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**Original Research**

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# Fracture Resistance of Three Different Post and Core Systems on Endodontically Treated Teeth: An *In Vitro* Study

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***Abstract:***

**Background:** Endodontically treated teeth are usually more susceptible to fracture because they have insufficient coronal tooth structure as a result of caries, trauma, or the endodontic procedure itself. Posts are recommended to strengthen weakened endodontically treated teeth against intraoral forces by distributing torquing forces along the roots. Currently, a wide variety of custom and prefabricated dowel systems are available to improve the retention of extra-coronal restorations of non-vital teeth.The objective of the study was to comparatively evaluate the fracture resistance and mode of failure of three types of dowel systems.

**Materials and Methods:** A total of 30 premolars were used in this *in vitro* study. The crown portion was removed at 2 mm from the cemento-enamel junction was endodontically treated. The specimens were randomly assigned to three groups to receive cobalt chromium cast metal post, carbon post, and zirconium post. The roots were embedded in the acrylic block, and a load was applied at 90° to the occlusal surface until fracture, at a crosshead speed of 1 mm/min. The data were analyzed statistically with ANOVA with *post-hoc* Tukey honest significant difference.

**Results:** Mean fracture resistance (KN) for cast post and core was highest with a mean value of 5.02 ± 0.32. The carbon post and zirconia post had a maximum load at failure of 1.67 ± 0.26 and 2.27 ± 0.23, respectively. The carbon fiber post and zirconium had a significantly lower strength than cast post and core.

**Conclusion:** All the three systems exhibited fracture resistance that can withstand normal functioning of an endodontic dowel system. Carbon fiber post showed a modulus of elasticity similar to dentin and can be used in most cases. Zirconia prefabricated dowels can withstand higher load but can end up with root fracture. Hence, the selection of dowel system should be based on an individual case basis.

***Key Words***: Carbon fiber post, endodontically treated teeth, fiber posts, fracture resistance, premolars, zirconia post

## Introduction

Endodontically treated teeth were usually more susceptible to fracture because they have insufficient coronal tooth structure as a result of caries, trauma, or the endodontic procedure itself.[1] Esthetic, functional, and structural rehabilitation of a pulpless tooth is critically important due to the loss of the tooth structure, altered physical characteristics by the altered collagen crosslinking, dehydration, altered esthetic characteristics of the residual tooth, and the impaired neurosensory feedback mechanism.[2] Endodontically treated teeth are usually restored using a crown to avoid fracture. A post is indicated in the endodontically treated teeth when it is severely damaged.[3] Coronal reinforcement is also indicated in teeth were more occlusal loads are directed.

Many options are available for the reconstruction of endodontically treated teeth varying from custom-made cast metal posts to pre-fabricated metal and non-metal posts.[4] They can be classified according to their structural composition as metal, ceramic, or resin reinforced with fibers. The advent of more advanced composite resin and ceramic materials has led to the development of wide variety of these non-metal endodontic posts.[5] The conventional cast metal post and the core were considered the standard option; however, these posts have biological and mechanical disadvantages such as high modulus of elasticity, lack of retention, and root fracture.[6] Traditionally, cast post and cores were made of metal, and its alloys and the material of choice is stainless steel, titanium, and titanium alloys. Other metal alloys that have been used are platinum-gold-palladium, chromium containing alloys, and brass. Newer materials, such as zirconia and fiber-reinforced posts, are widely used for restoration of teeth.[7]

The clinical success of fiber-reinforced dowels had been attributed to their modulus of elasticity, which matches that of dentin and resin luting cements. This reduces stress transmission to root canal walls and decreases the risk of vertical root fractures.[8] Zirconia ceramic posts are white, radiopaque with a modulus of elasticity higher than stainless steel. The high rigidity of zirconia ceramic posts produces higher stresses at the coronal portion where the tooth structure is minimal that can lead to more catastrophic root fractures *in vitro* compared to metal and carbon fiber posts.[9]

The fracture resistance of dowel-restored teeth has been the subject of numerous studies in the past. The clinical

performance of the post and core restorations may be due to mechanical failure in the form of post dislodgement, post and crown fractures, para-functional or cyclic loading factors, and thermal or chemical influences. Materials with which the posts are fabricated presents with certain properties that make them unsuitable for reinforcing the tooth. Therefore, it is necessary to evaluate the post systems for the appropriate selection. Hence, the objective of this study was to compare the fracture resistance and mode of failure of endodontically treated mandibular premolars restored with three different endodontic dowel systems, which included custom-made cast post (cobalt-chromium), carbon fiber post, and zirconium post systems.

**Materials and Methods**

The study was approved by the Department Review Board of the College of Dentistry, Prince Sattam bin AbdulAziz University. 30 human mandibular first premolars with roots of similar form were selected for the study, of which the specimens selected were from teeth after orthodontic extractions of individuals belonging to the age group 20-25 years age group. The teeth selected had a single canal with straight roots measuring approximately 21 mm. The teeth with caries; crack and restorations were not included in the study.

All external debris were removed from the tooth surface with an ultrasonic scaler (Cavitron Touch®, Dentsply, York, PA 17404, USA), and the teeth were stored in normal saline solution. The anatomic crowns of all teeth were removed 2 mm above the cemento-enamel junction. The exploration of the radicular canal was accomplished with No. 25 K-file (Dentsply Maillefer, Switzerland). The selected specimens had a uniform working the length of 17 mm approximately. Routine endodontic treatment was accomplished with hand instruments using step back technique to a size of 40 for a master apical file. Silicone stoppers were placed around the K-file shaft to control the working length, thereby ensuring the accuracy of the internal canal dimensions. The roots were obturated with Gutta-percha points (DENTSPLY Maillefer, Ballaigues, Switzerland) using zinc oxide-eugenol sealer. The master Gutta-percha point (size 40) was coated with sealer and seated in the canal to the predetermined working length. The excess Gutta-percha was removed using heated hand condensers. Vertical condensation was performed with the same instruments, and the pulp chambers were sealed with zinc oxide-eugenol temporary restoration (Dental Products of India, Mumbai, Maharashtra, India).

Cobalt chromium cast post was fabricated by the indirect impression technique. The final restoration was trimmed and finished as per the standard protocol.[10] The cobalt chromium cast posts were cemented using zinc phosphate cement. The prefabricated carbon fiber post (C-Post; Bisco Inc., Schaumburg, IL, USA) was coated with a resin and inserted into the previously treated post space, and the whole assembly was cured with visible light (Dentsply, Caulk, Milford, Detroit, USA). The Zirconium posts (CosmoPost, Ivoclar Vivadent, Inc. NY, USA) were surface treated using hydrofluoric acid followed by dentin bonding agent. These posts were cemented using the resin cement. A 4 mm height core was built on top of the post and fixed to the sectioned surface. The mounted specimens were tested with a universal testing machine (Instron 8500, Instron, Norwood, MA, USA) set to deliver an increasing load until failure. The crosshead speed was 1 mm/min, and the load was applied on the occlusal surface which was parallel to the long axis of the tooth. The specimens were tested in random order (Figure 1).

**Results**

A total number of 30 samples ($n = 10$) were tested to determine the fracture resistance of three different endodontic post systems made of cobalt chromium, carbon fiber, and zirconium ceramic. The cast post and core showed highest fracture resistance with a mean of 5.02 KN and a standard deviation of 0.32. Out of the two prefabricated post-tested, Zirconia showed better fracture resistance compared to carbon fiber post (Figure 2). The carbon fiber post had a mean breakage at 1.67 ± 0.26 KN compared to zirconia (2.27 ± 0.23 KN). Statistical


**Figure 1:** The specimen loaded in Instron machine for testing.

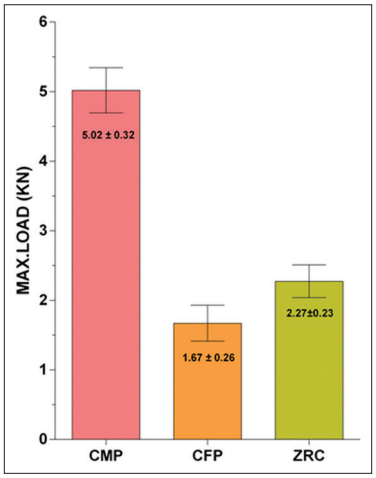


**Figure 2:** The maximum load applied to fracture resistance.

analysis showed significantly higher fracture resistance among three groups ($P < 0.01$). The observation of the fracture pattern showed that carbon fiber post fractured itself without creating fracture of the root. With zirconia mostly vertical root fracture was resulted on the application of load.

**Discussion**

Restoration of endodontically treated teeth is one of the most challenging problems facing the restorative dentist. As a result of the endodontic treatment, a major part of the tooth structure is lost due to biomechanical preparation during root canal therapy. They become very weak and brittle and also more prone to fracture compared to vital teeth.[11] Endodontically treated tooth with decreased coronal tooth structure is an indication for intra-radicular devices such as dowels or posts. These devices reinforce the root for providing the foundation for the future extra-coronal restorations.[5] The endodontic post offers retention and resistance for a core material and to provide a corono-radicular stabilization.

The longevity of endodontically treated teeth depends on the type of post and restoration used.[12] Several post and core systems are available varying from conventional cast post and core systems to prefabricated post made from a wide range of materials.[12] The rigidity of the post and core systems also could be a factor in the success since it has to transmit the stress to a less rigid substrate.[13]

In this study, we observed that the cast post and core had a significantly higher fracture resistance than the carbon fiber reinforced and zirconia prefabricated post. Cast post and core has been regarded as the "gold standard" in post and core restoration due to its superior success rate when there is minimal coronal tooth structure.[14] The carbon fiber posts are translucent and can transmit light thereby permitting the light curing of the adhesive materials within the root canal. Its chemical nature is compatible with the BIS-GMA commonly found in composite resins. The translucent fiber posts exhibit biocompatibility, high fatigue, tensile strength, and modulus of elasticity comparable with that of dentin and other fiber posts.[15,16]

Zirconia post has a high flexural strength, increased biocompatibility, corrosion resistance, and fracture toughness.[7] Due to its superior esthetic properties, the zirconia-reinforced post is getting more popularity. In this study, it was noted that the zirconium had significantly higher fracture resistance to glass fiber post. The post, with modulus of elasticity similar to dentin, is desirable to be used due to its homogenous stress distribution reducing the risk of fracture. In this study, the post systems failed at a stress above the masticatory load and hence can be used for restoration of endodontically treated teeth based on the appropriate clinical situations.[17]

In this study, carbon fiber posts showed lowest fracture resistance which is in agreement with earlier reports.[18,19] The modulus of elasticity of carbon posts is closer to that of dentin. Although the carbon posts are in close contact with the resin matrix, lowest resistance to fracture may be due to the value obtained from post composition and orientation of fibers. Fibers diverging from the posts in longitudinal axis results in stress transmission to the matrix. Posts with parallel fibers are able to withstand loads better than loads with obliquely oriented fibers. Hence, this orientation of fibers might have attributed to the lowest fracture resistance of carbon fiber posts.[13] Since the carbon fiber post have a comparable modulus of elasticity of root dentin, the forces are transmitted evenly which prevented root fracture.

Although this *in vitro* method of test to detect the fracture resistance is to mimic the clinical situation, limitation exists such as the application of monostatic load as well as the dynamic situation in the oral cavity.[20] The effect of periodontal ligament was also not simulated in this study, and earlier studies have shown that it is futile to replicate a system *in vitro*.[21,22]

**Conclusion**

This study was done to evaluate the fracture resistance of three different post systems, which were commonly used for restoring endodontically treated teeth with major loss of coronal tooth structure.

Within the limitations of the study, the following conclusions were drawn.

- Teeth restored with cast metal posts and cores exhibited the highest fracture resistance. Carbon fiber posts exhibited the least fracture resistance compared to zirconia posts and cast post systems.
- Majority of the teeth restored with zirconia posts showed catastrophic vertical root fracture.
- The carbon fiber post showed fracture of the post itself rather than the root.

Hence, the selection of the prefabricated as well as the cast post and core should be done based on the occlusal load and the parafunctional habits of the patients. The retrievably of the posts for retreatment is also another factor in the selection of posts.

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