

Evaluation of fracture strength of endodontically treated teeth restored by milled zirconia post and core with different post and core systems (An in vitro comparative study)

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ABSTRACT

Background: Restoration of root canal treated teeth with a permanent restoration affect in the success of endodontically treated teeth. This in vitro study was performed to evaluate and compare the fracture strength of endodontically treated teeth restored by using custom made zirconium posts and cores, prefabricated carbon fiber, glass fiber and zirconium ceramic posts.

Materials and method: Forty intact human mandibular second premolars were collected for this study and were divided into five groups. Each group contains 8 specimens: Group1: Teeth restored with Carbon Fiber Posts; Group2: Teeth restored with Glass Fiber Posts; Group3: Teeth restored with Zirconium Ceramic prefabricated Posts; Group4: Teeth restored with Zirconium Posts and Cores (copy milling); Group5: (Control Group). For groups 1, 2, 3, and 4; crowns were removed horizontally at the level of cement-enamel junction. Endodontic therapy was then done for all specimens in these groups using step-back technique. These specimens received standardized posts preparation (10mm depth), and then mounted in acrylic resin blocks. Panavia F 2.0 dual cure resin cement was used for cementation. The core build up was done with composite (Filtek P60). The specimens were then stored in saline and were subjected to compressive loads parallel to their long axes using universal testing machine (WP 300) until failure.

Results: Data obtained were analyzed by one-way analysis of variance and student t-test. The results showed that zirconium posts and cores possessed the highest significant differences followed by glass fiber posts, carbon fiber posts, and prefabricated ceramic zirconium posts. There were no significant differences between glass fiber, carbon fiber, and control group. The specimens were examined to determine the root fracture patterns and locations.

Conclusion: In the present study the fiber post treated teeth showed significantly more desirable fracture patterns compared to those restored with zircon posts.

Key words: Fiber posts, Manual milling, Fracture strength. (J Bagh Coll Dentistry 2013; 25(4):12-16).

INTRODUCTION

Functional, structural and esthetic rehabilitation of pulpless teeth are critically important to ensure successful outcome ⁽¹⁾. As a rule, root canal treated teeth are weak and brittle than intact teeth because of loss tooth structure, canal enlargement and cavity preparation ⁽²⁾. An ideal restoration should provide esthetic; function and protection for endodontically weakened teeth.

A post is a rigid structure that can be inserted in the root canal after root canal treatment ⁽²⁾. Recent studies suggest that the post should show an elastic modulus similar to dentin, which can efficiently transmit the stress from the post to the root structure ⁽²⁾. There are a wide range of endodontic posts from metallic to nonmetallic, rigid to flexible and esthetic to non-esthetic ⁽³⁾. The aim of this study is to evaluate and compare the effect of different types of post systems on fracture strength of endodontically treated teeth which are restored by zirconium posts and cores, prefabricated carbon fiber, glass fiber and zirconium ceramic posts.

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MATERIALS AND METHODS

Forty sound lower second premolars recently extracted for orthodontic purposes, of comparable size and shapes, were selected. All teeth were cleaned and stored in 0.1% thymol at room temperature.

The coronal portions of thirty two teeth were removed using a diamond saw mounted on straight hand pieces under water spray, perpendicular to the long axis of each tooth to produce a flat surface. The length was adjusted at 15 mm with digital vernier before cutting ⁽⁴⁾.

The canals of all teeth were prepared chemomechanically by step-back technique. Starting with file size #15 (K-File Dentsply, ballalgues, Switzerland) entered into the canal to full working length (14mm) up to size #45 as a master apical file (MAF); then stepping back 1mm fore every successively larger instrument till size #60. Irrigation and recapitulation were carried out to remove debris and prevent canal blockage. The final irrigation was carried with 5ml of 2.5% NaOCl solution followed by 5ml of distilled water then the roots were dried with paper points. The prepared canals were obturated by cold lateral condensation technique of guttapercha points using apexit plus sealer (Ivoclar-Vivadent,

Schaan, Liechtenstein). To simulate the periodontium, root surfaces were dipped into melted sticky wax to a depth of 2 mm apical to the facial CEJ junction to produce a 0.2 to 0.3 mm layer approximately equal to the average thickness of the periodontal ligaments.

Mold Construction

Roots mounted in cold cure acrylic resin using a metal mold with (20 mm length and 20 mm width); by using dental surveyor. After acrylic polymerization, root was removed and cleaned from wax (wax spacer)⁽⁵⁾. Condensation Silicon Impression Material light body (Aquasil Ultra LV, Dentsply) was delivered into the acrylic resin alveolus. The tooth was then reinserted into the test block⁽⁶⁾.

Sample grouping

The samples were randomly divided into five groups (n=8) according to the type of posts.

Group 1: Endodontic treated teeth restored with Carbon Fiber Posts (Carbonite[®], Nordin, Switzerland);

Group 2: Endodontic treated teeth restored with Glass Fiber Posts (Glassix[®], Nordin, Switzerland);

Group 3: Endodontic treated teeth restored with Zirconium Ceramic prefabricated Posts (Zirix[®], Nordin, Switzerland);

Group 4: Endodontic treated teeth restored with Zirconium Posts and Cores (copy milling);

Group 5: Sound teeth (Control Group).

Post space preparation was done with a low – speed straight hand piece attached to a dental surveyor with standard diameter (rubber stopper was attached to the pessoreamer (size Nr- 4 Ø 1.50, Nordin, Switzerland) the depth was adjusted to 10mm Thus 4-5mm of Gutta- Percha kept apically^(7,8) as in figure(1). For all specimens in groups 1, 2 and 3 the post were tried in to verify their fitness.



Figure 1: preparation of post space.

Wax pattern was constructed for each specimen in group 4 by direct waxing technique using type II blue inlay wax. A core with 5mm height, 6mm diameter was constructed by using copper ring. The wax patterns were invested, casted in to nickel-chromium alloy (EisenbacherDentalwaren, Germany) and de-invested. The metal cast posts and cores were cleaned, finished and tried on their alternative teeth samples.

The Zirkon Zahn unite used for milling of zirconium posts and cores. The metal posts were then seated in its position in the holding plate of the copy milling machine, the holding plate and zirconium block were attached to the clamping table of the copy milling machine. The zirconium oxide copy was formed simultaneously on the milling side. The milled structure is 30% larger than the wax pattern as zirconia undergoes shrinkage of 30% after sintering of milled restorations⁽⁸⁾.

Posts cementation

All post spaces were cleaned, dried and etched with 37% wt phosphoric acid gel (for 10seconds) then washed with distilled water⁽⁹⁾. ED PRIMER II (Kuraray, Japan) liquid A and B (as a bonding agent) mixed and applied; left for thirty (30 seconds), and air jet for ten seconds. Panavia F 2.0 dual-cure dental adhesive system (Kuraray, Japan) was used as cementing medium (figure 2a), while the post attached to the horizontal arm of the surveyor, the mixture was applied to the post surfaces. The post was then seated in to its respective space, using 2 kg constant load (figure 2b). Excessive material was removed by a micro brush within 40 seconds, and then light cured applied for 20 seconds^(7,8).



Figure 2: (a and b): cementation.

Fabrication of zirconium posts

Core builds up procedure

For groups 1, 2, and 3, the coronal portion of the posts (3mm) and the remaining tooth structure (2mm coronal to the CEJ) were cleaned from debris. A phosphoric acid 37%wt were applied to the area (for 15 seconds), after washing the acid bonding resin was applied using micro-brush and cured for 20 seconds. A plastic cylindrical matrix of 5 mm height and 6mm diameter used as a mold to build a standard core. After packing of composite in plastic matrix celluloid strip was placed over, one mm thickness glass slide was pressed under a load of 200gm for 1 minute⁽¹⁰⁾ (figure 3). The composite was light cured using a halogen light cure device for 40 second. After curing and removing the cylinder plastic matrix from the specimens, a further curing for 60 seconds, was carried out to all sides.⁽¹¹⁾



Figure 3: core built up

Testing procedure: The samples were placed on the flat table of the universal testing machine (WP 300) (Zwick, gunt, Humburg, Germany) (figure 4). A continuously increased compressive load was applied perpendicular on the flat occlusal surface of the core until failure. The load was measured in Newton (N). The mean failure load for each group was calculated.⁽¹³⁾

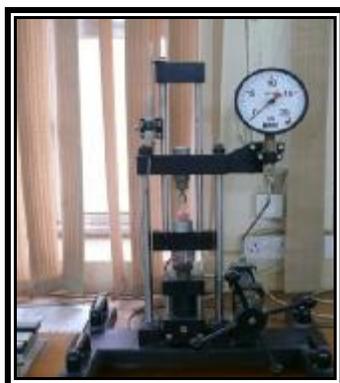


Figure 4: Testing procedure.

Failure location

After completion of testing procedures, all the specimens were examined using a magnifying lens to determine the root fracture patterns and

locations. The fracture patterns were divided into two groups⁽¹⁴⁾(figure 5):

- 1) Coronal fracture (desirable fracture).
- 2) Root fracture (undesirable fracture).



Figure 5: Failure location

RESULTS

Descriptive statistics

The means, standard deviations (S.D) of the fracture strength values with minimum and maximum values of each group were collected as in figure (6).

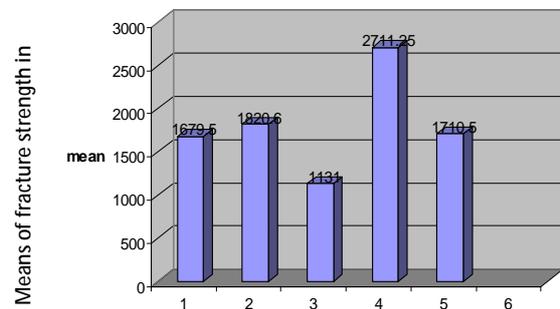


Figure 6: The bar charts showing means of fracture strength in N for all groups

One- way analysis of variance (ANOVA) was applied. The result was high significant difference among groups. Further analysis of the result using student's t- test was applied in order to localize the source of significance of the difference between groups. The results of T-test between the Groups can be summarized as following

Group 1: Shows non significant difference with group 2 and group 5 and significant difference with group 3. While high significant difference with group 4.

Group 2: Shows non significant difference with group 5 and shows high significance with group 3 and group 4.

Group 3: Shows significance difference with group5 and shows high significance difference with group4.

Group 4: Shows high significance difference with group5.

Failure location

Group 1: Seven teeth were fractured at the coronal part (composite core) and one tooth was with catastrophic failure (root fracture at the apical part).

Group 2 and group 3: all the fractures were in the coronal part (composite cores). No root failures.

Group 4: one tooth was fractured at the coronal part. The rest seven teeth were fractured at the apical part.

Group 5: all teeth were fractured at the coronal parts.

DISCUSSION

Sample selection

Since prefabricated posts were used in this study, human lower second premolars have been used because they have round to slightly oval shape canals.

Although, careful selection of the sample was performed to standardize the experimental procedures, in each group a range of failure load values could not be avoided. The variability of physical properties of human teeth may be a reason for such data range. ⁽⁴⁾

Periodontal ligament simulation

Thin layers of condensation silicon are used to simulate the periodontal ligament, provide a cushioning effect resembling the clinical conditions, and avoid the external reinforcement of the root structure by the rigid acrylic resin. ^(6,14)

Post space preparation and length

The minimum post length should be as long as the clinical crown, so the minimum length of 10 mm was selected as post length to achieve the standard condition ⁽¹³⁾.

Compression test

Attempts were made to simulate the force of the oral cavity on the roots on mandibular first premolars, while the teeth were oriented vertically in the alveolar bone ⁽¹⁴⁾. Occlusal surfaces of cores were prepared uniformly so that the forces can be applied at the long axis and at the middle of the teeth.

Fracture strength

Group 1 (Carbon fiber posts) and group 2 (Glass fiber posts)

Group 1 has lower mean fracture strength values compared with group 2 with non significant difference. This finding is in consistence with that obtained by **Mannocci et al.** ¹⁶, **Barjau et al.** ¹⁷. This may be due to that the carbon fiber postshave elastic modulus most similar to dentine, which means the system had more favorable performance with lower failure rate.

In comparison between Fiber posts and zirconia posts, the fiber posts are more elastic, so it is rational that the fracture strength of fiber treated groups be lower than Zirconia treated ones. These findings are consistent with **Rosentritt et al.** ³ and in contrary to **Mortazavi et al.** ¹³.

The mean of fracture strength of group 1 was lower than group 5 (control group), but statically the difference was not significant. The result of the present study agrees with **Anna-Maria et al.** ¹⁸ who found that intact teeth without posts showed higher mean of fracture load.

The mean fracture strength of group 2 was higher than group 5, but statically the difference was not significant. These results agree with **Torabi and Fattahi.** ¹⁴ These results seem to be more logical as bonding ability of glass fiber posts enables them to reinforce the root, although reinforcement is not enough to support root from fracture.

Group 3 (Zirconium ceramic prefabricated post):

This group showed the lowest fracture strength mean values than other groups. Statistically the difference was significant. This means that, zirconium ceramic posts failed with least amount of force compared with other groups. These results agree with **Rosentritt et al.** ³ and **Bittner et al.** ¹²

One possible of these results could be due to the lack of homogeneous chemical adhesion between prefabricated zirconium posts and the resin cement used in this study **Rosentritt et al.** ³ and **Ferrari et al.** ¹⁹

Another possible cause may be related to the coronal end design of prefabricated zirconium poststhat have many sharp angles (unlike other posts) which act as stress concentration areas under the continuous compression loading, causing crack propagation and fracture of surrounding core materialas compered with other groups (prefabricated posts G1 and G2).

Group 4 (Zirconium-oxide single unite post and core)

This group showed the higher mean failure load values than other groups with high significant difference. This finding agrees with **Wrbas et al**¹². In this group, both posts and cores are in single unit (one material) so the load will be directed to the weakest part which is the root.

Group 5 (Control group)

Teeth without preparation served as control group to assess the influence of post and core foundation on over all restored tooth.

Failure location

When the fracture occurs, the pattern of fracture is important as it acts as guidance for the restorability of fractured teeth. In the present study, the fiber post treated teeth showed significantly more desirable fracture patterns compared to those restored with zircon posts. This result agrees with **Mortazaviet al**¹³. This result suggests that zirconium posts and cores can be used when esthetic demands are important and the anatomy of the root canal and/or the extensive loss of coronal tooth portion require the use of custom post. Single unit zirconium post and core may be indicated when ceramic crown is used.

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