

## ***In Vitro* Effect of Zirconia and Zirconia Enriched Glass Fiber Composite Posts on Fracture Resistance of Endodontically Treated Teeth**

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### **Abstract**

**Objective:** Despite the advantages of esthetic posts, lack of studies on their fracture resistance has limited their clinical use. This study aimed to compare the effect of two types of esthetic posts namely zirconia and zirconia enriched glass fiber composite posts on fracture resistance of endodontically treated teeth against compressive forces.

**Methods:** This *in vitro* study was conducted on 20 mandibular premolar roots cut at the cemento-enamel junction (CEJ). The roots were endodontically treated and randomly divided into 2 groups of 10. After post space preparation, in group 1 zirconia posts (CosmoPost, Ivoclar, Liechtenstein) and in group 2 zirconia enriched glass fiber composite posts (Ice Light, Danville, USA) were cemented in the roots using a dual-cure resin cement (Panavia F 2.0, Kuraray, Japan) according to the manufacturer's instructions. The teeth were restored with composite resin cores (Lumiglass, RTD, France) using a prefabricated polyester matrix. After periodontal ligament (PDL) simulation by elastic polyether impression material (Impregum, 3M ESPE, USA), specimens were mounted in acrylic resin and subjected to 1195 Instron universal testing machine. Compressive load was applied at a 90° angle relative to the long axis of the teeth at a crosshead speed of 1mm/min until fracture. Since the data were normally distributed, t-test was used for statistical analysis.

**Results:** The fracture resistance was 816.69 (120.89) N for zirconia posts and 843.76 (120.93) N for zirconia enriched glass fiber composite posts and these values were not significantly different ( $p=0.62$ ). Fractures in group 2 were restorable.

**Conclusion:** The fracture resistance of zirconia and zirconia enriched glass fiber composite posts was not significantly different and both types of posts can be successfully used.

**Key words:** Endodontically treated teeth, Fracture resistance, zirconia enriched glass fiber composite post, Zirconia post.

**Please cite this article as:**

ZARBAKHSH A, JALALIAN E, MAZAHERI A, NOROZY M, FATOURECHI P. *In Vitro* Effect of Zirconia and zirconia enriched glass fiber Composite Posts on Fracture Resistance of Endodontically Treated Teeth. *J Dent Sch* 2015; 33(3): 161-168.

Received: 19.04.2014

Final Revision: 04.03.2015

Accepted: 07.03.2015

### **Introduction:**

Numerous studies have demonstrated that endodontically treated teeth are more fragile than vital teeth and may break easier. These teeth have often lost part of their structure due to caries or trauma. Loss of structure increases the fracture susceptibility of endodontically treated teeth (1). The main function of post is to provide

retention for a restoration and preserve the tooth structure via distributing the forces equally along the long axis of the tooth (2). Selection of an appropriate post is based on the remaining tooth structure, position of the tooth in dental arch, need for esthetics and functional loading of the tooth (2, 3). Conventionally, metal posts have adequate fracture strength but may cause complications due to susceptibility to corrosion,

difficult retrieval in case of need for retreatment, high modulus of elasticity compared to dentin and increased risk of tooth cracks and non-repairable root fracture (4). Non-metal posts can be divided into two main groups of composite posts and ceramic posts. Composite posts are made of carbon fibers, silica-quartz, zirconia or a combination of all and are covered by a polymer resin matrix, which is mainly epoxy resin (5, 6). Their application is justified since posts have to possess physical and mechanical properties similar to those of dentin in order to optimally distribute stresses applied to teeth. Thus, they would decrease the risk of root fracture (7-9). Zirconia ceramic posts were first introduced by Meyenberg *et al.* in 1995 (10) and reportedly have a flexural strength comparable to that of cast gold or titanium posts (11). It has been reported that teeth restored with fiber posts require much higher loads to break than teeth restored with zirconia posts (12).

However, further studies revealed that the fracture resistance of teeth restored with zirconia posts was equal to that of teeth restored with fiber posts (2, 3, 13). Akkayan and Gulmez in 2002 reported that the fracture resistance of teeth treated with zirconia posts was less than that of teeth restored with quartz fiber posts. However, the fracture resistance of teeth treated with zirconia posts was not significantly different from that of teeth restored with glass-fiber posts (8). Another study compared the fracture resistance of endodontically treated teeth restored with titanium and fiber-reinforced posts and reported that the fracture resistance of zirconia posts was higher than that of titanium posts and the fracture resistance of both was higher than that of fiber-reinforced posts (14). Another study evaluated the load applied to teeth restored with quartz fiber, carbon-quartz fiber and zirconia posts and it was reported that fiber reinforced posts decreased the risk of root fracture and showed higher success rate than zirconia posts (15).

Glass fiber composite posts containing 70% zirconia (Ice Light) were recently introduced to the market (by Danville, USA). The manufacturer claims that due to the presence of these fibers, these posts have flexural strength close to that of dentin (for better distribution of stresses).

Considering the existing controversies and limited information on the comparison of posts with different moduli of elasticity and their effect on fracture resistance of endodontically treated teeth, this study aimed to assess the fracture resistance of endodontically treated teeth restored with zirconia and zirconia enriched glass fiber composite posts against compressive forces applied parallel to the root axis. The null hypothesis was that the fracture resistance of teeth restored with zirconia posts would be similar to that of teeth restored with zirconia enriched glass fiber composite posts.

### **Methods:**

In this *in vitro* study, 20 mandibular premolar teeth (5) were immersed in saline solution after removal of external debris with ultrasonic scaler. The inclusion criteria were absence of hypoplasia, resorption or caries in the roots. Also, roots had to have similar diameter and length (with a mean length of approximately 14(1) mm, buccopalatal dimension of approximately 7-8mm and mesiodistal dimension of approximately 5-6 mm). The measurements were made using a standardized digital caliper (5, 15). All specimens were evaluated under a stereomicroscope at 2X magnification to ensure their soundness and absence of root fracture or cracks. Specimens were stored in saline solution at 37°C until the experiment. Tooth crowns were cut at the proximal CEJ using a metal disc (D & Z, Switzerland) with 0.2mm thickness and high speed hand piece under water coolant. All canals were instrumented by K files (Dentsply

Maillefer, Switzerland) from #35 to #60 (master file)(16) at the working length along with frequent irrigation with 5.25% sodium hypochlorite using the step back technique (all files were 25mm in length). Canals were dried with paper points and the chosen master cone was #35 for all teeth. Using #15 lateral cones, AH-26 sealer (Dentsply Maillefer, Switzerland) and #25 finger spreader (Dentsply Maillefer, Switzerland), the canals were filled 1mm short

of the working length using the lateral compaction technique (8). Next, the teeth were randomly divided into two groups of 10 (8, 9, 17). Zirconia posts (#2, with 1.4 mm diameter) (CosmoPost, Ivoclar, Liechtenstein) were placed in the roots in group 1. In group 2, zirconia enriched glass fiber composite posts (Ice Light, Danville, USA) with 1.4 mm diameter were used (Table 1).

**Table 1- Materials and posts used in this study**

<b>Materials</b>	<b>Manufacturer</b>
Zirconia post	Cosmo post, Ivoclar, Liechtenstein
Zirconia enriched glass fiber composite post	Ice light post, Danville, USA
Intracanal adhesive system (self-etch)	Liquid A&B Panavia F2.0, Kuraray, Japan
Cement system (dual-cure)	Paste A&B Panavia F2.0, Kuraray, Japan
Coronal adhesive system (light-cure)	Prime & Bond NT, Dentsply, Caulk
Composite (light-cure)	Lumiglass, RTD, France
Sealer	Sealer AH-26, Dentsply, Maillefer, Germany

For post space preparation in both groups, peeso reamers #1, 2 and 3 (Dentsply Maillefer, Switzerland), respectively and the specific drills in the kits (universal drill) were used. Post space was prepared in 10mm length and the 3-5 mm apical gutta percha was remained in the root canal (9, 12). After the use of specific drills, the finishing drill available in the kits was used for final preparation. A rubber stop on the drill shank was used as the reference guide for proper length of preparation. The remaining intracanal materials were removed using water spray and water- and oil-free air spray. Posts in both groups were tested in the canals and their passive fit was ensured (18, 19). In order for all posts to have the same length (15mm), the head of all posts was cut using 008 diamond fissure bur under water coolant (9). Post space was then dried using paper points.

A and B primers were mixed and applied to the canal by a microbrush according to the manufacturer's instructions (Panavia F2.0, Kuraray, Japan). After 30 seconds, the primer was dried by gentle air spray and excess material was removed by a paper point. A and B pastes

(Panavia F2.0, Kuraray, Japan) were mixed in equal amounts and applied to post surfaces. The posts were then placed into the canals. Excess cement was removed and the cement was light cured for 30 seconds using Coltolux 2.5 light curing unit (Coltene, Germany). OxyGuard II (Panavia F2.0, Kuraray, Japan) was applied around the neck of the posts for 3 minutes to ensure complete setting of cement (18). Coronal parts of the roots were etched by 37% phosphoric acid (Denfil etchant) for 30 seconds and rinsed with water for 60 seconds. Bonding agent (Prime & Bond NT, Dentsply, Caulk) was then applied and cured for 40 seconds. The crown was then built up by composite resin (Lumiglass RTD, France). Prefabricated polyester matrices were filled with composite and placed over the coronal part of the posts. Composite cores were cured for 40 seconds from 4 different directions.

To simulate periodontium around roots, 2mm apical to the CEJ was marked using a copying pencil (16). Then, an aluminum foil 2mm in thickness was cut in the form of root (triangular) and adapted over the root surface from the

marked area to the apex in such way that it had equal thickness in all areas. Using a surveyor, the specimens were embedded in autopolymerizing acrylic resin at a 30° angle.

After observing the initial signs of polymerization, the specimens were removed from the acrylic resin by pulling them out in a straight path by a rotating motion. Foils were removed from the root surface and elastic polyether material (Impergum, ESPE, USA) with an appropriate consistency was injected into the space created in the acrylic resin. The roots (without foils) were placed back in their respective locations in the acrylic resin (now filled with elastic polyether impression material) at the same angle as before (30°). After setting, excess impression material at the CEJ was removed using a scalpel. By doing so, adequate thickness of PDL was simulated (16, 17). During the experiment, all specimens were stored in saline solution at room temperature. The specimens were then subjected to compressive load in an Instron universal testing machine (Instron 1195 Co., UK) Compressive load with a circular cross-section was applied to the central fossa of the core at a 90° angle relative to the long axis of the tooth at a crosshead speed of

1mm/min. The device was connected to a curve drawer and with the first drop in pressure displayed on the monitor, the device stopped and the load at fracture was recorded. The specimens were then evaluated and the site of fracture was assessed under a stereomicroscope (19). Normal distribution of data was confirmed using one sample Kolmogorov-Smirnov test and t-test was used for statistical analysis.

### Results:

The mean and standard deviation (SD) of fracture resistance of specimens in Newton in the two groups are shown in Table 2. T-test found no significant difference in the fracture resistance of the two groups restored with zirconia and zirconia enriched glass fiber composite posts ( $p=0.623$ ) and teeth in both groups had similar fracture resistance. Type of fracture (in terms of location) was mostly non-restorable in zirconia post group and 100% of fractures in the zirconia enriched glass fiber composite post group were oblique and occurred in the cervical 1/3 of the roots and were restorable (Table 3).

**Table 2- The mean and SD of fracture resistance of the roots in the two groups of posts**

Groups/Fracture resistance	Number	Mean	Standard deviation	Mean standard error	T	p-value
CosmoPost (zirconia)	10	816.69	120.89	38.23	0.50	0.62
Ice light (zirconia enriched glass fiber composite)	10	843.76	120.93	38.24		

**Table 3- Location of the fracture line in the two groups and its frequency (%)**

Fracture location/Groups	Oblique fracture within the cervical one-third of the root	Oblique fracture in the apical two-third of the root	Vertical root fracture	Post fracture
CosmoPost (zirconia)	10%	80%	20%	—
IceLight (zirconia enriched glass fiber composite)	100%	10%	—	10%

## Discussion:

Many factors play a role in selection of prefabricated esthetic posts such as mechanical and physical properties, shape, esthetics, cost and technical sensitivity of posts (9). At present, zirconia posts are widely used due to optimal esthetics and chemical stability, high mechanical strength and hardness and having a modulus of elasticity similar to that of stainless steel posts. However, it is almost impossible to retrieve zirconia posts. Also, they are highly fragile and may cause non-restorable root fractures. These factors limit their application in the clinical setting (11). Fiber posts with a modulus of elasticity similar to that of dentin decrease the risk of root fracture and in case of occurrence, most cases of fracture can be restored (in contrast to posts with high modulus of elasticity)(2, 3).

This study compared the fracture resistance of teeth restored with two different types of tooth-colored posts namely zirconia post (group 1) and zirconia enriched glass fiber composite posts(group 2) and no significant difference was found between the two groups in terms of fracture resistance. Also, the fracture resistance recorded in both groups was higher than normal intraoral loads. Thus, both types of posts can be used for restoration of endodontically treated teeth.

Drawing an accurate conclusion in similar in-vitro studies on the fracture resistance of endodontically treated teeth restored with different types of posts is almost impossible because several variables such as tooth condition before extraction, age of tooth, storage condition of tooth and pulp status at the time of tooth extraction may affect the fracture resistance. Degree of tooth calcification and root anatomy resulting in placement of posts in inappropriate angles inside the root canal system and different root dimensions with variable degrees of convergence and divergence resulting in unequal

thicknesses of cement around posts may also play a role in this regard (9, 10).

If PDL had not been simulated, acrylic resin would have served as a ferrule and increased the fracture resistance (8). Hayashi *et al.* in 2006 reported that when not simulating the PDL, the fracture resistance increased for up to 2 times the rate when PDL was simulated (5). Yang *et al.* in a photo elastic study in 2001 reported that presence of crown on teeth restored with intracanal posts significantly decreased the stress applied to coronal dentin of root. In the current study, in contrast to some previous studies, crowns were not placed. Thus, variables such as structure, height, shape and thickness of material that could confound the results were eliminated. This way, the fracture resistance and structural integrity of a post and core system can be more accurately evaluated (21). Our study in this regard was similar to that of Dilmener *et al.* in 2006 (17) and Barjao *et al.* in 2006 (6).

It has been reported that masticatory forces are approximately 400-800N in the posterior areas (22) and the mean fracture strength values recorded in both groups in our study were higher than the mean value of masticatory loads. However, continuous application of loads in a short time and in only one direction is not similar to functional loads applied to endodontically treated teeth restored with posts and this was a limitation of the current study (22).

In the current study, we concluded that the fracture resistance of teeth restored with zirconia and zirconia enriched glass fiber composite posts was not significantly different. Jalalian *et al.* in 2009 (23) showed that the teeth restored with D.T. white fiber posts exhibited significantly higher resistance to fracture than D.T. Composite posts (Zirconia). Such controversial results and the differences with our findings may be explained by the fact that the above-mentioned studies compared zirconia and fiber-glass, carbon or quartz composite posts; whereas the

composite post used in our study zirconia enriched glass fiber, which can show completely different behavior than conventional composite posts (glass-carbon or quartz) due to having different composition and subsequently different physical and mechanical properties. Also, obtaining equal fracture resistance values in the two groups of zirconia and composite posts may be explained by the high percentage of zirconia in the composition of composite posts (70%). On the other hand Akkayan and Gulmez in 2002 demonstrated that the fracture resistance of roots with zirconia posts was similar to that of roots restored with glass-fiber posts (8). Zirconia enriched glass fiber composite posts used in this study can pass light according to the manufacturer and completely polymerize the surrounding cement deep in the canal. Also, these posts are presilanated and can therefore form a strong and direct bond with resin cement and composite (12).

Fractures were non-restorable in the zirconia post group, which is similar to the results of Akkayan and Gulmez in 2002 (8), Maccari in 2003 (9), Dilmener *et al.* in 2006 (17), Mitsui in 2004 (24) and Cormier *et al.* in 2001 (25). These results confirm the findings of studies stating that ceramic posts are rigid and apply more stress to the root structure than fiber posts and these results in non-repairable root destruction (11).

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Fracture in Icelight zirconia enriched glass fiber composite posts was restorable in 100% of the specimens and the fracture line was in the cervical one-third of the root (1-2mm) and was restorable via crown lengthening surgery (5). This finding is in accord with the results of Hayashi *et al.* in 2006 (5), Akkayan and Gulmez in 2002 (8) and Mitsui in 2004 (24). The reason is presence of high percentage of fibers in the resin matrix of Icelight posts, which result in a modulus of elasticity similar to that of dentin. Moreover, these posts form a homogenous mass with the composite core and resin cement and result in more equal distribution of forces on the root surface (26, 27).

## Conclusion:

Based on the results, it is concluded that teeth restored with tooth-colored posts (zirconia and zirconia enriched glass fiber composite posts) both have high fracture resistance against masticatory forces and the two groups were not significantly different in this regard. Thus, with regard to the unfavorable and unrestorable fracture created by zirconia posts, both types of posts are recommended for restoration of endodontically treated teeth.

## Conflict of Interest: "None Declared"

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