Received: 25th January 2015 Accepted: 10th April 2015 Conflicts of Interest: None

Source of Support: Nil

Original Research

Fracture Resistance of Teeth Restored with Various Post Designs and Cemented with Different Cements: An *In-vitro* Study

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How to cite the article:
Gaikwad A, Pal KS, Ranganath LM, Jain JK, Patil P, Babar G. Fracture resistance of teeth restored with various post designs and cemented with different cements: An *in-vitro* study. J Int Oral Health 2015;7(1):33-37.

Abstract:

Background: Studies have been carried out on endodontically treated teeth restored with and without ferrule, and influence of the cementing medium, to evaluate their effect on fracture resistance. This study was conducted on 28 freshly extracted maxillary central incisors. Specimens were restored with two types of post designs, and cemented with two different luting agents, and tested for fracture resistance.

Materials and Methods: A total of 28 freshly extracted maxillary central incisors were used. Specimens were restored with two types of post designs and cemented with two different luting agents and tested using Instron universal testing machine. The statistical analysis was performed using the Kruskal–Wallis test (H) and Tukey honest significant test.

Results: 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 resistance of even without ferrule.

Conclusion: There was a positive effect of a ferrule in increasing the fracture resistance. Resin cement showed better resistance than zinc phosphate cement.

Key Words: Core, endodontically treated teeth, ferrule, fracture resistance, luting agent, post

Introduction

Endodontically treated tooth were structurally compromised and present numerous problems because of coronal destruction from dental caries, fractures, and previous restorations or endodontic techniques. The result is loss of tooth structure and a reduction in the capability of the tooth to resist the intra-oral forces.[1] Posts and cores are commonly advocated to protect or strengthen the tooth against intraoral forces by equally distributing torquing forces within the radicular dentin to supporting tissues, thus dispersing the forces along the root, and provide retention for the core that replaced lost coronal tooth structure, and retain the restoration.[2,3]

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.[4,5] The cementing medium used for cementation of post and cores enhances retention, aids in fracture resistance, and better distribution of stresses.

The aims and objectives of the study were:
1. To compare fracture resistance of endodontically treated maxillary central incisors with and without ferrule post and core design
2. To compare and evaluate the influence of two different cements *viz*., zinc phosphate, and resin cement on fracture resistance of endodontically treated teeth.

Materials and Methods

The proposed study was undertaken to evaluate the effect of different post and core designs and two different cements on fracture resistance of endodontically treated teeth.

The two types of post and core designs studied were:
1. Post and core with ferrule
2. Post and core without ferrule.

Two different cements studied were:
1. Zinc phosphate cement
2. Resin cement.

The sample consisted of 28 freshly extracted maxillary central incisors (Figure 1) with no caries, cervical abrasion, injury from forceps, or fracture. Teeth were immersed in 5.25% sodium hypochlorite solution for 24 h to remove the surface deposits, and stored in saline. Hard and soft tissue deposits were removed from tooth surface manually using periodontal hand instruments. The crowns were decoronated by horizontally sectioning them 2 mm coronal to the cementoenamel junction and perpendicular to the long axis of teeth, with model trimmer (WhipMax, USA S. No. T04860431) at high-speed under water cooling.

Endodontic therapy was completed on all teeth using the crown-down technique. This technique involves early flaring with endodontic hand instruments followed by the incremental removal of canal debris, and dentin from the orifice to the apical foramen, using straight files in smaller to larger sequence with a reaming motion and no apical pressure once blinding occurs. 5.25% sodium hypochlorite was used as lubricant during canal preparation. Teeth were instrumented to file No. 40 (Dentsply, India) apically, leaving 1 mm apical seal, and canals were dried with compressed air and paper points. Teeth were obturated using No. 40 gutta-percha cones (Dentsply India. B. No. 030404), with zinc oxide-eugenol sealer using lateral condensation technique. The gutta-percha cones were cut with heated pluggers, and the canal orifice was sealed with zinc oxide eugenol cement. The roots were stored in saline solution.

The post space was prepared 1-week after the root canal obturation, using No. 4 gates glidden bur (Dentsply, India) , and Peeso reamer (Dentsply, India), ensuring at least 4 mm gutta-percha seal apically (Figure 2). Then all the specimens were embedded in auto polymerizing acrylic resin (Asian Acrylates, Mumbai).

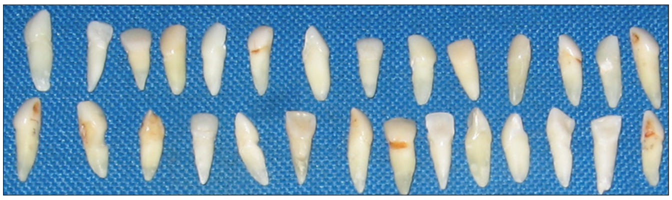


Figure 1: Extracted maxillary central incisors.

Figure 2: Samples with root canal treatment.

A ferrule (Figure 3) was prepared on 14 teeth. 2 mm of ferrule was prepared with a flat end diamond bur No. 170, using airotor handpiece (NSK, Pana Air B. No. B9568675) under constant water irrigation, and ×2 magnification, by a single operator. The ferrule preparation was 2 mm high with a width of at least 1 mm. These groups of teeth with ferrule were labeled as Group A (group with ferrule). The remaining 14 teeth were labeled as Group B (group with no ferrule).

Post and core wax patterns (Figure 4) were fabricated using blue inlay casting wax (Renfert, USA. B. No. 6820001). The wax patterns were formed directly over tooth specimens coated with a die lubricant (Dentecon Wax, and Die Lubricant, USA). Wax patterns were invested with high expansion phosphate-bonded investment material (Bellavest, Germany. B. No. 51090), and cast in cobalt - chrome alloy (Aalba Dental Inc. California, USA), in the centrifugal casting machine. 5 patterns were invested at a time for casting. Numbers from 1 to 5 were wrote down on each tooth with a permanent marker, and these numbers were marked on corresponding wax patterns with a needle. Marking was made on each sprue former of wax pattern for proper

Figure 3: Ferrule.

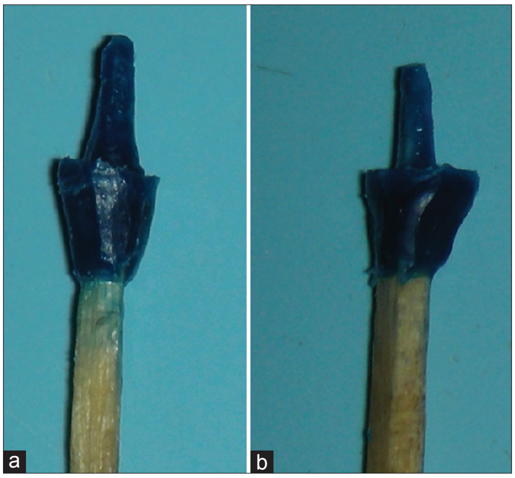


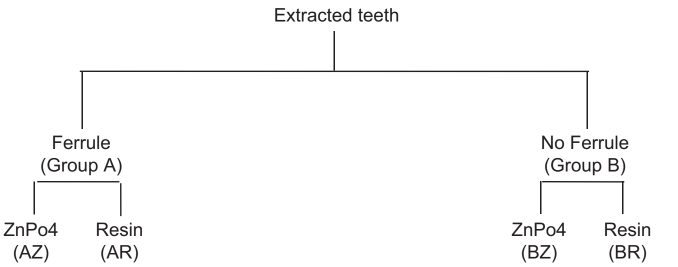
Figure 4: (a) Wax pattern with ferrule, (b) wax pattern without ferrule.

identification so that the casting should seat in corresponding teeth after casting. After removal from casting and cleaning, the posts and cores were sandblasted using Sandblaster (Renert-Basic professional No.2942, Germany) with aluminum oxide and adapted to roots. Any areas impairing perfect adaptation were removed with a carbide bur mounted on a high -speed handpiece under air/water cooling.

The post cores were then cemented to their corresponding teeth using zinc phosphate cement, and resin cements. The roots that received the posts, and cores cemented with zinc phosphate cement had their canal walls cleaned and rinsed with water for 1 min, and dried by air blast for 5 s. Zinc phosphate cement (Harvard B.No.1900604 & 1900605), was handled according to manufacturer's instructions and inserted into the canals with a lentula. The posts and cores were settled underhand vibration and kept under minimal pressure for 30 s. The teeth receiving zinc phosphate cement were grouped as Group AZ (ferrule and zinc phosphate cement), and BZ (no ferrule and zinc phosphate cement).

The roots that received the posts and cores cemented with resin cement had their canal walls etched with 32% phosphoric acid for 20 s, rinsed with water for 1 min, and dried with a gentle air blast. The posts and cores were sandblasted and coated with alloy primer using a brush. Primer A and B mixtures were applied and swabbed in the canal interior with an extra fine interdental brush for 20 s and dried by air blast for 5 s. The Panavia F cement (Kuraray Inc. B. No. 51664), was manipulated in equal portions of paste A and B and inserted into the canal with a lentula. The cement was also applied on the posts and cores. Then the posts and cores were settled underhand vibration and kept under minimal pressure for 30 s; the excess was removed and the posts and cores were cured in light curing unit (LoboLight LV II light curing unit, S. No. 62063, manufactured by GC Corp., Japan, for 20 s. The teeth receiving resin cement are grouped as group AR (ferrule and resin cement) & BR (no ferrule and resin cement). Overall four groups of teeth were prepared. Then the specimens were radiographed (Figure 5) to check roper fit of the posts and cores. All specimens were stored in saline solution and kept under refrigeration for 24 h.

Groups of specimens (Figure 6)



Methods of testing

All specimens were stored in saline solution and kept under refrigeration for 24 h. Fracture resistance test was carried out using Instron universal testing machine (Rauenstein, S No:2213/

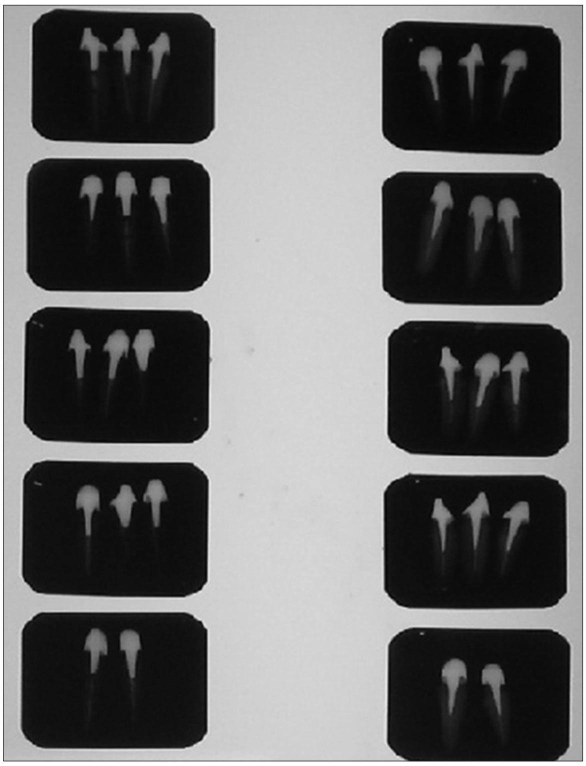


Figure 5: Radiographs.

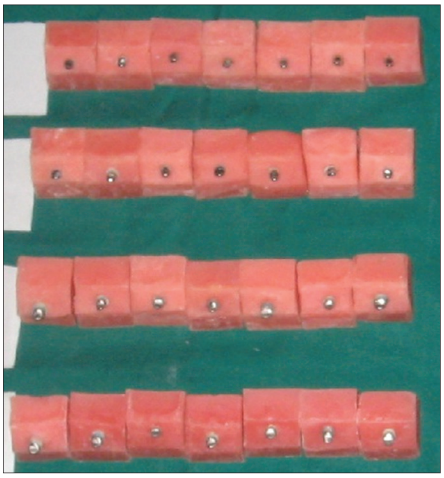


Figure 6: Samples divided into four groups after cementation.

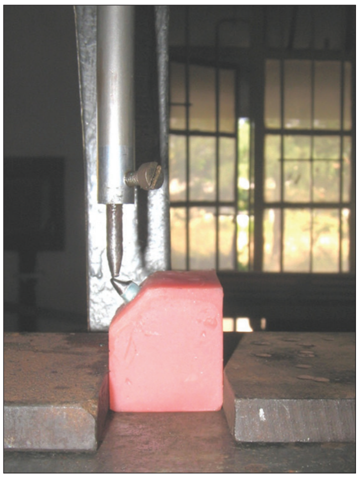


Figure 7: Testing of the samples.

R17 Germany), applying compressive load to the tooth specimen with a cross head speed of 0.5 cm/min at an angle of 135° to the long axis of the tooth until failure occurs (Figure 7). This angle of loading was chosen to simulate the contact angle in Class I relation between maxillary, and mandibular central incisors in natural dentition. During mastication also, load on maxillary incisors usually falls at this angle. The testing machine records the number of loads, and testing automatically discontinued when the system fails (i.e. post loosened because of loss retention or fracture of root and/or post). All procedures were performed by the same operator. Data were recordedand statistically analyzed.

Results

The statistical analysis was carried out using Kruskal–Wallis test (H) and Tukey honest significant test (HSD) test, with the statistical package for social science. Here the Kruskal–Wallis test (H) was used to compare the four properties for each material. The Tukey HSD test was used for multiple comparisons between four groups.

Table 1 shows the comparison of mean fracture load among the different groups. The mean and standard deviation along with probability '*P*' and '*H*' values are given (where '*H*' indicates Kruskal–Wallis test).

Table 1 shows the comparison of mean fracture load among the different groups (Kruskal–Wallis H). Here the $P = 0.001$ was found to be very highly significant and $H = 29.292$. Here the values obtained were highest for AR (post with ferrule, and resin cement), group followed by AZ (post with ferrule and zinc phosphate cement), BR (post without ferrule, and resin cement), BZ (post without ferrule, and zinc phosphate cement) groups.

Table 1: Comparison of mean fracture load among the different groups (Kruskal-Wallis).

Groups	Number	Mean	SD	Minimum	Maximum
AR	7	138.7414	23.64500	98.10	166.77
AZ	7	133.4571	19.03065	110.16	156.96
BR	7	127.5300	12.66466	107.91	137.34
BZ	7	106.5086	10.48733	98.10	117.72

P=0.001 very highly significant, SD: Standard deviation

Discussion

Teeth with a ferrule exhibited higher loads to failure compared to non-ferrule teeth.[6,7] As in the present study, most other studies have demonstrated the positive effect of a ferrule design incorporated in the preparation of endodontically treated teeth in increasing their fracture resistance.[7-9]

Resin cements are more retentive than zinc phosphate cements.[10-12] As in this study, few studies have reported that a ferrule increased the fracture resistance in endodontically treated teeth with cast posts cemented with zinc phosphate cement.[5,10,13]

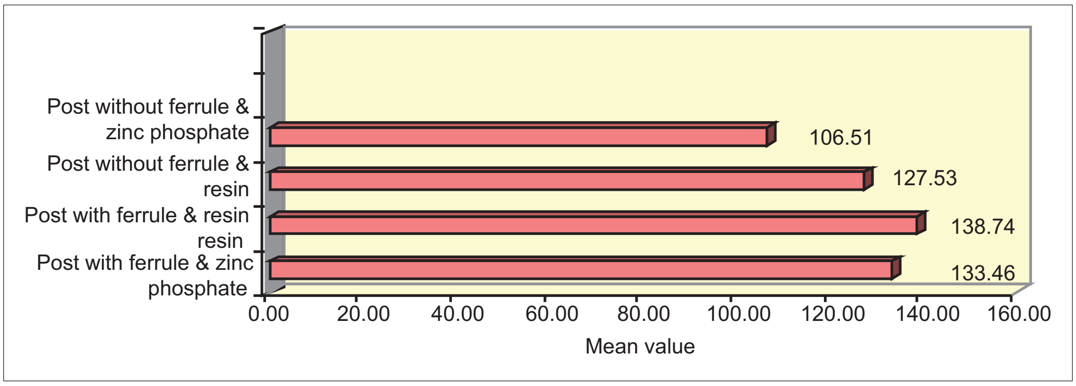
The groups with ferrule fared far better than the groups without ferrule in post and core design. Group AR (mean 138.7414 N) showed more fracture resistance when compared to Group BR (mean 127.5300 N). Group AZ (mean 133.4571 N) showed better fracture resistance than the Group BZ (mean 106.5086 N).

Group AR (mean 138.7414 N) showed better fracture resistance than the Group AZ (mean 133.4571 N). Group BR (mean 127.5300 N) showed better fracture resistance than Group BZ (mean 106.5086 N) (Graph 1).

There are some limitations to this study. Static loading does not directly replicate forces in the oral cavity with regard to both sizes of the load and nature of the load. Most pulpless teeth *in-vivo* probably fail as a result of fatigue failure, so resistance to static load is not the only issue of interest.[9] There are several avenues for improvement in further investigations. These include, fatigue testing of specimens fabricated using the same protocol. A comparison between static load and fatigue load could also be conducted to investigate any correlation between the results obtained.

Conclusions

1. The combination of the post with ferrule and resin cement showed the greatest fracture resistance of an endodontically treated tooth restored with post and core
2. The combination of the post without ferrule and zinc phosphate cement showed the least fracture resistance of endodontically treated tooth restored with post and core



Graph 1: Comparison of mean fracture loads among different groups.

3. There was a positive effect of a ferrule incorporated in the preparation of endodontically treated teeth in increasing their fracture resistance
4. Resin cement showed better fracture resistance than zinc phosphate cement.

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