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The Comparison of Fracture Resistance in Endodontically Treated Central Incisors Restored with Different Post-Core Systems

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Abstract

Introduction: The aim of this study was to compare the fracture resistance and fracture mode of the maxillary central incisors restored with four different post and core systems. Methods and Materials: Forty extracted Maxillary central incisors were selected. After root canal treatment, teeth were assigned to 4 groups (n=10). First group was restored with Gold alloy casting post & core as control group (GCPC), second group with zirconia post and heat pressed ceramic core (Zr/Cer), third group with zirconia post and composite core (Zr/Com) and fourth group with glass fiber post and composite core (GF/Com). Full metal crown prepared for each tooth and cemented with GI. After thermo cycling, compressive load was applied and fracture strength values and failure modes were evaluated. Data were analyzed by, one- away Anova and chi-square test (p<0/05). Results: The mean failure loads (N) were in this order: Zr/Cer group: 761±244/137, GCPC group: 728±283/198, Zr/Com group: 715±425/181, and GF/Com group: 444/9±97/724.The mean failure loads in GF/Com group was significantly lower than other groups (p =%001). The difference was not significant among other three groups. Concerning fracture mode, the highest percent of favorable fractures observed in the Zr/Cer group with six favorable fractures but there was no significant difference among studied groups (p=0/849). Conclusion: Central incisors restored with GF/Com represented significantly lower fracture resistance. There was not any significant difference in fracture modes of studied groups.

Keywords: Casting Post & Core, Fracture Resistance, Endodontically Treated Teeth, Glass Fiber Post, Zirconia Post.

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Introduction

The restoration of root-filled teeth to achieve optimum strength, esthetics and function still remains a challenge. pulpless teeth are considered to have a higher risk of fracture than vital teeth. (Sorensen and Martinoff, 1984) When most of the coronal structure of an endodontically treated teeth has been lost due to caries or root canal treatment , the use of post and core systems seems mandatory. (Makade et al., 2011) Posts are needed to retain a core for definitive restoration. (Creugers et al., 1993) The decision regarding the treatment plan and post insertion should be based on three factors: position of teeth in the arch (Heydecke et al., 2002) amount of remaining tooth structure (Kimmel, 2000) and esthetic. (Rosentritt et al., 2000; Zalkind and Hochman, 1998) There are a variety of endodontic posts. Some studies support casted post and core while others support tooth colored prefabricated posts. Esthetic consideration favors tooth colored post in anterior maxillary region where all ceramic crowns are used. (Ozcan and Sahin, 2013) Ceramic posts and fiber reinforced composite posts are examples of tooth colored posts. Zirconia is a widely used material because of its good chemical stability, high mechanical strength, high toughness. (Piconi and Maccauro, 1999) Some authors indicated that the high elastic modulus of elasticity of zirconia posts at 200 GPa (Guazzato et al., 2004) causes stress to be transferred to the less rigid dentin, thereby resulting in root fractures (Bateman et al., 2003) and finally as a hypothesis :a post should be more similar to dentin in physical properties to absorb more stress and transport forces less to the remaining structure. (Pegoretti et al., 2002) Whether this hypothesis is true or not, there are no consensus , some other authors indicated that :higher elastic modulus of zirconia posts resist their bending under loads thus less stress is transmitted to the tooth structure. (Heydecke et al., 2002) The cast gold post and core has been regarded as the "gold standard" in post-and-core restorations because of its superior success rate. (Creugers et al., 1993; Bergman and Lundquist, 1989) The fracture susceptibility of teeth restored with posts may be related to factors such as the amount of remaining tooth structure, which provides resistance to the fracture of the tooth, (Dumbrigue et al., 2006) as well as the characteristics of the post, such as the material composition, modulus of elasticity, diameter, and length. (Fokkinga et al., 2006) The aim of this laboratory study was to compare the fracture resistance and fracture mode of maxillary central incisors restored with four different post and core systems: gold casting post and core (GCPC), zirconia post with ceramic core (Zr/Cer), zirconia post and composite core (Zr/Com), glass fiber post and composite core (GF/Com).

Method and Materials

Forty freshly (not passed more than six months after extraction) extracted maxillary central incisors were selected on the basis of similar dimensions (total length:23±1mm, mesiodistal width in crvical:7±1mm, labiolingual width:6±1mm, root length:12≤) and absence of caries, visible fracture line or cracks. The hard and soft deposits were removed with hand scaling instrument. Teeth were then stored at room temperature in a solution of 0/9%saline.

Specimen preparation

All teeth underwent root canal treatment. The root canal was instrumented manually in a step-back technique to an apical size of ISO 40, and shaped to the size of ISO 60. The canals were dried with absorbent paper points and obturated with gutta-percha and sealer (AH 26). Denstply Germany) with cold lateral condensation technique.

The teeth were decorated perpendicular to the long axis, at a level 1/5mm incisal to the mesiodistal CEJ and 2mm incisal to the buccolingual CEJ with the use of a water-cooled diamond rotary cutting instrument. A 1mm shoulder finish line was prepared with 1mm diamond fissure bur on each specimens. The prepared teeth were randomly divided into 4 groups (n=10).

In group 1(GCPC):11mm of gutta-perca removed from the root canals with pesso-reamers(number2&3) , subsequently Antogear system drills (yellow: 1/3mm diameter, red :1/4mm, blue:1/5 , black:1/7mm) were used to enlarge the canals .A Duraley pattern (Pattern resin, GC , USA) was formed from the root canals .A core of 4mm height formed in a specimen with Duraley, and a custom mold from bleaching papers (Easy vac caskat 3 medes, Italy) fabricated on this core with vaccuformer and used for reconstruction of core in other groups except Zr/Cer group . Then the post and core unit removed from tooth structure. The post and core patterns were subsequently sprued and invested (Degovest impact degudent DENTSPLY, Germany). After the burn out and casting with gold type III (Degubond 4 dengudent GmbH Roden bacher chausst, Germany), prepared post and core were air abraded with Al2O3 particles (50 µm, 2/5bar, 4 mm distance). Subsequently post and cores were sinking in alcohol for 5 secs to remove contaminations. All canals were preconditioned with self - etching primer (ED-primer, kurary) for 30 sec. Alloy primer was applied on posts surface, then posts were cemented with Panavia (Panavia F2, kurary Japan), and light cured with QTH for 20 sec.

In group 2: Zr/Cer: after removal of 11mm of Gutta-perca from the root canals with pesso-reamers (number2&3), the root canals were enlarged using Cosmopost drills system (Ivoclar vivadent, Germany): red: 1/4mm width, black: 1/7 mm width. A prefabricated zirconia post (Cosmopost) with 1/7 mm width was tested in each canal. Subsequently posts were cut to a length 3 mm coronal to the prepared teeth. Each post was then air abraded with Al2o3 particles. Posts fitted in each canal and core patterns formed with wax and designed silicon molds. The post and core patterns then removed from the samples and subsequently sprued and invested. After the burn out and preheating process, the core was heat pressed from ceramic ingot (Medium opacity Mo e-max press litium disilicate glass) at 1180 and 0/3 -0/4 MPa pressure). The investment was removed and all surfaces were carefully air abraded. Posts were luted with the procedure described above.

In group 3: Zr/Com: zirconia posts were fitted in root canals as described above. After air abrasion posts cleaned by insertion in alcohol. Luting step performed as mentioned. Excess cement removed and post Circumstances light cured for 2 sec. Composite (Clear fill photo core kurary Japan) placed around inserted post and light cured from buccal and lingual for 20 sec and then the designed silicon mold was used to build–up and polymerized by QTH from buccal and lingual for 20 sec.

In group 4: GF/Com: Canals were prepared as mentioned for group 1(GCPC). Glass fiber reinforced composite posts (Fiber post, Anthogyr, France) inserted in canals. After cutting posts 3 mm above the buccal surface preparation, posts were air abraded, cleaned with alcohol and luted with Panavia as mentioned for group 3. Composite build -up also performed as group 3.

Crown fabrications

The crown patterns were directly waxed on the respective posts and cores by means of a silicone mold built on one waxed sample and casted in Ni- Cr alloy (Commend, USA). The crowns were finished and polished and cemented with GI luting agent (3M ESPE ketac cem Easy mix, Germany). Crowns were in 5/8 mm length from CEJ.

Specimens were subjected to thermo cycling between 5 °c and 55 °c, for 1000 cycle, 28 h with an intermediate pause of 12 sec.

The roots were blocked out with wax to depth of 2mm below the finish line to simulate the biologic width. Remaining root length was covered with Al foil with 0/1 mm thickness to simulate the periodontal membrane. The samples mounted in autopolymerizable transparent acrylic resin in 10cc syringe with 35mm height and 18 mm diameter. Before complete setting of acryl samples removed and Al foil replaced with Impergam (Impergam soft ESPE, Germany) which simulate PDL and again placed in acryl.

Sample fracture

The samples were placed in a cylindrical model in a universal Instron testing machine (Telcle, dartec series HCLO, England) an angle of 130 degrees to the long axis of the tooth and subjected to a compressive load on the palatal surface and 3mm below the incisal edge (fig 1).

The load was applied at the cross head of 1/5 mm/min and at the angle of 130o to samples long axis, until there was a sudden drop of the stress-strain curve. The readings were recorded. The predominant modes of failure of each specimen were evaluated.

Statistical analysis

The fracture resistance (maximum load to failure) after loading was compered among the 4 post and core types with 1-way analysis of variance (ANOVA). Chi square test was used to compare the fracture pattern among different groups.

Result

Fracture strength test

The mean and standard deviations for failure loads were shown in table 1. A statistically significant difference was observed among the failure loads in the studied groups. The load required to fracture the GF/Com group was lower than the other three groups (P = 0.0001). However, the values were not statistically significant within these other 3 groups. Although it was not statistically different, Zr/Cer group showed highest fracture resistance.

Fracture mode

Fig 2 represents results of fracture mode evaluation.

Among studied groups Zr/Cer group had the most number of favorable fracture patterns, but there were not any statistically significant differences among four studied groups by Chi square test(p=0/849).

Disscusion

The presence of the post significantly altered the stress distribution on the tooth. When a system with different components of different rigidity is loaded, the more rigid components, are capable of concentrating the stress, thus resisting greater force without distortion. If stress reach a critical value, a slowly growing crack causes a successive adhesive failure of the post-cement-root dentin interface. After loss of post adhesion, the post is more or less mobile within root and is consequently allowed to act as like a wedge. The fracture in dentin structure occurs from the inner region (adjacent to the root canal) to the outer surface of the tooth. If the dentine canal walls are thin or the resin cement is thick, less load is necessary to fracture the tooth. Thus the maximum load capability is affected by the strength of the surrounding hard tissue, which is directly correlated to the volume of dentin. (Silva et al., 2011) In present study all samples were similar in dentinal wall thickness so fracture resistance of reconstructed tooth was compared in similar situations.

In the current study,all specimens were restored and tested with complete-coverage of crowns to ensure standardization.The placement of a crown during endodontic restoration testing has been questioned,as this practice may obsecure the effect of different buildup techniques. (Sorensen JA and Engelman MJ, 1990) It is true that a crown creates a ferrule effect and variation in the load distribution when placed over a core buildup if the margins encircle a sound dentin collar. (Butz et al., 2001) However,testing post and core preparations without placement of a crown would not have reflected clinical practice.

In present study results indicated that fracture resistance of group restored with glass fiber post and composite core (GF/Com) was lower than all other groups which is consistent with other researchers’ opinion like: Fokkinga (2004), Quing (2007), Akkayan (2002) and Martinez (1998) although it was inconsistent with other studies like: Goto (2005), Mannosi (1999) and Mortazavi (2012), which concluded that fracture resistance of glass fiber posts were higher than casting post and cores. Fokkinga suggested that FRC posts show reduced stress transmission to the root because of isoelasticity compared to dentin (E-modulus of FRC posts=9 to 50GPa; dentin=14 to18 GPa). It should be noted that, in addition to importance of the E modulus of the post for the restoration’s strength, the load bearing capacity of the post must also be considered. Regarding this explanation lower Fracture resistance of glass fiber posts could be due to its lower load bearing capacity. Although it should be emphasized that a more favorable failure mode is more valuable than a high fracture resistance (Fokkinga et al., 2004).

In Mortazavi et al study the result was completely different in a way that fracture resistance of the group treated by fiber post was higher than the one treated by zirconia posts. They have justified this result by presenting that: bonded posts can increase tooth strength because of the proper adhesion between resin cement and dentin while zirconia posts impair a well continues adhesion (Mortazavi et al., 2012). Furthermore, heterogeneity in different studies result could be due to variation in length and diameter of posts, post’s brand and test’s design (Fokkinga et al., 2004).

In present study the highest fracture resistance was related to the group restored with zirconia posts and ceramic core (although not statistically meaningfull) which was consistent with findings of

Hydak and Butz (2002). Hydak represented that zirconia posts have the highest modulus of elasticity thus the post and core unit would undergo less bending under loading and eventually less stress would be transmitted to the tooth structure.

In current study GCPC group had the higher fracture resistance after Zr/Cer group. This is in accordance with what Quing (2007) and Fukkinga (2004) presented with regard to the higher fracture resistance of casting post and core systems.

Martinez (1998) and Sirrimaii (1999) also emphasized on the higher fracture resistance of casting post and core system. Since Casting post and cores have higher stiffness than glass fiber posts, can withstand greater forces without fracture, but the risk of irreparable root fracture would be increased (Silva et al., 2011). In current study findings did not confirm what Hydak and Gotto found regarding to lower fracture resistance of gold casting post and core systems.

In present study there was not any statistically significant difference about fracture pattern among four groups which may be related to the presence of complete coverage crowns and circumferential ferrule in all studied groups (Butz et al., 2001). The most favorable fracture pattern was related to the Zr/Cer group although it was not significant. This is consistent with results of Hydak (2002) study. Hydak suggested that the high elastic modulus of zirconia posts hinder their bending under loads thus less force would be transmitted to the tooth structure (Heydecke et al., 2002). This suggestion can justify our findings. Some other authors (Mannocci et al., 1999; Mortazavi et al., 2012; Sirimai et al., 1999; Sidoli et al., 1997; Asmussen et al., 1999) were not in same opinion. They suggested that the high elastic modulus of zirconia posts would transmit forces to the post dentin interface without any force absorption which could results in more irreparable fractures with this kind of posts.

In current study GF/Com group showed less desirable fracture patterns compared to other groups (although insignificant). This was in contrast with other authors opinion like Akkayan (2002) and Fokkinga (2004) who described that the similarity of elastic modulus between fiber posts and tooth structure results in more force absorption by fiber post and less stress transmission to the root and finally more favorable fracture pattern.

Finally, without further investigations it could not be completely distinct that whether more stiff posts are valuable regarding to stress distribution. Additionally, more other factors should be considered about mechanical features of the posts while selecting a post system.

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Figure 1: Image showing test specimen orientation in Instron mashine.

Table 1: Mean, range and standard deviations for failure loads of studied groups.

System	Failure loads values		
	Mean (N)	Max , Min (N)	Standard Deviation
GCPC	728	1310 , 430	283.198
Zr/Cer	761	1330 , 470	224.137
Zr/Com	715.5	1230 , 330	425.181
GF/Com	444.9	608 , 285	97.726

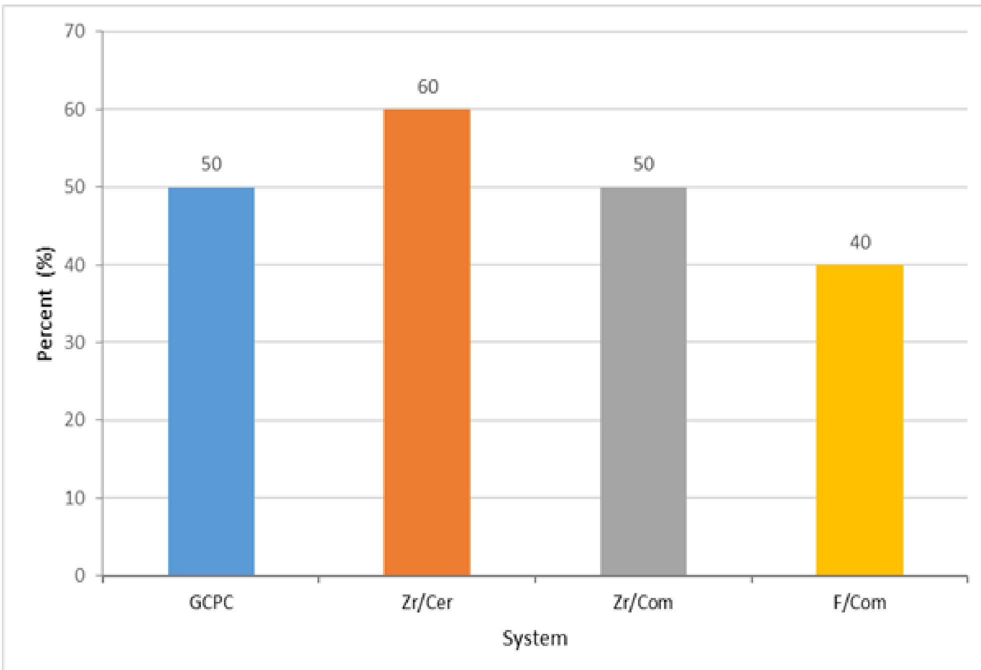

Figure 2: Results of fracture mode evaluation (percent of favorable fracture)