

THE EFFECT OF DIFFERENT POST MATERIALS AND CEMENTS ON FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH –AN *IN VITRO* STUDY

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ABSTRACT

Objective: To evaluate the effect of various post materials and cements on fracture resistance of endodontically treated teeth. **Material and methods:** Three post systems; custom made Ni-Cr post and core, prefabricated stainless steel and carbon fibre post with composite core and two different luting cements i.e glass ionomer and resin cements were used. **Results and conclusions:** Carbon fibre post cemented with resin cements showed higher failure load than Ni-Cr and stainless steel post and resin cement performed better than glass ionomer cement, the mode of fracture was more favourable with carbon fibre post than in metallic post.

Key words: Custom made Ni-Cr post, Glass ionomer cement, Prefabricated carbon fibre post, Prefabricated stainless steel post, Resin cement.

INTRODUCTION

Intact, non vital, anterior teeth that have not lost tooth structure beyond endodontic access preparation generally require only sealing of the access cavity. If moderate loss of tooth structure is there, a crown without post is indicated. A non-vital, anterior tooth that has lost significant tooth structure requires a crown with post.^{1,2,3,4,5}

Traditionally, post materials were metallic, but nowadays carbon fiber posts, zirconia posts and woven fiber composite materials etc. have been introduced. Metal and zirconia post have modulus of elasticity higher than dentin and provide resistance to bending under function and thereby may cause catastrophic fracture of the roots. Posts with modulus of elasticity that resembles to dentin (like

Fiberglass - reinforced composite matrix; woven fiber, ribbon reinforced composite matrix, or carbon fiber posts) provide greater ability to uniformly distribute the stresses which reduces the risk of root fracture.^{6,7,8,9}

Earlier, zinc phosphate, zinc poly carboxylate and glass ionomer cements were used for luting but now a days resin cements are preferred because dentin / resin/post can be joined via resin adhesion into one unit.^{10,11}

In this study, three post systems; custom made Ni-Cr post and core, prefabricated stainless steel and carbon fiber posts with composite core and two different luting cements i.e. glass ionomer cement and resin cements were used to evaluate the effect of different post materials and cements on fracture resistance of endodontically treated teeth,

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MATERIALS AND METHODS

35 intact, caries free, maxillary central incisors of patients aged 45-55 were obtained. Teeth were stored in normal saline at room temperature till the study was conducted. Root canals were prepared by the use of K-files (Mani Inc, Tochigi - Ken, Japan), enlarged to no. 45 files using step back technique and the prepared canals were obturated with laterally condensed gutta-percha points using AH-26 as sealer. After root canal preparation teeth were randomly divided into 4 groups, 3 groups of 10 specimens each and 1 control group of 5 specimens. The groups I, II & III were further subdivided into 2 subgroups of 5 specimens each. Specimens of groups I, II and III were sectioned 3 mm above CEJ⁵ and a shoulder finish line of 1 mm was created at this level around full circumference of teeth. Post space was prepared using a drill of 1.5 mm diameter up to a depth of 10 mm under full water irrigation (Figure 1, Figure 2 and Figure 3).



Figure 1



Figure 2



Figure 3

Group I teeth were restored with Ni-Cr post and core⁴, Group II with stainless steel post and composite core, Group III with Carbon fibre post and composite core. Group I, II, III were further subdivided into subgroups “a” and “b” having 5 specimen of each. In subgroup “a” posts were cemented with Glass ionomer cement whereas in subgroup “b” posts were cemented with resin cement. Group IV (Control) teeth were restored with crown preparations without post and core. Crown preparation was done according to the standardized technique with a uniform 1.0 mm reduction. Incisor to CEJ dimension was 6 - 7mm in all preparations. Crowns were fabricated on the teeth using Nidaur Ni-Cr alloy, then sandblasted and cleaned with steam under pressure. Resin cement was used to cement these crowns (Figure 4).



Figure 4

Root surfaces were marked 2mm below the CEJ and covered with two 0.1 mm foils. Specimens were then embedded in autopolymerizing acrylic resin surrounded by aluminium cylinders (Figure 5). After

first sign of polymerization, teeth were extracted from resin blocks and spacers were removed from the root surfaces (Fig 5). Silicon base impression material was injected into acrylic resin moulds (Figure 5), and teeth were reinserted into resin cylinders (Figure 5). Standardized silicon layers that simulated periodontal ligament were thus created. Specimens were mounted in retaining arm of Universal Testing Machine 'INSTRON' (Figure 6). The load was applied at a 130° angle to the long axis by use of a steel rod with rounded end. Point of load application was middle of the lingual surface. Cross-head speed was 50mm/min, and the specimens were loaded to fracture with load values measured in Kgs. Fracture mode was also recorded.

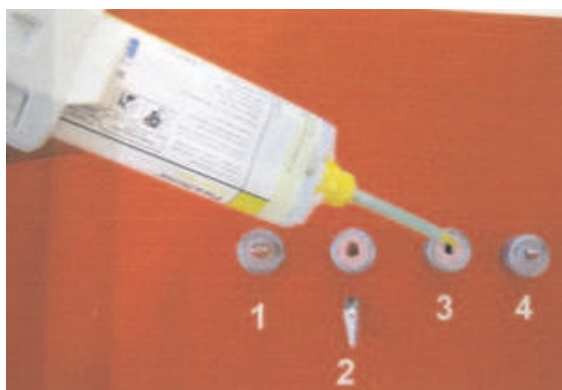


Figure 5

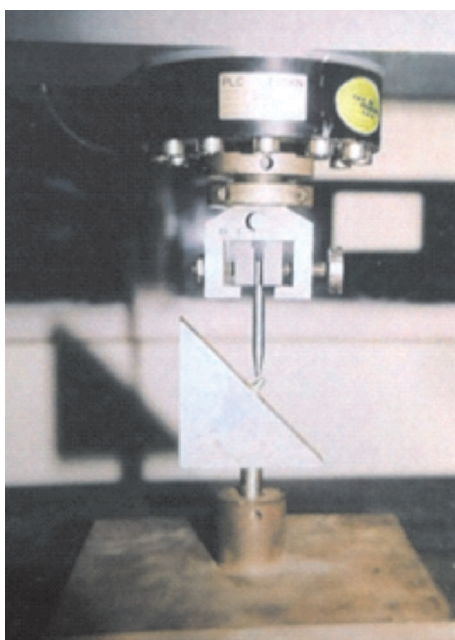


Figure 6

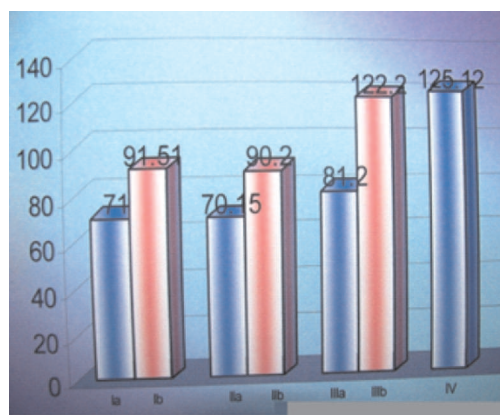
RESULTS

Comparison of mean values of all the groups is illustrated graphically in Graph 1. Mean and standard deviation of the obtained values for each group are presented in Table 1.

One way analysis of variance showed significant difference ($F = 9.45678$, $p < 0.0001$) between the groups (Table 2). Unpaired student 't' test was then conducted to establish which of the groups were significantly different from one another.

When Group Ia was compared with other groups using student 't' test there was a statistically significant difference ($p < 0.05$) between Group Ia and Ib, IIb, IIIa, IIIb, and IV. There was statistically insignificant difference ($p > 0.05$) between Group Ia and IIa ($p = 0.85859$).

When Group Ib was compared with other groups using student 't' test there was a statistically significant



Graph 1: Comparison of mean load failure of different groups (load in kgs)

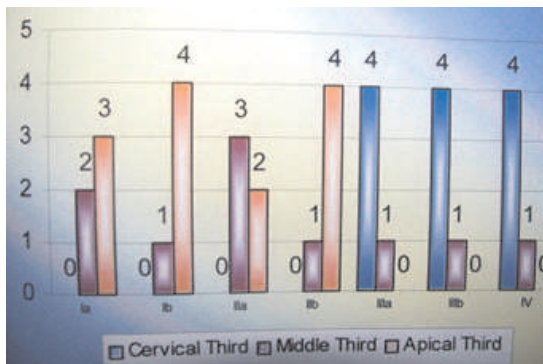
Table 1: Mean and Standard Deviation table

Group	No. of samples	Mean Load Failure (Kgf)	Standard deviation
Ia	5	71.00	6.0000
Ib	5	91.51	12.1175
IIa	5	70.15	8.4719
IIb	5	90.20	10.1737
IIIa	5	81.20	4.3397
IIIb	5	122.20	10.2235
IV	5	125.12	6.5793

Table 2: Analysis of variance (ANOVA) for failure load of various groups.

Source of Variation	Degree of freedom	Variance ratio	'p' value	Inference
Between group	3	9.45678	0.00014	Highly significant
Within Group	31			
Total	34			

difference between Group Ib and Ia, IIa, IIIb and IV and statistically insignificant difference ($p > 0.05$) between group Ib and IIb ($p = 0.33182$). Fracture mode of each group is illustrated graphically in graph 2. Results of fracture modes of each group were analysed with non parametric Chi - Square (χ^2) test. Test revealed that there were significant differences in fracture mode among the 4 groups. Value of Chi Square with 12DF is 29.8308, $p < 0.002961$.



Graph 2: Mode of fracture of various groups

DISCUSSION

Present study involved in vitro comparison of effect of three different post and core materials and two different luting cements on the fracture resistance of endodontically treated teeth. When teeth restored with custom made Ni-Cr post and core cemented with glass ionomer cement (Ia) were compared with teeth restored with Ni-Cr post and core cemented with resin cement (Ib), the mean load failure of group Ib (91.51kgs) was higher than that of group Ia (71.00 kgs) and the results were statistically significant ($p < 0.05$). The results obtained in the present study are in agreement with

Mendoza DB et al (1997)¹² who evaluated resin bonded preformed metal posts cemented with resin cement and zinc phosphate cement. He showed significantly more resistance to fracture with resin cement than with zinc phosphate. Higher failure load for group Ib can be explained by the fact resin cement has modulus of elasticity (16 GPa) which is almost comparable to dentin (18.3GPa). Thus, resin cement absorbs part of the load applied to the root, reducing the risk of root fracture. Similar results were seen when stainless steel posts cemented with glass ionomer cement (IIa) were compared with teeth restored with prefabricated stainless steel posts cemented with resin cement (IIb), and Ni-Cr posts cemented with glass ionomer cement (Ia) were compared with teeth restored with prefabricated stainless steel posts cemented with resin cement (IIb). When the teeth restored with prefabricated carbon fiber posts cemented with glass ionomer cement (IIIa) were compared with teeth restored with prefabricated carbon fiber posts cemented with resin cement (IIIb), the mean failure load for group IIIb (122.20kgs) was higher than group IIIa (81.20kgs) and the results were statistically significant ($p < 0.05$). Because resin cement showed bonding to both dentin and carbon fiber posts giving a single unit effect and causing uniform stress distribution but glass ionomer cement showed chemical bonding only to dentin. When the teeth restored with custom made Ni-Cr posts cemented with glass ionomer cement (Ia) were compared with teeth restored with prefabricated carbon fiber posts cemented with glass ionomer cement (IIIa), the mean failure load for group IIIa (81.20kgs) was higher than group Ia (71.00kgs) and the results were statistically significant ($p < 0.05$). Results of present study are in agreement with Isidor F et al (1996)¹³ who found that when intermittent loading of 2 cycles/sec., with a peak load of 250 N perpendicular to occlusal surface of crown was applied, carbon fiber posts had not failed

even after 1,000,000 loads where as teeth with custom cast posts or titanium posts failed before 260,000 cycles. Ottl et al (2002)¹⁴ found that carbon fiber posts had highest failure loads followed by metal posts and ceramic posts. Similarly Dean JP et al (1998)¹⁵ found the same about carbon fiber posts. Higher failure load for group IIIa can be explained by the fact that modulus of elasticity of carbon fiber posts (15GPa) was almost similar to that of dentin (18.3GPa) resulting in distribution of stresses along whole of the root dentin. Modulus of elasticity of Ni-Cr alloy (171.7GPa) was much higher than that of dentin resulting in concentration of stresses causing the teeth to fracture.

Results obtained in present study are contrary to those obtained by Hu YH et al (2003)¹⁶ and Raygot et al (2001)¹⁷, who found no difference in fracture load for carbon fiber posts and metal posts. Sidoli GE (1997)¹⁸ found that higher failure load was seen in cast metal posts and other metal posts and carbon fiber posts showed lowest mean values for failure load.

Mean failure load for group IIIa (81.20 kgs) was higher than group IIa (70.15kgs) and results were statistically significant ($p < 0.05$). Higher failure load for group IIIa can be explained as above for group Ia and IIIa.

Mean failure load for group IIIb (122.20kgs) was higher than group Ib (91.51kgs) and the results were statistically significant ($p < 0.05$). The higher failure load for group IIIb can be explained by the fact that when teeth were restored with carbon fiber posts and resin cement they behaved as one unit and thereby resulted in uniform stress distribution causing reinforcing effect on the tooth and effect of the posts can be explained as above for group Ia and IIIa. Similar results were seen when we compared group IIIb with Ia and IIIb with IIa.

When the teeth with only a crown and no post and core (Group IV) were compared with Groups Ia, Ib, IIa,

IIb and IIIa the mean failure load for Group IV (125.12kg) was higher than mean failure load of Group Ia (71.00kgs), Ib (91.51kgs), IIa (70.15kgs), IIb (90.20kgs) and IIIa (81.20kgs) and results obtained were statistically significant. This showed that natural tooth with endodontic treatment performed better than all these groups. Guzy GE found the same in his study.¹⁹

When teeth restored with prefabricated carbon fiber posts cemented with resin cement (IIIb) was compared with control group (IV), the mean failure load for Group IIIb (122.2kgs) was almost similar to that for Group IV (125.12kgs) and results so obtained were statistically insignificant ($p > 0.05$). This can be explained by the fact that carbon fiber post and resin cement when used, act as one unit and behaved like a natural tooth.

Mode of failure of different groups revealed that unfavorable (middle and coronal third) root fractures were seen in teeth restored with Ni-Cr and stainless steel posts, and favorable root fractures with carbon fiber posts. In teeth restored with carbon fiber posts uniform distribution of stresses occurs whereas concentration of stresses occurs with metallic posts which may lead to fracture of root.^{20,21,22}

CONCLUSION

- Resin cement performed better than glass ionomer cement irrespective of post material used.
- Carbon fiber posts showed higher failure load than custom made Ni-Cr posts and prefabricated stainless steel posts.
- Carbon fiber posts cemented with resin cement performed almost equal to the endodontically treated teeth with no post and core.
- Mode of fracture was more favourable with carbon fiber posts group than in metallic posts.

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