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Original Research

Comparative evaluation of the fracture resistance of cast metal post, custom made glass fiber reinforced post, prefabricated glass fiber reinforced post, and carbon fiber reinforced posts in endodontically treated teeth – an in vitro study

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ABSTRACT:

Background: Endodontically treated teeth were known to present a higher risk of biomechanical failure compared to vital teeth. To restore back the strength of fractured root canal treated teeth, a post and core would serve as an ideal solution which protects the weakened tooth. Hence; we evaluated the fracture resistance of different post systems in endodontically treated teeth. **Materials & Methods:** Forty human maxillary central incisor teeth, extracted for periodontal reasons will be taken for the study with a minimum of 10 samples in each group: Group I – Custom made metal post; Group II – Custom fabricated glass fiber reinforced post; Group III – Prefabricated glass fiber post; Group IV – Carbon fiber reinforced post. All samples were decoronated at cemento-enamel junction and endodontically treated. Post space was prepared and selected posts were cemented. The composite cores were prepared at a height of 5 mm. All specimens were mounted on the acrylic block, and subjected to the compressive force at 1 mm diameter at an angle of 45° to the long axis of the tooth using Instron Universal Testing Machine. The force at fracture was measured in MPa. **Result:** It was observed that custom fabricated cast post and cores presented with higher fracture strength than those teeth with custom made glass fiber, prefabricated glass fiber, prefabricated carbon fiber posts.

Key Words: Cast post core, Everstick post, Prefabricated glass fiber post, Carbon fiber post, Fracture resistance of endodontically treated teeth

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INTRODUCTION

Restoration of grossly mutilated endodontically treated teeth plays an important role in modern restorative dentistry. Posts are often required to restore these teeth to provide a coronaradicular stabilization of the core material.^[1]

The cast post-and-core procedure has been advocated as the gold standard restoration for decades. Nevertheless, metal posts and cores are associated with inferior aesthetics, also they might corrode causing gingival and tooth discoloration.^[2] Hence with the increasing demand for esthetic and better physical quality, various tooth-colored posts such as glass fiber reinforced post, carbon fiber post, zirconia post, and composite post were developed.

Recently a new type of adhesive and flexible fiber posts was introduced. The post is made of silanated glass fibers in thermoplastic polymer and light curing resin matrix. The patented resin mixture is called interpenetrating polymer network structure (IPN).^[3] The IPN structure is responsible for proper bonding between the post surface and a restorative or luting composite resin. The IPN structure also makes EverStick posts flexible and sticky before light curing.^[4] Because of the flexibility, good IPN bond with direct composite resins and remaining tooth tissues, EverStick post could be very useful for direct aesthetic restorations of anterior teeth.

There are very few published studies comparing the fracture resistance of the metal and fiber posts. Hence the present study was aimed to compare the fracture

resistance of endodontically treated teeth restored with different posts such as cast metal, custom made glass fiber reinforced, prefabricated glass fiber reinforced and carbon fiber reinforced posts.

MATERIALS & METHODS

A total of forty recently extracted human maxillary central incisors with similar root sizes, were selected and stored in saline until they were used. Their roots were examined for any cracks or caries. With the use of a diamond disc (Mani Inc, Japan), the teeth were decoronated, while all resulting roots had the length of 15 mm, 2 mm coronal to the amelocemental junction, at a level corresponding to the clinical gingival margin.

Endodontic treatment was performed using hand K-files (SybronEndo, Mexico) to a master apical file size of 40. 3% Sodium hypochlorite (Prevest DenPro Limited, India) irrigation was used during the cleaning and shaping. The canals received a final wash with 17% EDTA (MD Cleanser, MetaBiomed, Korea) to remove any traces of sodium hypochlorite. The roots were obturated with laterally condensed gutta-percha using 40-size gutta-percha (Dentsply, Maillefer, Switzerland) as a master cone and a resin sealer (AH Plus, Dentsply Maillefer, Switzerland).

Root canal filled roots were stored in normal saline at room temperature (24 – 28°C) to prevent dehydration for 24 h.

The teeth were randomly assigned to four experimental groups (n=10) as follows:

Group A: Cast metal post and core

Group B: Custom-made glass fiber post with composite core

Group C: Prefabricated glass fiber post with composite core

Group D: Prefabricated carbon fiber post with composite core

In all groups, the excess gutta-percha was removed using Gates Glidden drills (Mani Inc, Japan). The post space preparation was done with Peeso-Reamer (Mani Inc, Japan) up to number 4 size to a depth of 10 mm. A minimum apical seal of 5 mm of gutta-percha filling was retained. And also before cementation of the posts, the canal was cleaned with EDTA and sodium hypochlorite and dried with paper points.

Group A Specimen preparation:

Direct technique was used to fabricate a post core pattern with inlay wax (GC, India). The core height of all group is standardized as 5mm. The pattern was casted with Type IV Ni Cr alloy (RUBY max white, India) using a lost wax technique. The post was cemented with the dual cure adhesive resin cement (Paracore, Coltene/whaledent, Switzerland).

Group B specimen preparation:

The custom-made glass FRC posts in group B were handled according to the manufacturer's instructions. A bundle of preimpregnated glass fibers (GC Everstick, India) was cut to a length of 10 mm. This

bundle was inserted into the canal and initially light cured (CRB curing light, India) for 20s. Thereafter, the post was removed from the canal and additionally light cured for 40s. The post was then inserted in the canal and an additional bundle of preimpregnated glass fibers was placed along and adhered to the post, and initially light cured (20s). The custom-made FRC post was removed from the canal and finally light cured (40s). The FRC post system was then wetted with resin (GC Stick Resin, India) and protected from light while the cement was being prepared. Post was cemented using dual cure adhesive resin cement (Para core, Coltene) and core built up was done with composite resin.

Group C specimen preparation:

The length of the post in the canal was marked and the trimmed glass fiber post was replaced in the canal to confirm its length. An adhesive primer and bonding agent (Parabond, Coltene) was applied to the canal and an adhesive resin cement (Paracore, Coltene) was dispensed into the canal. Post was seated in the canal and the adhesive resin cement was light-cured for 60sec. The core was established with the successive addition of composite resin (Coltene, Germany)

Group D specimen preparation:

In group D, the carbon fiber post cementation and core build up was done same like procedures explained for group C.

Each root was fixed in cylinders with 30mm diameter and 30mm height with acrylic-resin (DPI, Mumbai) keeping 2mm of the cervical root exposed. Previous to acrylic immersion, the root was evolved with a 0.6mm-thick foil (Adapta foil). The tooth was positioned into the cylinder and the acrylic resin was applied. After the first signals of acrylic polymerization, the tooth was removed along with its long axis. The foil was removed and elastomeric material (Affinis, Coltene/Whaledent, Switzerland) was injected into the resin acrylic blocs and the tooth was repositioned, creating a standardized layer that simulates the periodontal ligament (approximately 60 micrometers).

Testing procedure:

The samples were subjected to thermocycling (5000 cycles between 5°C–55°C with a dwell time of 30 seconds at each temperature) and stored in saline for 24 hours at 37°C in a humidor (100% relative humidity). All specimens were stored in saline for 24 h prior to the mechanical testing.

After 24 h, the fracture resistance was evaluated in a Universal Testing Machine (Instron, Central Institute of Plastics Engineering and Technology, Guindy, Chennai, India) with load at a 135° angle to the root long axis (45° to the horizontal plane) with a crosshead speed of 0.5 mm/min (Figure 1).

Statistics

Data were entered in Microsoft Excel spreadsheet, corrected for errors if any and analyzed using SPSS

version 21.0. Quantitative variables were presented as mean ±, standard deviation (Tables 1 and 2). One way analysis of variance (ANOVA) for comparison of means was used. For the post hoc comparisons, the Tukey test was used.

A two-sided ‘P’ value of < 0.05 was taken as statistically significant.

RESULTS

Teeth in group 1 (cast metal post) needed the maximum load application in order to fracture. Among these experimental groups teeth restored with cast metal post (group 1) have the highest fracture resistance followed by group 2 (teeth restored with custom made glass fiber post) and teeth restored with carbon fiber post (group 3). Teeth restored with prefabricated glass fiber post needed the least amount of force to fracture.

Table 1: Depicts the mean and SD of the entire sample (n=10 teeth per group)

Groups	Mean	Standard deviation
Group 1 (cast metal post)	807.70	100.837
Group 2 (custom made glass fiber post)	598.70	45.622
Group 3 (pre-fabricated glass fiber post)	400.80	38.183
Group 4 (prefabricated carbon fiber post)	509.90	40.408

Table 2: Graphical comparison of four groups

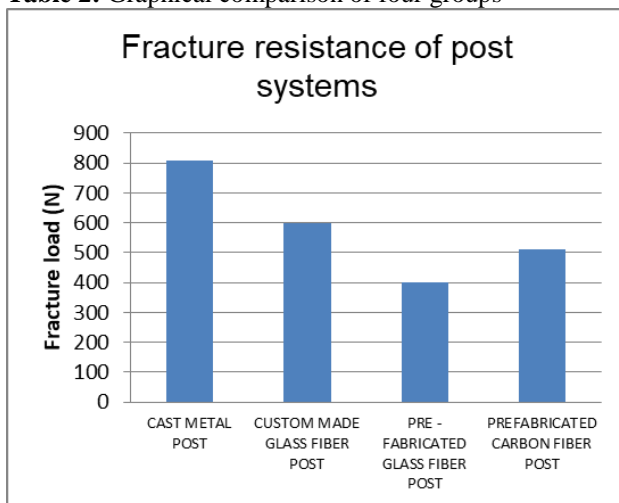


Figure 1: Fracture resistance testing under universal testing machine



DISCUSSION

To restore back the strength of fractured root canal treated teeth, a post and core would serve as an ideal solution which protects the weakened tooth.^[5]

Human maxillary anterior teeth are more susceptible to trauma and receive more angular forces. Hence they were selected to represent the best possible option to simulate the clinical situations.^[6] The posts used were chosen to represent frequently used systems in daily practice.

The present results showed that teeth reinforced with the cast post and cores present a significantly higher resistance to fracture than the other groups with fiber posts. It could be explained by their capacity to allow a high amount of stress concentration previous to bending because of their higher modulus of elasticity(200 Gpa), and previous to transmitting stress to the tooth, promoting higher failure resistance.^[7-10] In addition, the juxtaposition of the cast post to the root canals minimizes the cement layer and may contribute to increased fracture strength.^[7,11]

These results are consistent with those of Balkaya and Birdal,^[12] Okamoto et al,^[13] Asmussen et al,^[14] and Dejak and Mlotkowski.^[15] who indicated that teeth restored with cast posts demonstrated higher fracture resistance than those with fiber posts and that cast posts produced lower stresses in the dentin and luting cement than the fiber posts. Martinez-Insua et al,^[16] studied the fracture resistance of teeth restored with carbon fiber posts and cast posts. They reported a significantly higher fracture threshold for cast post and cores.

Also, the significantly higher characteristic strength of custom made glass fiber posts could be explained by its intimate fit along the root canal walls compared with other prefabricated fiber post systems with poorer fit, which resulted from the absence of drills for post space preparation matching that of the definitive post dimension, resulted in a thicker cement layer. Therefore, the lower fracture strength of the prefabricated fiber post groups may also be attributed to the displacement of fracture of the resin cement layer, composite core or the post during the mechanical testing.^[17]

These results are in agreement with Frater et al,^[18] who studied the fracture resistance of premolar teeth restored with fiber reinforced composite posts. He used both prefabricated glass fiber post and EverStick

post for both single and multipost technique. And he found out that the group with EverStick posts had higher failure loads than the group with prefabricated glass fiber posts.

In a study by Fokkinga et al^[19] there was no significant difference in mean failure loads between EverStick fiber group and cast metal and prefabricated fiber reinforced posts group. In that study, the roots were not filled, which might have influenced the results because retention of adhesive restorations is also influenced by the contamination of the bonding surface.

Among all the four groups, the lowest fracture resistance values were observed for teeth with prefabricated glass fiber posts than the carbon fiber posts group. These results may be explained by the higher modulus of elasticity of carbon fiber post than the glass fiber post. This is in accordance with the study by Pereira et al,^[20] who indicated teeth with carbon fiber post demonstrated higher characteristic strength than the glass fiber post group.

Loney et al,^[21] showed that different load angles result in different fracture strengths. Moreover, the resistance of a restoration in the oral environment is not determined by failure load alone. Meanwhile, it is not feasible to simulate the whole complexity of the oral cavity with laboratory tests.^[22,23] And the problem of cyclic loading, however, is that it is very time consuming and surrogate variables are required to describe failure.^[24,25]

The placement of a crown during endodontic restoration testing may obscure the effects of different build-up techniques.^[24] Hence, cores were not restored with crowns to exclude any external strengthening influence on the post and core foundations. And also extrapolation to a clinical situation cannot be made without the use of crowns; hence this might be a limitation of the study.

We recommend further *in vitro* studies evaluating the resistance of these commercially available posts under thermomechanical loads and clinical evaluations can contribute to choosing the best available post system in the market.

CONCLUSION

Within the limitations of this *in vitro* study, considering the conditions evaluated, it can be concluded that:

- Custom fabricated cast post and cores present with higher fracture strength than those teeth with different fiber post systems.
- Among the tested four groups, prefabricated glass fiber posts group presented with the lowest fracture resistance values.
- Mean values of the fracture strength of all groups were higher than the mean values of bite force observed in the literature which indicates that these post systems are acceptable to use clinically.

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