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## **Evaluation of Fracture Resistance in Endodontically Treated Teeth Through Four Restorative Methods: An *in vitro* Study**

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The purpose of this study is to compare the fracture strength of anterior teeth through four different methods. In this experimental study 24 central maxillary teeth were used. The crown of them was cut. They were divided into four groups. After preparing a post space, in the first group the FRC post with composite core used and then celluloid crown was used. In the second group, as the first one with this difference the crown was metal. In the third group the dentatus pin with composite core used and the crown was formed by celluloid. In the fourth group the way was as the third one but a metal crown issued. The examples mounted in an acrylic blocks and were pressed in Instron machine, as well the press power was calculated. The results were analyzed with one-way variance and Duncan test. There was no significant relationship between the break points of the four groups ( $p = 0.44$ ). The most amount of fracture load was for the first group and the lowest place was for the second group. Crown doesn't provide more strength for tooth in this condition.

**Key words:** Fracture strength, carbon fiber-reinforced composite post, metal crown, Dentatus post

## INTRODUCTION

Most endodontically treated teeth require a post-and-core build-up for restoring the teeth to optimum health and function. Selection of an appropriate post-and-core system from the wide variety of those available may be a clinical dilemma (Aquaviva *et al.*, 2003).

Selection of a post and core system should satisfy many interrelated biologic, mechanical, and esthetic factors to optimally restore the endodontically treated tooth to adequate form and function (Mc Donald *et al.*, 1990).

Using the Dentatus post is one of the restoring methods before crown placement. These posts don't have enough strength consequently when the higher force applied, they break in the canal and when the post has no perfect retention and its height is short, the post come out of the root (Sorensen and Engelman, 1990).

Recently, carbon fiber posts are purported to have mechanical properties that closely match the tooth (Duret *et al.*, 1996). They have the modulus of elasticity the same as dentin. Then the stress are distributes in root better and the fracture of endodontically restored teeth is less than other posts (Aquaviva *et al.*, 2003).

*In vitro* studies, however have demonstrated that carbon fiber posts have inferior strength compared with metal posts when subjected to forces simulating those in the oral cavity (Pilel and Hicks, 2003). Metal posts are rigid and they can break the roots (Isidor *et al.*, 1996).

Hock (1976) demonstrated that the strength of post crowned teeth is related to the remaining coronal tooth structure and the dowel designs do not have any effect on the strength of teeth.

Dean *et al.* (1998) evaluated the influence of endodontic and restorative procedures on fracture resistance of teeth, and to compare the incidence of root fracture in teeth with clinical crowns removed that were restored with three different types of post and a composite core build-up. The groups with post and composite build-ups failed at significantly lower force than the teeth in which the crowns had not been removed. The group restored with the carbon post had no root fractures, whereas there were fractures in each of the parallel and tapered post groups.

Carbon Fiber Posts (CFP) are widely used in the restoration of endodontically treated teeth to enhance the mechanical behavior in spite of metallic posts and to prevent vertical fractures of the tooth under chewing loads (Santis *et al.*, 2000).

Reygot *et al.* (2001) study was undertaken to characterize the fracture resistance and mode of fracture in endodontically treated incisors restored with cast post-

and-core, prefabricated stainless steel post, or carbon fiber-reinforced composite post systems. The use of carbon fiber-reinforced composite posts did not change the fracture resistance or the failure mode of endodontically treated central incisors compared to the use of metallic posts.

The purpose of this study is to compare the fracture strength of hardly desturctioned anterior teeth which restored by four different methods.

## MATERIALS AND METHODS

This study was conducted in Dental Research Center of Mashhad University of Medical Sciences from December 2007 to October 2008.

In this experimental study, 24 central maxillary recently extracted teeth because of periodontal problems selected, and they stored in physiologic serum. The crowns of them were cut perpendicular to their long axes, 1 mm above the cemento enamel junction, using a diamond disk. The root heights were 12 mm. Endodontic treatment was then carried out for all of the teeth the same as each other. The sealer was calcium hydroxide (AH 26 De Tray Zurich. Switzerland), Eugenol free, because of using the resin cement. Twenty four hours after completing canal instrumentation, the post space was prepared, removing part of the gutta percha with pizorimer No III (Mani, Germany) and then conforming the canal with Prapost system drills (Coltene/Whaledent) to a diameter of 1.2 and a depth of 8 mm from the sectional coronal surface. The sectional coronal surface was formed the same as the carries were removed and the outer surface of it had 1 mm width and 3 mm depth. A guideline was also cut for crown restoration using chamfer margin in cervical portions 0.5 to 1 mm from the coronal surface. The specimen's studied were divided into 4 groups of 6 teeth each according to the type of posts and cores used for restoration:

- After preparing a post space, it was etched with phosphoric acid 37% for 15 sec, then the specimen was washed with water for 30 sec and dried by paper point. Then the FRC post (RTD, France) was cemented with Panavia F2 (Kurary, Japan) in canals in standardized proportions conforming to manufacturers' directions. Cores were formed by composite (Tetric Ceram HB) and then the crown of it was formed by celluloid crown and composite (Vivadent, Tetric ceram Ivoclar) around 8 mm. (Newman *et al.*, 2003)
- In the second group, as the first one, canal was etched with phosphoric acid 37% for 15 sec, then it

was washed for 30 sec and it was dried by paper point. Then the FRC post was cemented with Panavia F2 (Kurary, Japan) in canals. After the core was formed by the Tetric ceram HB the metal crown was used

- In the third group the dentatus pin (Dentatus, Switzerland) with composite core Tetric ceram HB (Vivadent, Ivoclar) were used and the crown was formed by celluloid and composite ones. (Newman *et al.*, 2003)
- In the fourth group the way was as the third one with this difference that a metal crown issued

For load testing, the examples were fixed along their long axes into copper cylinders filled with self-polymerizing acrylic resin (Formatray, Ker), ensuring that approximately 2 mm of dental margin emerged from the resin surface. The restoration then was subjected to progressive compression force in the Instron device (Zwick, Japan) and the cross head speed of 2 mm min<sup>-1</sup> under the angle of 45 were pressed as well the press power was calculated. The results were analyzed with One-way variance and to compare the average break point of the groups of two the Duncan examination way is used.

### RESULTS

The mean fracture loads in the groups from the most to the lowest ones were:

- **Group A:** Fiber post with composing core and celluloid crown
- **Group B:** Fiber post with composing core and metal crown
- **Group C:** Dentatus post with composite core and celluloid crown
- **Group D:** Dentatus post with composite core and metal crown

Table 1 indicated the mean and standard deviation of the groups. The most of fracture load was 20.515 Kgf for the first group (A) and the least one was 15.428 Kgf for B groups.

For comparing the fracture strength between groups, one-way ANOVA was used. Table 2 indicated that there was no significant relationship between the break points of the four groups (p = 0.44). The most required amount of fracture load was for the first group and the least place was for the second group.

In this study the fracture position was investigated in groups. Four positions based on created fracture places in teeth are:

Table 1: Mean, standard deviation, minimum, and the maximum load of all groups

Groups	No.	Mean	Maximum	SD	Minimum
A	6	515/20	31/24	481/3	36/16
B	6	428/15	97/21	416/4	75/10
C	6	466/18	32/31	298/8	75/10
D	6	311/18	97/21	363/3	56/13
total	24	180/18	32/31	265/5	75/10

Table 2: Comparison of the fracture strength in all groups with one way ANOVA analysis

SOV	Sum of squares	df	Mean square	F-value	Sig
Between groups	78/740	3	26/247	0/939	0/440
Within groups	559/019	20	27/951		
Total	637/759	23			

- **Fracture A:** The lowest fracture line is placed above the metal crown margin
- **Factor B:** The lowest fracture line is placed between crown margin and tooth region inside acrylic cast
- **Fracture C:** The lowest fracture line has reached the tooth root inside acrylic cast
- **Fracture D:** There is more than one fracture line that has extended vertically as well as horizontally

The results of the exact Fissure test that the distribution of fracture kinds is related to groups. As it is clear, fracture C and D were seen in Dentatus post groups while fracture A and B was only seen in FRC groups.

The created fractures in Dentatus post were undesirable and in root, which made the restoration of the teeth impossible.

### DISCUSSION

In this research the fracture strength of hardly destruction anterior teeth, which reconstruction thorough four different methods, were investigated. The results are discussed in two sections.

The first section is related to restore teeth by FRC post with composite core and celluloid crown, and Dentatus post with composite core and celluloid crown. In these two groups, except the used posts, all the things were the same as each other. There was no significant relationship among the rates of fracture resistance in these two groups. Mean while in group A (FRC post with composite core and celluloid crown), the fracture resistance was 20.515 Kgf and in group C (Dentatus post with composite core and celluloid crown), it was 18.466 Kgf.

This result is in agreement with Newmans' (2003) study, in which the fracture strength of stainless steel post was 18.33 Kgf (Newman *et al.*, 2003).

This statement was demonstrated in Deans *et al.* (1998) study too.

The use of carbon fiber-reinforced composite posts did not change the fracture resistance or the failure mode of endodontically treated central incisors compared to the use of metallic posts (Reygot *et al.*, 2001). This statement is in agreement with this research somewhat.

The strength of post crowned teeth is related to the remaining coronal tooth structure and the dowel designs do not have any effect on the strength of teeth (Hock, 1976).

This subject was demonstrated in the present research too. Dowels had different designs but the amount of remaining coronal tooth structures were the same in all groups, and then there was no significant relationship between the break points of the four groups.

The second section of this discussion is related to the teeth with post core and metal crown.

In group B (FRC post with composite core and metal crown), the mean fracture resistance was 15.428 Kgf and in group D (post with composite core and metal crown), it was 18.311 Kgf. There was no significant relationship among the rates of fracture resistance of in these two groups.

This is exactly demonstrated by Hu *et al.* (2003) and evaluated the fracture resistance and the mode of failure of endodontically treated teeth restored with four post-and-core systems (serrated, parallel-sided, cast post and core; serrated, parallel sided, prefabricated post and resin-composite core; Carbon-Fiber-Reinforced (CFC) post and resin-composite core; and ceramic post and resin-composite core). Full-coverage metal crown was fabricated and cemented onto each tooth. Each specimen was subjected to a compressive load at a 45-degree angle to its axis until failure. Here was no significant difference in the failure loads among groups (Hu *et al.*, 2003).

Linde (1984) said that an endodontically central incisors restored with composite resin didn't need metal crown. Composite cores have been reinforced and retained in their roots, almost in every case by screw-posts.

In the present study, it was demonstrated that there was not significant differences in the fracture strength among groups it was due to that the lack of ferrule in teeth, that the crown could not have any effect on increasing the fracture strength in teeth not because of using resin cement.

It was showed, that more than 1mm ferrule structure can increase the fracture strength of the teeth (Mezzomo *et al.*, 2003; Nicolls and libman, 1995).

In this study, the amounts of tooth structure were the same and it was less than 1 mm over the CEJ. It is obvious, that this structure was not enough to play the ferrule effect roll in the teeth by metal crowns. Then in

groups B and D (metal crown groups), the fracture resistance was less than groups A and C (Celluloid crown groups). In this situation, metal crown does not enhance the fracture strength. Then it was concluded that metal crown increases the fracture strength in teeth with enough ferrule at least 1-2 mm.

In the studies, on the type and position of created fractures in different kinds of post and core systems, similar results have been obtained. In a research done by Krejci and Muller (1994), it was seen that in Para post group with composite core, most forces have been transferred to root and caused fracture. But in FRC post and composite core group, all fractures occur at crown.

These results were confirmed in our study. Post stiffness is the key parameter to cause resistance to bending under function. Occlusal forces are transferred to root through dowels. The more dowels, cements and restorative materials act similar to dentin under function, the less force will be focused in forming components of root. It has been reported that the danger of root fracture with metal dowels is more (Isidor *et al.*, 1996).

In this study, the results were the same; it means the created fractures in Parapost groups were of undesirable type and in root and in group FRC desirable restorable coronal fracture was created.

## CONCLUSION

Within the limitation of this research, the following conclusions were drawn:

- There was no significant relationship among the rates of fracture resistance of groups
- The most fracture load level was achieved with the first group. (FRC post, composite core and celluloid crown)
- In this situation metal crown does not enhance the fracture strength

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