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Comparative Evaluation of The Fracture Resistance and Fracture Patterns of Endodontically Treated Anterior Teeth Restored with Two Different Esthetic Posts: An In Vitro Study

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ABSTRACT

Aim: This in vitro study compares and evaluate the fracture resistance and fracture patterns of endodontically treated anterior teeth restored with two different esthetic posts namely the glass fibre and zirconia posts.

Material and method: Twenty freshly extracted maxillary central incisors free of cracks, caries, fractures, and restorations were selected for the study. The anatomic crowns of all teeth were removed perpendicular to the long axis of the tooth, from the most incisal point to 2mm above the proximal cementoenamel junction (CEJ), with the use of a water cooled flat end tapered diamond abrasive (Diabur, Mani, India) to simulate grossly destroyed tooth. All the teeth were prepared with a torpedo diamond abrasive to establish a chamfer finish line at the level of cement enamel junction. The standardization followed for post space preparation in teeth are the post length of 13mm length to be prepared in the root. Cementation of fibre post and zirconia post are done. Core was built for all the samples. Ni-Cr crowns are cemented on the samples. All the teeth with post core and coping were embedded in acrylic block for testing purpose. The samples were tested for fracture resistance under static load by using Universal testing machine.

Results: Statistical analysis was made with independent student's T test and P value less than 0.05 was considered significant. Samples with zirconia posts exhibited greater fracture resistance than those with glass fibre posts. However, the differences in the mean values between the two Groups were not statistically significant. This study indicates that both the esthetic posts, namely glass fibre and zirconia posts exhibited similar fracture resistance statistically. Visual inspection of the fracture patterns of the endodontically treated anterior teeth restored with glass fibre and zirconia posts have revealed that use of zirconia posts exhibited 60% of the root fracture while glass fibre posts exhibited 60% of crown fractures.

Conclusion: The mean maximum load value for fracture resistance for test samples with zirconia posts was higher than that for the test samples with glass fibre posts.

Keywords: Glass fibre post, Zirconia posts, Universal testing machine, Fracture resistance.

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INTRODUCTION

The success of current endodontic procedures has resulted in the preservation of many teeth with minimum or without remaining coronal tooth structure. Endodontically treated teeth have been found to exhibit higher risk of fracture than vital teeth because of desiccation or premature loss of moisture supplied by the vital pulp, coronal destruction from dental caries, trauma, previous restorations and excessive removal of radicular dentin during endodontic treatment.[1] The restoration of endodontically treated teeth is important to ensure successful treatment outcome. Restoration provides protection and reinforcement of the tooth, and also prevents the passage of microorganisms and organic liquids into root canals. Endodontically treated teeth with extensive loss of coronal tooth structure are commonly restored with a post and core and a crown. [2]

The available post and core designs can be divided in to custom fabricated metal post and core and prefabricated post to which core is adapted.[3] There is a wide range of availability of non-metallic esthetic posts such as fibre reinforced posts, ceramic posts and zirconia posts.[4] These posts have number of advantages over the metallic and carbon fibre posts. They have superior natural appearance than the metallic posts, good strength, resiliency that reduces fracture potential commonly seen with traditional metal posts, modulus of elasticity close to dentin and provide excellent biocompatibility. They do not discolors teeth or gingival tissue. They are insoluble and impermeable to oral fluids and are corrosion resistant.[4,5] Fracture resistance is of greater importance than retention because the post can be recemented if dislodged from tooth. However, if root fractures the tooth is invariably lost. [6]

Laboratory studies have investigated a number of physical properties such as rigidity, flexural strength, fracture resistance of the post and post/root relationship, retention testing of posts in the canal, core retention on the post, scanning electron microscopy of the post/root interface, microleakage, corrosion of metals with fibre posts, thermal stress, spectrophotometric analysis, cytotoxic properties and radiopacity of various post-core systems.[7] The present in vitro study compares evaluate the fracture resistance and fracture patterns of endodontically treated anterior teeth restored with two different esthetic posts namely the glass fibre and zirconia posts.

MATERIALS AND METHOD

a) Selection of teeth:

Twenty freshly extracted maxillary central incisors free of cracks, caries, fractures, and restorations were selected for the study (Fig 1). The external debris was removed with an ultrasonic scaler (Pizeon, Switzerland), and the teeth were stored in saline solution (Nirlife, India) until testing. The root lengths were measured from the cemento enamel junction of the proximal side to the root apex with a vernier caliper. A minimum of 14mm length was maintained for all the specimens. They were randomly divided into two groups A(glass fibre posts) and B(zirconia posts) of 10 samples each.

b) Preparation of teeth for root canal treatment:

The anatomic crowns of all teeth were removed perpendicular to the long axis of the tooth, from the most incisal point to 2mm above the proximal cementoenamel junction (CEJ), with the use of a water cooled flat end tapered diamond abrasive (Diabur, Mani, India) to simulate grossly destroyed tooth (Fig.2). All twenty teeth were prepared in a similar manner. Access opening was done and the pulp extirpated with a barbed broach. All the 20 samples were endodontically treated using K-files (Fig.3) by a step-back procedure. The root space was sequentially prepared from size 15 to 50 size file. After intermittent rinsing with 2.5% sodium hypochlorite, the endodontic treatment was completed with lateral condensation of gutta-percha points (Gutta Percha Points; DENTSPLY) and eugenol-free sealer (Ah plus; Dentsply, Germany). The root canal fillings were allowed to set for 24 hrs.

c) Tooth preparation:

All the teeth were prepared with a torpedo diamond abrasive to establish a chamfer finish line at the level of cement enamel junction. The finish line was established circularly for standardization purpose and to get a crown ferrule of 2mm (Fig.4).

Core ferrule of 0.5mm was obtained by preparing a contrabevel of 0.5mm at the coronal end of the tooth with a thin tapering diamond abrasive.

d) Post space preparation:

The length and diameter of the Glass fibre posts & zirconia posts measured 17mm and 1.4mm at the broadest end respectively. Guttapercha was removed from the root canals with the peaso reamer provided by manufacturer to create the space of 13mm from the coronal edge of tooth, leaving a minimum of 3mm of guttapercha apically. Post space preparation was checked by placing the post in the space created in the root. All the ten samples of group A were prepared for post space in a similar manner.

e) Cementation of post:

Self-adhesive dual cure resin cement (Rely X U 100 , 3M ESPE, Germany) was applied in to the canal and thin layer of resin cement on the posts with help of periodontal probe. The posts were inserted in to the canal and the excess cement was removed. The coronal end of each dowel was positioned directly in contact with the tip of the light unit and was light polymerized for 40 seconds with a light cure (Confident, India) unit as per the manufacturer recommendation.

f) Core build-up:

Dentin was prepared by etching the tooth surface with 37% phosphoric acid (D-tech, India) for 15 seconds. Etchant was rinsed off with water for 10 seconds. Once etching was done the tooth surface was dried with compressed air. 2-3 coats of bonding agent (Adper single bond 2, 3M ESPE, Germany) was applied on the etched tooth surface. It was then thinned out by air blowing gently and light cured for 10 seconds as per the manufacturers' recommendations. A light-polymerizing composite core (Z 100, Restorative, 3M ESPE, Germany) was built on the sample in an incremental manner. The height of the core was maintained to 4.0 mm from the coronal edge of the tooth and finished with an ultrafine diamond abrasive (Fig.5). Core was built for all the samples of Group A and B in a similar manner.

g) Cementation of Ni-Cr copings:

Type I glass ionomer powder and liquid (G C Corporation, Japan) was taken in the mixing pad in a ratio based on manufacturers' recommendation. Both powder and liquid were mixed with folding technique and used to lute the copings on the tooth specimens (Fig.6). Excess material was removed and copings were allowed to set.

h) Embedding teeth with post core and copings in acrylic blocks:

All the teeth with post core and coping (Fig.7) were embedded in acrylic block for testing purpose, the root surface of the teeth were dipped in the dipping wax till the level of cement enamel junction to get a even thicknesses of 0.3mm. This was done to simulate space for the periodontal ligament. A custom made silicone mold was fabricated. The silicone mold was fabricated with polyvinyl siloxane impression material with an internal mold block size is 25mm height and 15mm width. Sample was placed perpendicular to the floor with the help of surveyor in to the mold space. Autopolymerizing clear acrylic resin was poured in to the mold and the tooth was positioned till the level of wax near cementoenamel junction. The resin was allowed to polymerize. This procedure was done for all the samples to obtain individual resin blocks for all the test samples.

i) Testing of samples for fracture resistance:

The samples were tested for fracture resistance under static load by using Universal testing machine. To simulate the load in the anterior teeth, the force was applied at 45^0 to the long axis of the tooth. A metal jig was fabricated (Fig-8) to position the resin block so that it would create an angle of 45^0 to the floor. The metal jig with the resin block was mounted in the lower member and the upper member had the vertical straight rod. A shear force was applied to the metal coping at a cross head speed of 1mm / min until fracture occurred (Fig.9). The maximum fracture loads were recorded in Newton. The fracture pattern was also recorded (Fig.10,11).

Fig 1: Extracted maxillary central incisors

Fig 2: Tooth cut to 2mm from cementoenamel junction

Fig 3: Root canal treated tooth

Fig 4: Prepared tooth with ferrule and post space

Fig 5: Tooth with core buildup

Fig 6: Tooth with cemented coping.

Fig 7: samples embedded in acrylic blocks.

Fig 8: Custom made mounting jig.

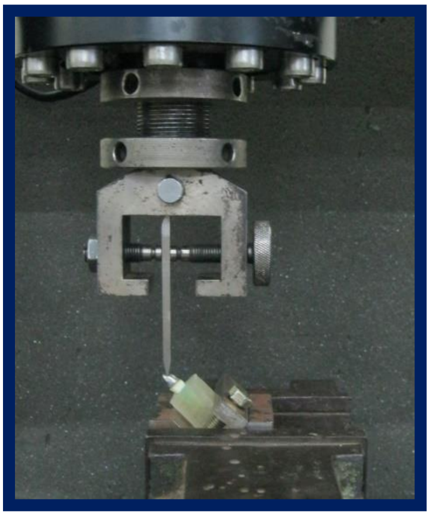


Fig 9: Testing sample in universal testing machine.

Fig 10: Fracture samples of group A

Fig 11: Fracture samples of group B.

RESULTS

The fracture patterns with respect to various locations of fracture of endodontically treated anterior teeth were tabulated and compared for Group A and Group B samples.

Table I: Comparison between mean values of maximum load for fracture resistance of Group A and B using Independent student's T-Test.

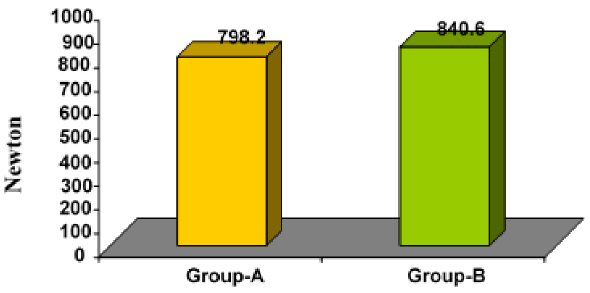
GROUP	Number of samples	Mean	Std. Deviation	P - value
A	10	798.20	+/-222.424	0.639
B	10	840.60	+/-172.353	

P value > 0.05; insignificant

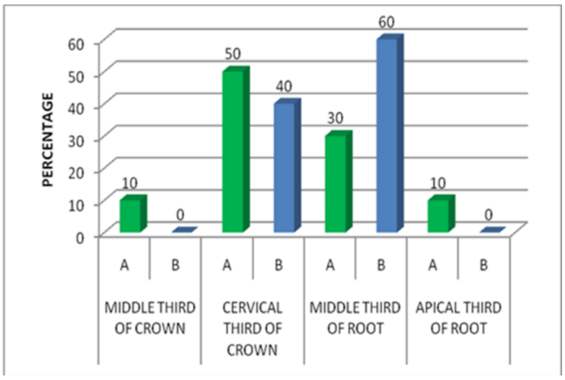
Inference – On statistical comparison of the mean fracture resistance values of Groups A and B, P value > 0.05, denoting no statistical significance between the two Groups.

Table II: Comparison of fracture patterns with respect to locations of fractures of Group A and Group B samples.

Groups	No. of samples (n)	Middle third of crown	Cervical third of crown	Middle third of root	Apical third of root
A	10	1	5	3	1
B	10	0	4	6	0



Graph III: Comparison of mean values of maximum load for fracture resistance of Group A and B samples.



Graph IV: Comparison of fracture patterns with respect to location of fracture of Group A and B samples.

The present in-vitro study has several limitations testing the samples in static loading; it does not directly replicate forces in the oral cavity with regard to size of load and nature of load. Most pulpless teeth in vivo probably fail as a result of fatigue failure, so resistance to static loads is not the only issue of interest. The specimens were not thermal cycled and ageing was not done, which has the effect of degradation of the luting agent and may possibly influence the outcome. Only maxillary central incisors were used, these results can only be applied to that group of teeth. Furthermore, cement pressure was not standardized, as only finger pressure was used. It is also important that clinician consider the various types of materials available for post systems, as well as their mechanical properties. Future research is necessary to clarify the effects of different length of new post systems on the resistance to fracture.

DISCUSSION

The following discussions were drawn from in vitro study, which was conducted to comparatively evaluate the fracture resistance and fracture patterns of endodontically treated anterior teeth restored with two different esthetic posts:

1. The mean maximum load for the fracture resistance of endodontically treated anterior teeth with glass fibre posts was found to be 798.20 Newtons.

2. The mean maximum load for the fracture resistance of endodontically treated anterior teeth with zirconia posts was found to be 840.60 Newtons.

3. On comparison, the mean maximum load value for fracture resistance for test samples with zirconia posts was higher than that for the test samples with glass fibre posts. However, the difference in mean values was found to be statistically insignificant. (p value >0.05)

4. The fracture patterns with respect to locations of fractures for Group A samples were as follows: Middle third of crown – 1 tooth (10%), cervical third of crown -5 teeth (50%), middle third of root -3 teeth (30%) and apical third of root -1 tooth (10%)

5. The fracture patterns with respect to locations of fractures for Group B samples were as follows: cervical third of crown -4 teeth (40%) and middle third of root -6 teeth 60%).

6. On comparison, Group A samples exhibited 10% of fracture in middle third of crown while Group B samples exhibited no fracture in middle third of crown. Group A samples exhibited 50% of fracture in cervical third of crown while Group B samples exhibited 40% of fracture in cervical third of crown. Group A samples exhibited 30% of fracture in middle third of root while Group B samples exhibited (60%) of fracture in middle third of root. Group A samples exhibited 10% of fracture in apical third of root while Group B samples exhibited no fracture in apical third of root. Overall, samples with glass fibre posts exhibited greater crown fracture (60%) while samples with

zirconia posts exhibited greater root fracture (60%).

CONCLUSION

Statistical analysis was made with independent student's T test and P value less than 0.05 was considered significant. Samples with zirconia posts exhibited greater fracture resistance than those with glass fibre posts. However, the differences in the mean values between the two Groups were not statistically significant. This study indicates that both the esthetic posts, namely glass fibre and zirconia posts exhibited similar fracture resistance statistically.

In this in vitro study, the post and core foundations with glass fibre and zirconia posts exhibited higher values of fracture resistance (798.20 N, 840.60 N) than the maximum physiological forces of 200N acting on the teeth in the oral cavity.[8] Therefore, it may be suggested that endodontically treated anterior teeth restored with these posts would resist normal occlusal forces. Hence, these posts can be used as an alternative to cast post core or prefabricated metallic posts in the maxillary anterior region. Further studies to examine fracture mechanics, as well as long-term clinical investigations are needed to evaluate the performance of glass fibre and zirconia posts.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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