surface of the waxed crowns, an area was demarcated for loading from the universal testing machine (Kratus Model K-2000; Dinamômetros Kratos Ltda) to apply the load. The wax patterns were sprued, invested (Cristobalite; Whip Mix Corp), and cast in a nickel-chromium alloy (Durabond; Comercial Odonto
The crowns were cemented with the same material as for the posts. The roots were tested with a universal testing machine (Kratus K2000 MP, Dinamômetros Kratos), with a 500 N load cell at a crosshead speed of 0.5 mm/min. The specimens received the compressive load 3.0 mm below the incisal edge of the crowns, at a 135-degree angle to the long axis of the root (45 degrees relative to the horizontal plane), which simulated the occlusal contact of the antagonist tooth in an angle class I relationship (Fig. 2).

### RESULTS

Statistically significant differences among the groups were found (ANOVA) ($P<.002$). The Tukey honestly significantly difference (HSD) test confirmed that the mean shear strength for the control group was significantly higher than for the other groups. When the shear strength among the groups restored with glass fiber posts was compared, no significant differences were found among them ($P>.05$) (Table I).

### DISCUSSION

The first null hypothesis, that no significant difference would be found in the effect of post length on fracture resistance was not rejected, but the second null hypothesis that no significant difference would be found among the types of posts was rejected. The main function of an intraradicular post is to offer retention and support to the future restoration. The increase in the intraradicular length of the glass fiber posts did not significantly influence the resistance to shear load of endodontically treated teeth.

There are several formulas to determine the intraradicular length of metal prefabricated posts or custom cast posts and cores. In this study, in a similar manner to the study performed by Isidor et al, 3 intraradicular lengths of glass fiber posts were used. At least 4.5 mm of apical gutta percha was retained in the canal to assure apical sealing of the root canal.

Catastrophic root fractures occurred when cast post and cores were tested. This has been observed in other studies. In contrast, retrievable core fractures occurred in the groups restored with glass fiber posts. All restored teeth with glass fiber posts failed because of cementation failure between the core and the remaining root dentin. This type of failure is considered reparable and has been reported in other studies. The average load of failure in this study was higher than the average load of failure found in other studies for cast posts and cores.

| A | Control group, cast post and core with 10 mm of intracanal length. |
| B | Group 1/3, prefabricated glass fiber post with 5 mm of intracanal length. |
| C | Group 1/2, prefabricated glass fiber post with 7.5 mm of intracanal length. |
| D | Group 2/3, prefabricated glass fiber post with 10 mm of intracanal length. |
Table I. Means (SDs) of failure load for each group and Tukey honestly significantly difference test

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>634.94 ±53.25a</td>
</tr>
<tr>
<td>1/3</td>
<td>200.01 ±28.07b</td>
</tr>
<tr>
<td>1/2</td>
<td>212.17 ±17.12b</td>
</tr>
<tr>
<td>2/3</td>
<td>236.08 ±19.68b</td>
</tr>
</tbody>
</table>

SD, standard deviation. Groups with same superscripted letters are not significantly different at P<.05.

The teeth in this study presented no remaining coronal dentin and no ferrule. This represented the more challenging condition for the use of posts because the presence of at least 2.0 mm of remaining coronal dentin increases the resistance to fractures of teeth restored with prefabricated posts.\(^3,5\) In teeth with cast posts and cores, and in those with glass fiber posts, a complete metal crown was used to simulate a typical restorative clinical condition; this methodology has been adopted in another study.\(^14\) However, it is important to highlight that in vitro studies present several limitations. The most important is the difficulty in simulating the mechanical condition present in the oral environment. First, the tooth is not rigidly fixed in the bone because the periodontal ligament allows micromovement of the root and modifies the distribution of forces, thereby acting as a buffer. A second important factor is the modification of the distribution of functional loads, which can influence the final results. With a cemented crown, the stresses of functional loads concentrate at the cervical portion of the tooth.\(^9,10,15\) This stress concentration applied to glass fiber posts with a lower modulus of elasticity than Type IV gold alloy explains the failures observed in groups 1/3, 1/2, and 2/3 of the present study. With the dislocation of the crown and of the core, an increase of the stress on the post occurs, which causes the cementation failure. A third important factor was that this study was performed in vitro by using static loading, which could not completely replicate clinical conditions. For more meaningful results, further studies should incorporate thermocycling and mechanical fatigue until failure.

In the control group, because the cast post and core had a much higher modulus of elasticity and rigidity,\(^15\) the crown walls provided higher retention and stability to the crown restoration. However, this core transmitted more stress from the crown to the post and core, and, therefore, to the remaining root dentin, and the failure occurred when the load exceeded the limit of resistance to the root fracture.\(^7\)

Although many suggestions have been made regarding the intraradicular length of posts, few studies have been performed to specifically evaluate this variable with metallic and glass fiber posts.\(^5,20\) Even though few studies have been performed with glass fiber posts, the disadvantages of post length are the same in metal and nonmetal posts. The post length, although important to the mechanical behavior of metal posts, is not as important in glass fiber posts. In this study, all the experimental specimens were made of glass fiber with different lengths and failed at similar loads. These loads are below those expected during function when considering the masticatory forces reported by Neill et al.\(^20\) Catastrophic root fracture is a rare occurrence, and the major clinical complication of fiber reinforced composite posts is adhesive failure (clinically expressed as post-crown debonding).\(^26\) Pereira et al.\(^27\) reported that the self-adhesive resin cements and the glass ionomer cements presented higher push-out bond strength values than the dual-polymerizing resin cements.

**CONCLUSIONS**

The intraradicular length of glass fiber posts was not a relevant factor in the failure load of endodontically treated teeth. Irreparable root fractures occurred in the group with cast posts and cores, whereas repairable failures occurred in the groups with glass fiber posts.

**REFERENCES**


Corresponding author:
Dr Jefferson Ricardo Pereira
Rua Recife 200, Aperto 601
Bairro Recife Tubarão, SC 88701-420
BRAZIL
E-mail: jeffripe@rocketmail.com

Copyright © 2014 by the Editorial Council for The Journal of Prosthetic Dentistry.