ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 5, Issue – 3, May - 2022, Page No. : 300 - 308

Comparative Evaluation of Fracture Resistance of Various Prefabricated Post System using Different Luting Agents - An Invitro Study

[1]Dr. Anamika Kumari, Senior Lecturer, Dept. of Conservative Dentistry & Endodontics, Mithila Minority Dental College & Hospital Darbhanga, Bihar.

[2]Dr. B Rajkumar, Head and professor Dept. of Conservative Dentistry & Endodontics, Babu Banarasi Das College Of Dental Sciences Lucknow, UP.

[3]Dr. Jaimesh Kumar Bhagat, Senior lecturer, Dept. of Conservative Dentistry & Endodontics, Mithila Minority Dental College & Hospital Darbhanga, Bihar.

[4]Dr. Neha Verma, Senior Lecturer, Dept. of Conservative Dentistry & Endodontics, Buddha Institute of Dental Sciences & Hospital, Patna, Bihar.

[5]Dr. Pragyan Paliwal, Senior Lecturer, Dept. of Conservative Dentistry & Endodontics, Babu Banarasi Das College of Dental Sciences, Lucknow, UP.

[6]Dr. Ruchi Paharia, Dept. of Conservative Dentistry & Endodontics, Babu Banarasi Das College Of Dental Sciences, Lucknow, UP, Flat 101, Omega Green Park, Faizabad Road, Lucknow.

Corresponding Author: Dr. Anamika Kumari, Senior Lecturer, Dept. of Conservative Dentistry & Endodontics, Mithila minority Dental College & Hospital Darbhanga, Bihar.

Citation of this Article: Dr. Anamika Kumari, Dr. B Rajkumar, Dr. Jaimesh Kumar Bhagat, Dr. Neha Verma, Dr. Pragyan Paliwal, Dr. Ruchi Paharia, “Comparative Evaluation of Fracture Resistance of Various Prefabricated Post System using Different Luting Agents - An Invitro Study”, IJDSIR- May - 2022, Vol. – 5, Issue - 3, P. No. 300 – 308.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Objective: The purpose of the study was to evaluate the fracture resistance of various prefabricated post system using with different luting agents.

Materials & Methods: A total of 70 extracted human maxillary incisors were collected, decoronated at CEJ level to obtain a root length of 16±1 mm and treated endodontically. Samples were then divided into 7 groups (6 experimental & 1 control) of 15 teeth each. Fiber posts and luting cements used were carbon fibre Post with resin cement, carbon fibre Post with GIC, glass fibre Post with resin cement, Glass fibre Post with GIC, Zirconia fibre Post with resin cement, Zirconia fibre Post with GIC). Post space preparation was done and posts were luted with respective dual cure resin cement. For fracture resistance test core build up was done with direct composite with light cured. Fracture resistance tests were performed using universal testing machine at a cross head speed of 1.5 mm/min. Failure modes were also evaluated.

Results: The mean fracture resistance of Group 4 was highest followed by Group 6, Group 2, Group 5, Group 7, Group 3 and Group1, the least (Group 1 < Group 3 < Group7 < Group 5 < Group 2 < Group 6 < Group 4). The fracture resistance of Group 4 was highest and significantly ($P < 0.001$) higher than all groups, thus considered as the best fibre post among studied post system.

Conclusion: The highest fracture resistance was observed with glass fibre post (Ever stick post) luted with dual core resin cement.

Keywords: Carbon fibre post, glass fibre post, zirconia fibre post, luting cement, fracture resistance.

Introduction

The restoration of endodontically treated teeth is challenging as these teeth lose a significant part of the tooth structure due to trauma, caries, and access cavity preparation.[1] Restoration of which is accomplished by using post and core to prevent further destruction and enhance the retention of the crown.[2] The choice of restoring endodontically treated teeth is guided by esthetics and strength.[3] The choice of the post is dependent on external configuration, morphology of root surface diameter (Root length, tooth anatomy, root width, canal configuration, amount of coronal tooth structure), geometrical configuration of dowel (post length, post diameter, post design, post position in the dental arch), luting material and method used to fabricate these systems.[4] Traditional cast post and core technique is hectic owing to the time consumption, temporization, laboratory and material costs. Therefore, prefabricated posts were introduced which were either metallic or nonmetallic, stiff or flexible.[3] As a result of which, aesthetic posts gained popularity. Fibre reinforced composite (FRC) posts are widely used due to their superior mechanical properties and are claimed to prevent vertical tooth fractures under chewing loads. Glass fibre and zirconia ceramics increase the transmission of light within gingival tissue and underlying root, enhancing the esthetics and distributing the stress over a broad surface area, increasing the load threshold at which the dowels begin to show evidence of microfractures.[5] The quality of cement plays an important role for post retention. There are many luting agents such as zinc phosphate, polycarboxylate, Glass ionomer cement, Resin modified glass ionomer cement & resin cement.[6] Glass ionomer cement adhere to tooth structure by chemical bonding. Resin cement are essentially insoluble in oral fluids and possess high compressive strengths recommended to cement fibre and zirconia ceramic posts with their effective bonding, flexibility and cushioning effect they contribute to uniform stress distribution between the post and the dentinal wall. Hence the purpose of this study was to evaluate the fracture resistance of prefabricated carbon fibre post, glass fibre post & zirconia fibre posts cemented with various luting agents such as resin cement & glass ionomer cement under in vitro conditions.

Materials & methods

A total of 70 single rooted permanent maxillary incisors were extracted from the Department of Oral & Maxillofacial Surgery, Babu Banarasi Das College of Dental Science, Lucknow & sterilized in an autoclave at 121 C, 15 psi, for 15 minutes. After disinfection the samples were stored in normal saline solution at room temperature.

Teeth were sectioned at the cemento–enamel junction with diamond disc under coolant, such that the remaining standard root length of all tested teeth was

16±1 mm. Root canal treatment was carried out on all specimens and obturation was done by lateral condensation technique using 6%, No. 25 gutta percha (Dentsply Sirona, Ballaigues, Switzerland) as master cone. The samples were divided into 7 experimental groups with 10 samples in each experimental group on the basis of prefabricated post system and luting cements used for post endodontic restoration (Table 1).

Group 1: Control group in which root canal treated teeth with no post.

Group 2: Carbon fibre with post resin cement.

Group 3: Carbon fibre post with Glass ionomer cement (GIC).

Group 4: Glass fibre post with resin cement.

Group 5: Glass fibre post with GIC

Group 6: Zirconia fibre post with resin cement.

Group 7: Zirconia fibre post with GIC.

Root canals were prepared with number 3 Gates Glidden drills until the depth of 11mm, keeping 4 to 5mm as an apical seal. The post space preparations were standardized through flaring with peso reamer up to #4 Prior to cementation, post space was rinsed with 5 ml of normal saline for 30 seconds & dried with paper points.

In test group 2, 3 Carbon fibre post of 1.0 mm diameter was used.

In test group 4, 5 Glass fibre post of 0.9 mm diameter was used.

In test group 6, 7 Zirconia fibre post of 1.0 mm diameter was used.

Posts of Group 2, 4, 6 were luted with dual cure resin cement, the post space was etched with 37% phosphoric acid (Ivoclar Vivadent, USA) for 15 seconds & rinsed with distilled water for 15 seconds & dried with paper points. Bonding agent was applied with micro brush & cured for 20 seconds. The resin cement (Fluor core, DMG, America) was applied with lentulospiral in the root canal space, then posts were luted with dual cure resin cement & placed into the canal following that excess material is removed carefully. Cements were light cured for 40 seconds & waited for the polymerization (Figure 1 and Figure 2).

Posts of group 3, 5, 7 were luted with GIC. The powder and liquid of glass ionomer cement was dispensed on a cooled glass slab and mixed quickly (30 seconds) with the help of plastic spatula, first increment of cement was incorporated rapidly to produce a homogenous milky consistency by folding motion. Consistency of cement was string up to 3-4 cm from slab. Post was luted with GIC and the cement was applied with lentulospiral in the canal. Post was placed & maintained the finger pressure. The excess cement was carefully removed (Figure 1 and Figure 2).

Evaluation of Fracture Resistance

In all the samples for fracture resistance, test core build up was done with direct composite and light cured. Root surface of all the specimens were dipped into the molten wax to a depth 2 mm below the CEJ to produce a 0.2-0.3mm layer to simulate the thickness of the periodontal ligament. Teeth were mounted in acrylic resin blocks. Each tooth was removed from the resin block when the first sign of polymerization was observed. Once the resin block was polymerized, the wax spacer was removed from the root surface, self-cure acrylic resin in the custom fabricated metal mould of resin blocks were dewaxed by immersing them in hot water. The light body impression material (aquasil LV, Dentsply) was mixed and coated over the roots and the teeth were reinserted in the resin blocks, and the impression material was allowed to set and trimmed to provide a flat surface, such that 2mm of the root protrudes out of the block, then excess material was removed. Each specimen with the acrylic block was mounted on a universal testing machine. Middle point of palatal side of the incisal edge was 135° to the long axis (Figure 3).

Statistical analysis

Data was presented in form of mean ± standard deviation. Groups were compared by one factor analysis of variance (ANOVA) and the significance of mean difference between (inter) the groups were done by Turkey's HSD (honestly significant difference) post hoc test after ascertaining normality by Shapiro-Wilk's test and homogeneity of variance between groups by Levene's test. Discrete (categorical) data were summarized in number (n) and percentage (%) and groups were compared by chi-square ($\chi 2$) test. A two-tailed (α=2) $P < 0.05$ was considered statistically significant. Analyses were performed on SPSS software (Windows version 22.0).

Results & discussion

The mean fracture resistance of Group 4 was the highest followed by Group 6, Group 2, Group 5, Group 7, Group 3 and Group 1, the least (Group 1 < Group 3 < Group 7 < Group 5 < Group 2 < Group 6 < Group 4).

Comparing the mean fracture resistance of 7 different groups, ANOVA showed significantly different fracture resistance among the groups ($F=58.86$, $P < 0.001$) (Table 2).

Further, comparing the difference in mean fracture resistance between the groups (i.e., pair wise comparison), Tukey test showed significantly ($P < 0.05$ or $P < 0.01$ or $P < 0.001$) different and higher fracture resistance of Group 2, Group 3, Group 4, Group 5, Group 6 and Group 7 as compared to Group 1 (Figure 4).

Controversy exists regarding the restorative techniques of endodontically treated teeth especially in severely damaged teeth. Dental clinicians have always been in search of restorative techniques with higher durability and survival rate, lower cost, and fewer procedural steps for such teeth. The evaluation of whether a post is needed depends on how much natural tooth substance remains to retain a core build up and support the final restoration after caries removal and endodontic treatment are completed. [6] The retention of post also varies, depending on the type of luting cements. The luting agents currently available for dental restoration are zinc phosphate, polycarboxylate, glass ionomer, resin modified glass ionomer, and adhesive resin cements. [3]

Li XJ et al demonstrated that resin cements are essentially insoluble in oral fluids and possess high compressive strengths and are generally recommended to cement fibre and zirconia ceramic posts. Composite resin cement systems with their effective bonding, flexibility and cushioning effect of the cement layer contribute to uniform stress distribution between the post and the dentinal wall. In addition, Narmin Mohammad et al explained that no significant difference was present in fracture resistance between glass ionomer and resin cements used for post cementation.[7] Due to lack of substantial conclusive literature on the strength and success of these materials, the present in vitro study was designed.

In this investigation, comparative evaluation of fracture resistance of three different post system was done with two different luting agents. The highest fracture resistance was observed in relation to group 4, in which glass fibre posts and resin cement system were used for restoration. The mean value of fracture resistance of group 4 was 280.46 N. This could be due to the multiphase polymer matrix of these types of posts consisting of both linear and cross-linked polymer phases (semi-interpenetration polymer network, semi-IPN). The monomers of the adhesive resins and cements can diffuse into the linear polymer phase, swell it, and by polymerization, form interdiffusion bonding resulting in monoblock effect. This will result in reduced stress formation at post/dentin and post/cement interfaces.

The above results are consistent with Omar Ahmed et al [8] who also observed that combination of Ever stick post and resin cement have higher fracture strength in their study. However, research done by Abdul-Jabbar T et al [4] demonstrated that glass fibre posts and resin cement combination have lower fracture resistance. According to them this may be attributed to the modulus of rigidity of post material. Higher modulus of rigidity results in less bending of the post/core unit under load, consequently less stress is exerted on the tooth.

In present examination, mean value of fracture resistance of zirconia post with resin cement (Group 6), was 228.21 N. This could be due to high modulus of elasticity of zirconia post, which causes less force concentration of post and core and areas where the dentin wall is thin, which may decrease the incidence of fracture. Ipek Sahin et al [9] concluded in their study that combination of zirconia post and resin cement have higher fracture strength, which correlates to findings of the present study. Results of this study are not supported by Sareh Habib Zadeh et al, [10] who demonstrated that zirconia post with resin cement have lower fracture resistance and concluded that the rigidity and high elastic moduli of titanium and zirconia caused direct transfer of forces to the tooth without any decrease or absorption by the post and core system and were considered to be the main cause of their fractures. This study showed mean difference of fracture resistance between the group 4 (glass fibre post with resin cement) and group 6 (Zirconia fibre post with resin cement) was 52.25 N which could be due to diffusion of monomers of the adhesive resins and cements into the linear polymer phase that swell it and by polymerization form interdiffusion bonding between glass fibre and resin cement. This will result in reduced stress formation at post/dentin and post/cement interfaces.

Above results are similar to investigation conducted by Neena Chandran et al [2] who stated that zirconia fibre post with resin cement have lower fracture resistance than glass fibre post with resin cement. However, this result is not agreed with the in vitro study conducted by Abdul-Jabbar T et al, [4] they stated that fracture resistance of zirconium posts was higher than glass fiber posts with resin cement. This could be explained on the basis of modulus of elasticity of post material, as zirconia posts had the highest modulus of elasticity among the post types tested. Higher modulus of elasticity results in less bending of the post/core unit under load consequently, less stress is exerted on the tooth therefore low chances of fracture. Mean value of fracture resistance of carbon fibre post with resin cement in this study (Group 2) was 228.21 N, which is considered as satisfactory result. This could be explained as posts cemented with dentine bonding resin cements suggest less microleakage.[11] This works the mechanical stability of the post cement interface and mechanical stresses distribution in the cement layer, leads to higher fracture resistance. These findings are supported by R DeSantis et al, [12] they demonstrated higher fracture resistance of carbon fiber post with resin cement. However, this study results were not supported by G Bateman et al [13] they observed that fracture resistance was lower of carbon fiber post with resin cement than other tested post systems. This could be explained as Carbon fiber posts are stiff and possess approximately 10-fold higher modulus elasticity than dentin. [14] In the current research, groups with the resin luting system showed considerably higher mean fracture loads than those with glass ionomer cement. The results indicate that resin luting systems provided additional fracture resistance to post. According to Cohen BI et al [15] cementation of a post with a dentin-bonding system could theoretically provide internal bracing of the root and preserve the critical interface between dentin and post. In addition, to providing flexibility and cushioning effect of the cement layer, resin cements might contribute to uniform stress distribution between the post and the dentinal walls, and absorb micro movements of an artificial crown resulting from occlusal forces more effectively than conventional brittle cement.

In our investigation, fracture resistance of glass fibre post luted with glass ionomer cement (Group 5) was 180.19 N. This could be due to the adherence glass ionomer cements to dentin through chemical and micromechanical retention. They have two distinct reactions, the first occurring when they consume all of the water present in their chemical composition and the second only when water is available from other sources, for instance, from the dentin tubules.[16] The setting reaction causes an initial contraction, but an increase in volume as a result of hygroscopic expansion takes place after material maturation.[17] For that reason, an improved interaction between cement and dentin is expected, which may lead to increased fracture resistance to displacement of the post.[18]

Carlos Torres et al [19] observed fracture resistance of glass fibre post with glass ionomer cement to be appropriate in their investigation, which is in accordance to present study. However, these results are contrary to the findings of Diana Ferreira et al [20] who concluded that glass fibre post luted with glass ionomer cement has lower fracture resistance. The variation in this paper can be explained on the basis of high viscosity of GIC due to which it might have not proper distribution up to the apical region. It is necessary to consider that this result might have been influenced by the design of the tested post as well. In this report, fracture resistance of zirconia fibre post with glass ionomer cement (Group 7) was 135.82 N. This could be explained as cement used to lute such posts would rely on micromechanical retention provided by sandblasting the posts. As Omar Bawazir et al has demonstrated that sandblasting procedure slightly increase bond strength of GIC with metal, this possible increased bond strength might be the reason for appropriate fracture strength observed in this group. Above results are in agreement with the findings of Shi Vaughn March an et al [21] who also reported appropriate fracture resistance of zirconia fibre post with glass ionomer cement. Fracture resistance of carbon fibre post luted with glass ionomer cement (Group 3) in the present study was 128.60 N. This could be due to lower filler content and because of low luting thickness in bonding applications hydrated substances more efficiently facilitate ionization of the acidic monomers followed by acid-base neutralization reactions involving the tooth and the base filler. Therefore, it may lead to an appropriate bonding between carbon fibre post and glass ionomer cement which may cause low fracture resistance.

In the literature,[22] maximum incisal forces of anterior teeth varied, but the amount was almost always below 200 N which is much lower than the failure loads of fibre post found in this study. The results obtained in this vitro investigation, may not accurately reflect the in vivo situation. Therefore, further research is suggested, using dynamic loading combined with thermocycling as well as further long-term follow-up in vivo survival studies of teeth restored with fiber-reinforced posts.

Conclusion

Our study concluded that highest fracture resistance was observed with glass fibre post luted with resin cement system and lowest fracture resistance was observed with carbon fibre post with glass ionomer cement. The endodontically treated teeth without post system showed the least fracture resistance demonstrating the need to reinforce the tooth. Finally, within the limitations of this in vitro study, it can be stated that glass fibre posts with resin cement can be recommended as a better alternative to the zirconia fibre post and carbon fibre posts in the maxillary anterior teeth region. Glass fibre post can be recommended as an esthetic and force resistant restoration in endodontically treated anterior teeth.

References

1. Aggarwal, R. et al. Comparative evaluation of fracture resistance of various post systems using different luting agents under tangential loading. J. Oral Biol. Craniofacial Res. 3, pp 63–67 (2013).
2. Neena C., Noushad M C, Biji B. Comparative evaluation of fracture resistance of endodontically treated teeth restored with three different post and core systems and two different luting agents – an invitro study. Int J. Of Rec Sci Rec. Vol. 8, Issue 5, Pp. 17087-17091, May, 2017
3. Mannocci, F. & Cowie, J. Restoration of endodontically treated teeth. Br. Dent. J. 216, pp 341–346 (2014).
4. Abdul-Jabbar, T. et al. Fracture resistance of three post and core systems in endodontically treated teeth restored with all-ceramic crowns. King Saud Univ. J. Dent. Sci. 3, pp 33–38 (2012).
5. Freedman, G. The carbon fibre post: metal-free, post-endodontic rehabilitation. Oral Health 86, pp 23–26, 29–30 (1996).
6. Colley IT, Hampson EL, and Lehman ML.; Retention of post crowns: Br. Dent. J. 1968; pp 63:124.
7. Mohammadi, N., Ajami, A. A., Kimyai, S. & Aval, M. R. Effect of different luting cements on fracture resistance in endodontically treated teeth. Iran. Endod. J. Issue 3, pp 97 (2008).
8. El-Ela, O. A. A., Atta, O. A. & El-Mowafy, O. Fracture resistance of anterior teeth restored with a novel nonmetallic post. J. Can. Dent. Assoc. pp 74, (2008).
9. Sahin, I., Kara Yilmaz, H., Çiftçi, Z. Z. & Kirzioglu, Z. Fracture resistance of prefabricated primary zirconium crowns cemented with different luting cements. Pediatr. Dent. Issue 40, pp 443–448 (2018).
10. Habib Zadeh, S., Rajati, H. R., Hajmiragha, H., Esmail Zadeh, S. & Kharazifard, M. Fracture resistances of zirconia, cast Ni-Cr, and fiber-glass composite posts under all-ceramic crowns in endodontically treated premolars. J. Adv. Prosthodont. Issue 9, pp 170–175 (2017).
11. Bachicha, W. S., DiFiore, P. M., Miller, D. A., Lautenschlager, E. P. & Pashley, D. H. Microleakage of endodontically treated teeth restored with posts. J. Endod. Issue 24, pp 703–708 (1998).
12. Santi's, R. D. et al. Carbon fiber post adhesion to resin luting cement in the restoration of endodontically treated teeth. J. Mater. Sci. Mater. Med. Issue 11, pp 201–206 (2000).
13. Bateman, G., Ricketts, D. N. J. & Saunders, W. P. Fibre-based post systems: a review. Br. Dent. J. Issue 195, pp 43–48 (2003).
14. Dean, J. P., Jeansonne, B. G. & Sarkar, N. In vitro evaluation of a carbon fiber post. J. Endod. Issue 24, pp 807–810 (1998).
15. Cohen, B. I., Pagnillo, M. K., Newman, I., Musi Kant, B. L. & Deutsch, A. S. Retention of three endodontic posts cemented with five dental cements. J. Prosthet. Dent. Issue 79, pp 520–525 (1998).

16. Yiu, C. K. Y. et al. Interaction of glass-ionomer cements with moist dentin. J. Dent. Res. Issue 83, pp 283–289 (2004).

17. Cury, Á. H. et al. Effect of hygroscopic expansion on the push-out resistance of glass ionomer-based cements used for the luting of glass fiber posts. J. Endod. Issue 32, pp 537–540 (2006).

18. Pereira, J. R. et al. Push-out bond strengths of different dental cements used to cement glass fiber posts. J. Prosthet. Dent. Issue 110, pp 134–140 (2013).

19. Torres-Sánchez, C. et al. Fracture resistance of endodontically treated teeth restored with glass fiber reinforced posts and cast gold post and cores cemented with three cements. J. Prosthet. Dent. Issue 110, pp 127–133 (2013).

20. de Araújo, D. F. G. et al. Influence of 2% chlorhexidine digluconate on bond strength of a glass-fibre post luted with resin or glass-ionomer based cement. J. Dent. Issue 42, pp 735–741 (2014).

21. March an, S., Coldero, L., Whiting, R. & Barclay, S. In vitro evaluation of the retention of zirconia-based ceramic posts luted with glass ionomer and resin cements. Braz. Dent. J. Issue 16, pp 213–217 (2005).

22. Hock D. Impact resistance of posts and cores. [Master's Thesis] Ann Arbor: University of Michigan, School of Dentistry; 1976.

Legend Figures

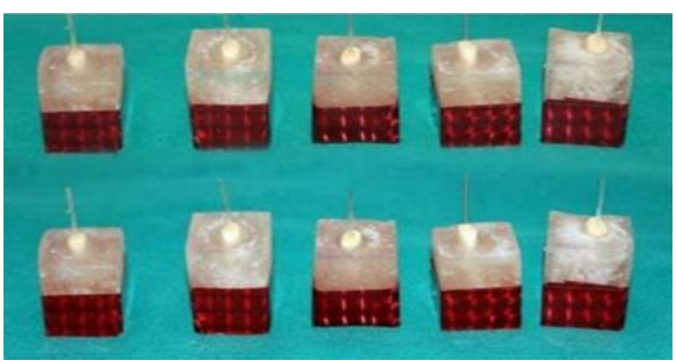

Fig 1: Sample Preparation with Carbon fibre post

Fig 2: Sample Preparation with Glass fibre post

Fig 3: Fracture resistance test using universal testing machine

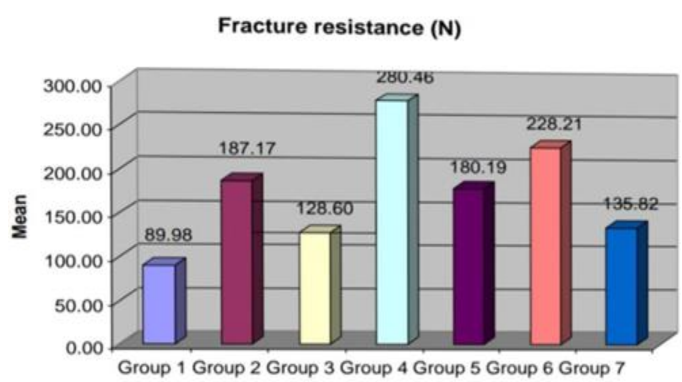

Figure 4: Fracture resistance testing for all the tested groups

Table 1: Group allocation and distribution of samples in different groups

Treatments (Luting agents)	Group name	Total sample (n=70) (%)
Control group or root canal treated teeth	Group 1	10 (14.3)
Carbon fibre with resin cement	Group 2	10 (14.3)
Carbon fibre with GIC cement	Group 3	10 (14.3)
Glass fibre post with resin cement	Group 4	10 (14.3)
Glass fibre post with GIC cement	Group 5	10 (14.3)
Zirconia fibre post with resin cement	Group 6	10 (14.3)
Zirconia fibre post with GIC cement	Group 7	10 (14.3)

Table 2: Fracture resistance (N) of 7 different groups

Group	Fracture resistance (N) (Mean ± SE) (n=10)	F value	P Value
Group 1	89.98 ± 5.38	45.97	< 0.001
Group 2	187.17 ± 10.96		
Group 3	128.60 ± 9.99		
Group 4	280.46 ± 7.29		
Group 5	180.19 ± 6.76		
Group 6	228.21 ± 7.79		
Group 7	135.82 ± 9.38		