Research Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2019;9:3:149-157.

Comparative Evaluation of Fracture Resistance of Various Post Systems Using Different Luting Agents Under Tangential Loading: An Invitro Study

Snehal V Ukey[1*] Suresh Khiyani[2] Konjengbam Nongdamba[3] Saili Wadkar[4] Sumit Duryodhan[5] Sneha Chole[6]

[1]PG Student, Department of Prosthodontics, Aditya Dental College, Beed, Maharashtra, India.
[2]Professor and Head, Department of Prosthodontics, Aditya Dental College, Beed, Maharashtra, India.
[3]PG Student, Department of Prosthodontics, Aditya Dental College, Beed, Maharashtra, India.
[4]PG Student, Department of Prosthodontics, Aditya Dental College, Beed, Maharashtra, India.
[5]PG Student, Department of Prosthodontics, Aditya Dental College, Beed, Maharashtra, India.
[6]PG Student, Department of Prosthodontics, Aditya Dental College, Beed, Maharashtra, India.

ABSTRACT

Background: To compare fracture resistance of endodontically treated teeth restored with various post systems using different luting agents under tangential loading.

Materials and methods: 40 freshly extracted maxillary anterior teeth were collected and stored in normal saline were disinfected with 0.5% sodium hypochlorite. They were stored in normal saline to prevent dehydration before and during experimental procedures. Teeth are divided into 4 groups of 10 teeth each and restored with fiber posts, prefabricated metal posts, custom made posts and luted with glass ionomer cement, resin cement and zinc phosphate cement. Teeth were endodontically treated, and post space preparation is done. All the specimens were subjected to load (newton, N) on the lingual surface at a 135° angle to the long axis with a universal testing machine until it fractured.

Results: Custom made posts has higher fracture resistance as compared to other groups. There exist statistical significant difference ($p=0.001$) between group A and group B. No statistically significant difference was observed between group A and group C. Group D has highly statistically significant greater fracture resistance ($p<0.001^{**}$) as compared to group A(control).

Conclusions: Teeth restored with custom made posts showed better resistance to fracture than teeth restored with fiber post, prefabricated metal post. Control group showed least fracture resistance as compared to other groups. Among luting agents, custom made posts luted with adhesive resin cement showed higher fracture resistance followed by glass ionomer cement and zinc phosphate cement.

Keywords: Tangential loading, Adhesive resin cement, Fiber post, Cast post, Prefabricated metal post.

INTRODUCTION

Endodontic treatment is an attempt to save and preserve the tooth with damaged pulp in function. Success of endodontic therapy depends upon a combination of a three dimension pneumatic seal along with adequate post endodontic restoration to make the pulpless teeth to function as an integral part of the dental arch. Coronally deficient teeth with sound root are often critical to restore. Coronal tooth structure loss requires utilization of the radicular dentin for support of core. Posts are often used to retain a core in endodontically treated teeth that have minimal remaining tooth structure. Post

Received: Feb. 14, 2019: **Accepted**: Apr. 29, 2019
*__Correspondence Dr. Snehal V Ukey.__
Department of Prosthodontics, Aditya Dental College, Beed, Maharashtra, India.
Email: ukeysnehal3@gmail.com

pISSN 2278-0076
eISSN 2321-9270

and core equally distributes torquing forces to radicular dentin to supporting tissues and thus protect and strengthen the tooth against intraoral forces. It disperse forces along the root and provide retention for the core which has replaced the lost coronal tooth structure.[1]

The post functions primarily to aid the retention of the restoration and to protect the tooth by dissipating or distributing forces along the tooth. On the contrary, the tooth is weakened if dentin is sacrificed to place a large diameter dowel. The decision regarding post placement should be based on the amount of remaining tooth structure, anatomic position of the tooth, functional load on the tooth and esthetic requirement of the tooth.[2]

Endodontically treated teeth are at higher risk of fracture than vital teeth due to the decreased moisture content in dentin and most of the times, compromised structural integrity. For functional and esthetic concerns, complete coverage crown restorations along with post and core is often recommended to enhance retention of crowns.[3] One of the functions of a post-core is to distribute the applied forces along the root to avoid fracture. Recent reports suggested that the rigidity of the post should be equal or close to that of the root to distribute any occlusal force evenly along the long axis of the tooth.[4]

In general, P&C systems can be divided into two categories: Casting and Prefabricated P&C.Prefabricated posts can be made of metal or tooth-colored materials.[5]Endodontically treated anterior teeth are traditionally being restored with cast metal post and cores. These metallic posts have a much higher modulus of elasticity than the supporting dentin. This mismatch in modulus could lead to stress concentration and leads to failure; inferior esthetics as they do not allow light transmission; might corrode due to gingival and tooth discoloration. These disadvantages of the metal post have lead to search for a plastic based material that has modulus closer to that of dentin.[1]Cast metal P&C systems are widely used due to their favorable physical properties, high strength, and good retention. However, failure to achieve the desired aesthetics is a major problem encountered upon using cast metal systems.[5] It is generally accepted that for a cast restoration extending at least 2 mm apical to the junction of the core, and remaining tooth structure, encirclement of the root with ferrule will protect the endodontically treated tooth against fracture by counteracting and better distributing the stresses generated by the post.The cementing medium used for cementation of post and cores enhances retention, aids in fracture resistance, and better distribution of stresses.[6]

FRC posts are composed of carbon, glass, or quartz fibres embedded in epoxy resin. They have bonding ability to dentin and the core material. They can reinforce the tooth, and as their elasticity is compatible with dentin, they can absorb stresses and protect the root from fracture. FRC posts have a lower fracture strength compared to cast posts and cores, but in cases of failure, the post or core will fracture, instead of the roots in cast post and core restored teeth.[7]

With the increasing demand for esthetics in today's era post and core system used for supporting translucent all ceramic restoration had to be looked for. The glass fibre posts were introduced in 1992 with this aim. Glass fiber posts provide increased light transmission through the root, giving more life-like appearance to the prosthesis. The modulus of elasticity of glass fiber post is comparable with that of dentin which reduces chances of root fracture due to stress concentration. Glass fiber posts also eliminate the problem of corrosion and hypersensitivity that occurs with metal posts.With its many advantages, the fiber reinforced post is becoming a paramount restorative option for endodontically treated tooth.[8]

FRCs, particularly glass fiber-reinforced posts, have been recommended as an alternative to cast or prefabricated metal posts because of recent advances in adhesive technologies. Their current popularity in restorative dentistry is associated with their rigidity and modulus of elasticity, which is similar to those of dentin, in addition to their superior esthetic properties, lower dentinal removal and ability to be bonded to dentin with adhesive luting resins.[9] In addition, FRC posts do not result in metal corrosion or allergic reactions, and can be easily removed from root canals in cases of endodontic failure.[10]

The custom-made post is the time-proven method for post and core construction. When properly designed, the custom-made post can conform to a canal of any shape to provide maximum retention and allow a more even distribution of stresses throughout the tooth structure. A dental ferrule is an encircling band of cast metal around the coronal surface of the tooth as part of the core or artificial crown and may be of benefit in reinforcing root filled teeth. A protective or “ferrule effect” could occur owing to the ferrule resisting stresses such as functional lever forces, the wedging effect of tapered posts, and the lateral forces exerted during the post insertion.[11]

The strength of the teeth depends on the amount of remaining dentin, and endodontically treated teeth are at higher risk of failure. For many years, cast posts and cores have been the most widely used type of post. However, they have some disadvantages, such as root fractures, corrosion and even loss of post retention. Tooth preparation for cast posts and cores requires removing a larger amount of root dentin, which leads to higher risk of tooth fracture. Root fracture is the most serious type of failure in post-restored teeth.To avoid root fractures, a post having a modulus of elasticity similar to that of dentin helps in distributing the stress of occlusal load in a uniform pattern. The new development of glass fiber post systems provides an alternative for the final restoration of endodontically treated teeth.[8,12]

For the restoration of endodontically treated teeth, the use of fiber-posts luted with resin cement and combined with composite core build-up materials is becoming very frequent. (Resin cement used in post space during luting procedure contribute to bond strength between resin luting agents and post canal regions.) The selection of the composite plays an important role, not only for the clinical success of a post/core restoration but also for the quality of the post/core interface, where different materials are in close contact.[13] The use of composite as a core material has also enhanced the ability to reproduce the shade and translucency of natural teeth. The restoration of teeth with adhesively cemented internal restorations offers improved mechanical stability over cemented restorations.[14]

The restoration of teeth with adhesively cemented internal restorations offered improved mechanical stability over cemented restorations. Glass ionomer powder has been shown to be weak and brittle as compared with resin-based materials. Glass ionomers have also exhibited unfavorable in vitro cyclic fatigue characteristics and low compressive strengths compared with resin-based luting cements.[3]

Another cement used is zinc phosphate cement used to lute the post space. It has good compressive strength (if correctly proportioned), adequate film thickness (25 um), and reasonable working time but disadvantages are low tensile strength ,no chemical bonding, and solubility in oral fluids. Zinc phosphate cement is one of the oldest luting cements which has been in use for long because of advantages like high early strength which makes it suitable for cementation of prefabricated or for a cast metal post core.[5]

With a number of manufacturers claiming their product's superiority over custom cast and prefabricated post core system, this in vitro study was designed to evaluate the fracture resistance of various post systems using different luting agents under tangential loading after thermocycling.

The null hypothesis stated that there was no significant difference in fracture resistance of teeth restored with the above-mentioned post systems luted with above-mentioned luting cements.

MATERIALS AND METHODS

40 freshly extracted maxillary anterior teeth were collected and stored in normal saline and disinfected with 0.5% sodium hypochlorite .They were stored in normal saline to prevent dehydration before and during experimental procedures.

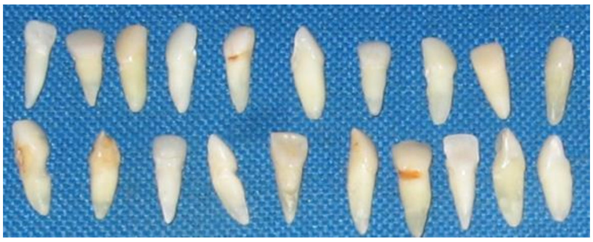

Fig 1: Freshly extracted tooth

Inclusion Criteria

a. All samples were caries free

b. All samples were fracture free
c. All Selected samples were devoid of debris and calculus
d. All samples had complete root formation.

Exclusion Criteria

a. Tooth with two or more canals
b. Roots with aberrant anatomy
c. Roots with open apices

DIFFERENT CEMENTS STUDIED WERE:

1) Glass Ionomer cement
2) Resin cement
3) Zinc Phosphate cement

SPECIMENS ARE ARRANGED INTO FOUR GROUPS

Group A :Control group
Group B :Fibre post
Group C :Prefabricated metal posts
Group D :Custom made post.

SECTIONING OF THE SAMPLE:

All the collected samples were marked and decoronated 2mm above the cemento-enamel junction with double sided diamond disc mounted on high speed hand piece.

ROOT CANAL TREATMENT.

a. The root canal was prepared using the sequential endodontic file from No.10 to size of No.35. b.Irrigation was done after every file instrumentation with alternate 2.5% sodium hypo chlorite and17% ethylene diamine tetra acetic acid followed by final irrigation with saline for 1 min. c.Canals were dried with absorbent paper points. d.Obturation was done using gutta-percha and endodontic sealer (AH 26) by conventional step-back technique.

PROCEDURE FOR GROUP A SPECIMENS.

Access cavities were sealed with light cure composite resin and crown preparation of 8 mm from incisal edge to cervical region was made. The specimen teeth in group B, C and D were prepared by removing the crown of the teeth with a fine grit diamond wheel perpendicular to the long axis of the teeth with remaining tooth length standardized to approximately 16 mm. A shoulder of 1 mm was prepared around the full circumference of tooth with cylindrical diamond bur.

PROCEDURE FOR GROUP B SPECIMENS

The post space preparation was done till 2/3rd of root length by removing root canal filling material using peeso remears NO.1,2 then the canal space was enlarged using the drills provided by the manufacturer. Self cure adhesive resin cement (Selfcem) was applied on prepared walls of canal.FRC post was coated with resin cement and inserted into the canal and excess cement was cleared. The post space preparation was done to a depth of 10 mm with a drill matching the diameter of fibre post. After post space preparation, the fibre post was luted with adhesive resin cement, glass ionomer cement, zinc phosphate cement. The dimensions of the core simulated with the crown preparation.

PROCEDURE FOR GROUP C SPECIMENS

The post space preparation was done to a depth of 10 mm with drill matching the diameter of stainless steel post.After post space preparation, metal posts were luted with 3 different cements similar to group B.

PROCEDURE FOR GROUP D SPECIMENS

Post space preparation was done similar to Group B. Post and core wax patterns were fabricated using blue inlay casting wax.The wax patterns were formed directly over tooth specimens coated with a die lubricant. Once the pattern was made, additional resin was added to make the core. Core of a post replaces the missing coronal tooth structure and thereby forms the shape of the prepared tooth to receive a crown. Wax patterns were invested using high expansion phosphate-bonded investment material and casted in nickel - chrome alloy, in the centrifugal casting machine.The custom made posts were luted with 3 different cement similar to group B.

BASED ON DIFFERENT LUTING AGENTS ,GROUP B, C AND D ARE FURTHER DIVIDED INTO

GROUP B

B1:Fibre post luted with zinc phosphate cement.
B2:Fibre post luted with adhesive resin cement.

B3:Fibre post luted with glass ionomer cement

GROUP C

C1:Prefabricated metal post luted with zinc phosphate cement.
C2:Prefabricated metal post luted with adhesive resin cement.
C3:Prefabricated metal post luted with glass ionomer cement.

GROUP D

D1:Cast post luted with zinc phosphate cement.
D2:Cast post luted with adhesive resin cement.
D3:Cast post luted with glass ionomer cement.

MOUNTING OF TOOTH SAMPLE IN ACRYLIC RESIN BLOCK.

Root surfaces were dipped into melted wax to a depth of 2mm below the facial CEJ to produce

a 0.2-0.3mm layer approximately equal to the average thickness of periodontal ligament. Teeth were then mounted in acrylic resin block .Each tooth was removed from resin block when first signs of polymerization were observed. The wax spacer was removed from root surface and space was filled with light body polyvinyl siloxane impression material. Cold cure acrylic resin was used for the fabrication of resin blocks in which the specimens were mounted.

MECHANICAL LOADING

The samples were subjected to thermocycling (5000 cycles between 5oC to 55oC with a dwell time of 30 sec at each temperature) and stored in distilled water for 24 h at 37oC in a humidor (100% relative humidity) to simulate conditions in the oral cavity prior to the fracture test. The samples were then mounted on acrylic mould and tested on(UTM) Universal Testing Machine. A compressive load was applied 2 mm cervical to the incisal edge on the palatal aspect, at an angle of 130^0 to the long axis of the tooth at a crosshead speed of 1.5 mm/min. Mean failure load values were calculated for all groups [Table 1].The force of fracture was measured in Newton. The statistical analysis was done by Tukey's post hoc test and ANOVA test. The analysis of variance was used to compare mean differences between the groups to evaluate fracture resistance.

Fig 2: Testing samples with UTM

RESULTS

Comparison of fracture resistance of endodontically treated teeth restored with different posts. Highest fracture resistance was found in group D (custom post) followed by group B (fibre post,group C (pre-fabricated metal post) and least in group A(control).On comparison of fracture resistance of endodontically treated teeth restored with different posts using anova f test , it was found that there exist statistical significant difference ($p<0.05$) among different posts. On using tukey's post hoc test to find individual pair wise comparisons, it was found that there exist statistical significant difference ($p=0.001$) between group A and group B. No statistically significant difference was observed between group A and group C. Group D has highly statistically significant greater fracture resistance ($p<0.001$**) as compared to group A(control).No statistically significant difference ($p>0.05$) exist between group B and group C, group B and group D respectively. Group D has statistically significant greater fracture resistance ($p<0.05$) as compared to group C (pre – fabricated metal).

DISCUSSION

Prefabricated post systems have become more popular because they can provide satisfactory results while saving chair time and reducing costs. Tooth colored fiber reinforced posts have esthetic advantages, including increased transmission of light through the root and the overlying gingival

Table 1: Showing Fracture Resistance of Different Groups.

Fracture Resistance	Mean	S.D	ANOVA F TEST	p value, Significance
GROUP A (CONTROL	251.64	115.30	F = 11.168	p = 0.001, significant difference
GROUP B (FIBRE)	480.01	121.70		
GROUP C (PREFABRICATED METAL)	374.38	140.80		
GROUP D (CUSTOM MADE)	535.6	134.36		

Table 2: Comparison of failure loads in Newton (N) of endodontically treated teeth restored with group B(fibre post) luted with zinc phosphate(B1),adhesive resin cement(B2),glass ionomer cement (B3).

FRACTURE RESISTANCE GROUPB (FIBRE POST)	Mean (Newton)	S.D(Newton)	ANOVA F TEST	p value, Significance
GROUP B1 (ZINC PHOSPHATE)	159.0	24.68	F=38.65	p<0.001**
GROUP B2 (ADHESIVE RESIN CEMENT)	443.3	60.00		
GROUP B3 (GLASS IONOMER CEMENT)	291.6	22.47		

Table 3: Comparison of failure loads in Newton (N) of endodontically treated teeth restored with group C (prefabricated metal post)luted with zinc phosphate(C1),adhesive resin cement(C2),glass ionomer cement (C3).

FRACTURE RESISTANCE GROUP C (PRE FABRICATED POST)	Mean(Newton)	S.D(Newton)	ANOVA F TEST	p value, Significance
GROUP C1 (ZINC PHOSPHATE)	106.3	9.71	F=53.46	p<0.001**
GROUP C2 (ADHESIVE RESIN CEMENT)	264.9	23.62		
GROUP C3 (GLASS IONOMER CEMENT)	185.3	20.15		

Table 5: Comparison of failure loads in Newton(N) of endodontically treated teeth restored with group D (custom made post) luted with zinc phosphate(D1),adhesive resin cement(D2),glass ionomer cement (D3).

FRACTURE RESISTANCE GROUP D (CUSTOM CAST POST)	Mean (Newton)	S.D(Newton)	ANOVA F TEST	p value, Significance
GROUP D1(ZINC PHOSPHATE)	241.3	29.58	F=25.37	p=0.001*
GROUP D2 (ADHESIVE RESIN CEMENT)	577.9	90.17		
GROUP D3(GLASS IONOMER CEMENT)	368.0	35.27		

tissues.[1]The use of tooth-colored posts, such as ceramic posts and fiber-reinforced composite (FRC) posts, is common because of better aesthetic results. Furthermore, ceramic posts demonstrate a high strength and hardness, while fiberglass posts show a lower strength and a higher elasticity . FRC posts have a higher flexural strength than metal P&Cs and zirconia posts.[5]FRC posts have a lower fracture strength compared to cast posts and cores, but in cases of failure, the post or core will fracture, instead of the roots in cast post and core restored teeth.[7]

Cast metal P&C systems are widely used due to their favorable physical properties, high strength, and good retention. However, failure to achieve the desired aesthetics is a major problem encountered upon using cast metal systems. The custom-made post is the time-proven method for post and core construction. When properly designed, the custom-made post can conform to a canal of any shape to provide maximum retention and allow a more even distribution of stresses throughout the tooth structure. A dental ferrule is an encircling band of cast metal around the coronal surface of the tooth as part of the core or artificial crown and may be of benefit in reinforcing root filled teeth. A protective or "ferrule effect" could occur owing to the ferrule resisting stresses such as functional lever forces, the wedging effect of tapered posts, and the lateral forces exerted during the post insertion [11]

The present in vitro study was conducted to evaluate and compare fracture resistance of fiber posts, prefabricated metal posts and custom made posts in endodontically treated teeth luted with three different cements zinc phosphate cement, adhesive resin cement and glass ionomer cement. Results showed Group D(custom made posts) has highly statistically significant greater fracture resistance (p<0.001) as compared to group A(control). All the fractures in the control group were non restorable.

Kianoosh Torabi, Farnaz Fattahi 2009[7]evaluated fracture resistance of endodontically treated teeth restored by different FRC posts and found that cast post and core had the highest failure load of all FRC posts. Dastjerdiet al 2015[9] evaluated fracture resistance of upper central incisors restored with different posts and cores and found that cast posts and cores exhibited higher fracture resistance. Results of this study are relevant to the present study results. Gaikwad et al 2015[6]evaluated fracture resistance of teeth restored with various post designs and cemented with different cements and found that ferrule helped in increasing the fracture resistance of endodontically treated teeth. Resin cement showed better results than zinc phosphate cement. The combination of the post with ferrule and resin cement showed the greatest resistance. The combination of the post without ferrule and zinc phosphate cement showed the least resistance. Resin cement increased the fracture resistance without ferrule. In present study we found that custom made post exhibited the maximum fracture resistance while control group exhibited the least fracture resistance among the four groups. Group D(Custom made post) exhibited higher mean fracture resistance followed by group B(fiber post), group C(prefabricated metal post) and group A(control).On comparison of fracture resistance of endodontically treated teeth restored with different posts using anova f test , it was found that there exist statistical significant difference ($p<0.05$) among different posts. According to Gaikwad A et al study resin cement shows higher fracture resistance amongst other cements used, which is relevant to present study results.

CONCLUSION

This in vitro study was conducted to evaluate and compare fracture resistance of different posts i.e.Fiber post (Reforpost) , Prefabricated metal post (Denta IScrew posts), Custom made post (Cast post) in endodontically treated teeth luted with three different cements.Comparison of subgroups with reference to control group and inter group comparison was done using one way ANOVA f test followed by tukey's post hoc test. Within the limitations of this study, following conclusions were drawn:1. The results showed that endodontically treated teeth restored with custom made posts were as strong as the other groups.

2. Teeth restored with custom made posts with 2 mm ferrule showed highest resistance to fracture.

3. Teeth restored with custom made posts showed better resistance to fracture than teeth restored with fiber post, prefabricated metal post. Control group showed least fracture resistance as compared to other groups.

4. Among luting agents, custom made posts luted with adhesive resin cement showed higher fracture resistance followed by glass ionomer cement and zinc phosphate cement.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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