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A Comparative Evaluation of Fracture Resistance of Root Canal Treated Maxillary Anterior Teeth Restored with Four Different Post System-An in Vitro Study

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Abstract

Aim: The purpose of this study to compare the fracture resistance of four different post system in endodontically treated teeth.

Materials and method: Eighty extracted intact single rooted teeth are used, treated endodontically, and distributed into the following four groups: Group1 (n=20) Prefabricated glass fiber, Group2 (n=20) Prefabricated carbon fiber post, Group3 (n=20) Prefabricated gold- plated metal post, Group4 (n=20) Custom made cast post. All specimens are quasi-statically tested with a universal testing machine until the fracture occur until the fracture occur. The cross-head speed is 1mm/min at an angle of 135 degrees to the long axis of the tooth at the center of palatal fossa. Failure of loading will be recorded when a sudden deep was observed in the force versus time graph. The failure mode is determined by visual inspection. Two typical root fracture mode is determined follow:

1. Specimen presenting the cervical third fracture is classified as favorable mode.
2. Specimen presenting middle and apical fracture is classified as an unfavorable or catastrophic mode.

Result: on comparison of maximum load Mean value observed for Ni-Cr Cast is 143.45 with standard deviation of 27.70, mean value observed for Glass Fiber is 224.38 with standard deviation of 29.27, mean value for carbonfiberis160.24 with standard deviation of 30.78 and mean value for Gold Plated metal was160.18with standard deviation of 12.13. on comparison of maximum stress Mean value observed for Ni-Cr Cast is 11.34 with standard deviation of 1.79, mean value observed for Glass Fiber is 5.30 with standard deviation of 1.80, mean value for carbon fiber is 8.48 with standard deviation of 2.13 and mean value for Gold Plated metal was 7.87 with standard deviation of 2.37. on comparison of maximum strain Mean value observed for Ni-Cr Cast is 0.07 with standard deviation of 0.06, mean value observed for Glass Fiber is 0.21 with standard deviation of 0.09, mean value for carbon fiber is 0.11 with standard deviation of 0.05 and mean value for Gold Plated metal was 0.15 with standard deviation of 0.20.

Conclusion: Within the limitations of this study it can be concluded that Endodontically treated teeth restored with glass fiber and prefabricated metal post are more resistant to fracture load than those restored with carbon fiber posts or cast posts and core. Because of their rigidity, restoring endodontically treated teeth with carbon fiber posts or cast posts and core can lead to tooth fracture. Presence of fiber posts changes the failure mode, and the fracture pattern was mainly favorable. The fiber posts followed by prefabricated gold-plated metal post are readily retrievable after failure, whereas the remaining post systems tested are no retrievable.

Keywords: Endodontically Treated Teeth, Fracture Resistance, Four Different Post Systems, Universal Testing Machine.

Introduction

Extraction was the suggested treatment of choice for most teeth that were grossly carious in earlier days, but today the focus of dental therapy has shifted to a more conservative approach. The massive success of endodontic therapy has allowed for the restoration of such teeth and teeth has also reinstated it as a long-term functional unit inside the oral cavity[1]. The loss of coronal tooth structure due to caries and trauma. If the loss is large in amount, the natural tooth structure cannot support a restoration and a post is necessary to retain an artificial core that will restore the lost structure[2]. Primary motive of a post is to retain the coronal restoration in an endodontically treated tooth that has suffered an extensive loss of crown structure[3]. Special techniques are usually necessary to restore root canal treated teeth as their tooth structure is considerably lost. The selection of specific materials and technique for the restoration of endodontically treated teeth is categorized by the changes that accompany root canal therapy such as1

a) The amount of remaining tooth structure
b) Physical changes in tooth structure
c) The anatomic position of the tooth
d) The occlusal forces on the tooth
e) The restorative requirements of the tooth and
f) The esthetic requirements of the tooth.

Endodontically treated teeth are at higher risk of fracture due to the decreased moisture content in dentin and most of times, compromised structural integrity of teeth poses higher risk of fracture than vital teeth.

For functional and esthetic concerns, complete coverage crown restoration along with post and core is often recommended to enhance retention of crowns4. Restoration of endodontically treated teeth is necessary for preserving the remaining tooth structure, function and restoring aesthetic. Due to structural defect caused by caries, trauma or previous restoration, many ETT need reconstruction by post and core to become reasonably functional. The main reason for the use of a post in these teeth is to create a mechanical retention for the core; however, this can lead to an increased risk of tooth fracture[5].

During endodontic and restorative procedures, the most important changes in tooth biomechanics is attributed to the loss of tissue either at radicular or coronal levels, which points out the importance of a highly conservative approach6. The significance of remaining cervical tissue, it is now known as the ferrule effect is considered the most important feature for the fracture resistance of endodontically treated teeth[7]. Now according to the studies, it is well known that the use of posts to restore endodontically treated teeth does not increase the strength of the remaining tooth. Posts only provide retention to the restoration[8]. It is now known, that dentin like rigidity reduces stress concentration at the dentin-post interface so that forces are more evenly transferred to the root and incidence of root fracture decreases[9]. The unification of adhesive techniques into post and core procedures has altered post designs and has resulted in the use of new materials. Thus, there should have ability to obtain a bonded tooth -post- core -crown "Monoblock" type of restoration, instead of a collection of heterogenous materials.[10]

However, steer clear of unnecessary post would eliminate related treatment risks, such as perforation of the root and further weakening of the tooth through additional substance loss when the root canal space is prepared for a post. Post should only be used when there is prognosis of teeth is good or fair[11]. In molars, the use of the post retained core is often unnecessary due to sufficient dentin thickness and axial loading condition.

Because single rooted teeth are loaded non axially, more stress develops when masticatory forces are exerted[12]. Studies have focused on strengthen the remaining tooth structure after root canal treatment. However, although adhesive dental materials, coronal coverage, or post placement have been suggested for coronal reinforcement, properly restored teeth may fracture, because of weakened root canal treated roots. Therefore, one of the goals of filling the root canal with either sealer/gutta percha or both sealer/gutta percha and cement/post is to fortify the endodontically treated root to increase fracture resistance[13]. When remaining coronal tooth structure is less than 5 mm in height, it may be increased either surgically through a crown lengthening procedure or orthodontically through forced extrusion of the tooth. Both procedures result in satisfactory and predictable increase in coronal tooth structure but may be contraindicated in situations in which the crown to root ratio is compromised or where further exposure of tooth structure will have adverse esthetic results.

As coronal tooth structure is increased by crown lengthening, the corresponding osseous supported tooth structure is decreased. This change in the crown to root ratio may hinder the tooth less resistant to lateral forces. A 1:1 crown to root ratio has been advocated as the minimum ratio necessary for resisting lateral forces that may occur during function[14].

The post placement must be based on such as anatomic position of tooth, amount of the remaining tooth structure, esthetic requirement of the tooth, functional load on the tooth. Endodontic post can be of metallic and non-metallic, preformed and custom made, stiff and flexible and esthetic and non-esthetic[15]. The design of resin posts reinforced with glass fiber post are retained on the dentinal wall by means of adhesion with cement. Accurate adaptation of post to the wall is very important. The shape of FRC can be conical, cylindrical, or combined. The conical post has sufficient retention, with the preservation of dentin in the coronal area of the canal. The cylindrical post is very good for retention and evenly distribute the stress up to the entire length of the canal16. Fiber posts are made up of resin material and filler component consisting of glass fiber, which have same modulus of elasticity as dentin and distribute the load forces evenly along the root[17].

Glass fiber reinforced post systems are composed of unidirectional glass fiber in the resin matrix that strengthened the structure of the post. To obtain optimal esthetic, translucent quartz fiber post systems are recently introduced as alternative. To compare the fracture resistance of endodontically treated teeth restored with different post systems such as zirconia, titanium and fiber -reinforced post which concluded that the fracture strength of zirconia post is superior to titanium post and both are superior to fiber reinforced post[18]. The carbon fiber post is made up of an organo-mineral composite with optimal mechanical properties. The weight of carbon fiber represents 64%.the matrix which is epoxy resin 36% that embeds the carbon fibers.it is claimed that the compatibility between the carbon fibers and the epoxy resin resulted the cohesion of the material[19]. A carbon fiber post has some crucial properties that make it potentially useful such as corrosion-resistant, biocompatible and strong. Carbon fiber post is reported that it has same modulus of elasticity as dentin that's why it resulting in fewer root fracture[20].

Cast posts and cores most commonly used for teeth with little remaining coronal structure[21]. They are versatile and allow best filling in the root canal treated teeth. They show good adaptability to the configuration and angulation of root canal walls. And it has ideal connection to the core with no possibility of separation. This is cast post and core is made up of Ni-Cr alloy.it also have some disadvantages such as inferior esthetics, as they don't allow the light transmission.it might be corrode and cause gingival and tooth discoloration. Some kind of difficulty might be occur in fabrication, fitting and retrieval[22].

The aim of this study is a comparative evaluation of fracture resistance of four different post system in endodontically treated maxillary anterior teeth.

Materials and methodology:

Eighty extracted intact single rooted teeth are used, treated endodontically, and distributed into the following four groups

Group 1 (n=20) Prefabricated glass fiber post

Group 2 (n=20) Prefabricated carbon fiber post

Group 3 (n=20) Prefabricated gold-plated metal post

Group 4 (n=20) Customer made cast post

Sample preparation

Eighty recently extracted caries free single rooted maxillary anterior teeth will be selected and stored in 0.1 % thymol solution at 25 degrees Celsius until use. The teeth will be cleaned with a hand scaler and stored at room temperature during the study. Root canals (1mm shortened to root apices) will be cleaned and shaped using the step back technique to apical size 45 and then obturate with gutta percha points and eugenol free epoxy amine resin sealer using lateral condensation technique. The teeth will be stored in distilled water at room temperature for 4 days sign of polymerization.

To create the PDL situation, the roots will be immersed in melted wax at a depth of 2mm below cemento-enamel junction and then embed in acrylic resin blocks. Afterward teeth roots will be embedded in auto polymerizing resin up to 2 mm apex of CEJ and orient with their long axes perpendicular to the horizon using a customer made parallelometer. Each root will be removed from the resin block upon appearance of primary The wax spacer will be replaced by a silicon based impression material, which will be injected into the acrylic resin. Then, the tooth will be reinserted into the resin blocks and the excess impression material will be removed using a surgical blade.

Root canal filling material (gutta percha and sealer) will be removed using (except for control group) using no. 1,2,3 and 4 Gates Glidden burs. Post spaces will be prepared using a low speed corresponding drill provided by the post manufacturer to achieve a post space length of 10 mm in all groups. All posts will be air borne particle abraded with 50 micrometer alumina particles for 5 secs at 0.25 MPa and ultrasonically cleaned in 96% isopropanol for 3 min. The post spaces will be then rinsed with 5% sodium hypochlorite solution, irrigate with 70% ethanol and dried with absorbent paper points. The walls of post etch with 37% phosphoric acid for 15 rinse with water spray and air dried. The posts will be coated with freshly mixed self-adhesive resin cement that were applied using disposable micro-brushes. Each post will be seated with finger pressure for 10 seconds. Excess resin cements will spread to cover the occlusal part of the post. Light-polymerizing composite resin cores will be fabricated according to the manufacturer's instructions. All procedures will be performed by the same operator.

Loading of specimen

All specimens are quasi-statically tested with a universal testing machine until the fracture occur until the fracture occur. The cross-head speed is 1mm/min at an angle of 135 degrees to the long axis of the tooth at the center of palatal fossa. Failure of loading will be recorded when a sudden deep was observed in the force versus time graph.

The failure mode is determined by visual inspection. Two typical root fracture mode is determined follow

1.Specimen presenting the cervical third fracture is classified as favourable mode.

2.Specimen presenting middle and apical fracture is classified as an unfavourable or catastrophic mode.

Results

Fracture load data were analyzed using SPSS software (SPSS version 18.0 for window). Data were explored for normality using the Anderson -darling test, which showed normally distributed data. across all four groups, fracture load was analyzed using one- way ANOVA followed by multiple comparisons with tukey's honest significance test (a=0.05). failure modes were recorded and statistically analyzed with chi square test among groups for determining the correlation between post systems and failure mode (favourable or restorable/unfavorable or non-restorable)

One Way Analysis of Variance (ANOVA) Test was carried out for comparison among four groups. P-Value less than 0.05 shows that, there is significant difference observed among four groups.

Mean value observed for Ni-Cr Cast is 143.45 with standard deviation of 27.70, mean value observed for Glass Fiber is 224.38 with standard deviation of 29.27, mean value for carbon fiber is 160.24 with standard deviation of 30.78 and mean value f or Gold Plated metal was160.18 with standard deviation of 12.13.

One Way Analysis of Variance (ANOVA) Test was carried out for comparison among four groups. P-Value less than 0.05 shows that, there is significant difference observed among four groups.

Mean value observed for Ni-Cr Cast is 11.34 with standard deviation of 1.79, mean value observed for Glass Fiber is 5.30 with standard deviation of 1.80, mean value for carbon fiber is 8.48 with standard deviation of 2.13 and mean value for Gold Plated metal was 7.87 with standard deviation of 2.37.

One Way Analysis of Variance (ANOVA) Test was carried out for comparison among four groups. P-Value less than 0.05 shows that, there is significant difference observed among four groups.

Mean value observed for Ni-Cr Cast is 0.12 with standard deviation of 0.10, mean value observed for Glass Fiber is 0.17 with standard deviation of 0.07, mean value for carbon fiber is 0.13 with standard deviation of 0.07 and mean value for Gold Plated metal was 0.11 with standard deviation of 0.08.

One Way Analysis of Variance (ANOVA) Test was carried out for comparison among four groups. P-Value less than 0.05 shows that, there is significant difference observed among four groups.

Mean value observed for Ni-Cr Cast is 293.08 with standard deviation of 62.18, mean value observed for Glass Fiber is 282.80 with standard deviation of 39.01, mean value for carbon fiber is 232.46 with standard deviation of 64.15 and mean value for Gold Plated metal was 316.52 with standard deviation of 76.02.

One Way Analysis of Variance (ANOVA) Test was carried out for comparison among four groups. P-Value less than 0.05 shows that, there is significant difference observed among four groups.

Mean value observed for Ni-Cr Cast is 13.59 with standard deviation of 3.50, mean value observed for Glass Fiber is 8.00 with standard deviation of 2.34, mean value for carbon fiber is 11.84 with standard deviation of 3.38 and mean value for Gold Plated metal was 16.39 with standard deviation of 3.91.

One Way Analysis of Variance (ANOVA) Test was carried out for comparison among four groups. P-Value less than 0.05 shows that, there is significant difference observed among four groups.

Mean value observed for Ni-Cr Cast is 0.07 with standard deviation of 0.06, mean value observed for Glass Fiber is 0.21 with standard deviation of 0.09, mean value for carbon fiber is 0.11 with standard deviation of 0.05 and mean value for Gold Plated metal was 0.15 with standard deviation of 0.20.

Chi-Square test is carried out to test correlation between failure mode and post systems. P- Value observed is less than 0.05. Shows significant correlation between failure mode and post system.

Discussion

This study evaluated the influence of different post systems on fracture resistance of root canal treated maxillary anterior teeth. Natural teeth were used for the preparation of the specimens. The dimensions of the experimental teeth were evaluated statistically in order to eliminate the possible variation in size. All roots were received endodontic treatment and care was taken to fabricate standard cores and metal crowns. To create the PDL situation, the roots were immersed in melted wax at a depth of 2mm below cemento-enamel junction and then embedded in acrylic resin blocks Afterward teeth roots were embedded in auto polymerizing resin up to 2 mm apex of CEJ and orient with their long axes perpendicular to the horizon using a custome made parallelometer.

Each root was removed from the resin block upon appearance of primary sign of polymerization. The wax spacer was replaced by a silicon-based impression material, which were injected into the acrylic resin. Then, the tooth was reinserted into the resin blocks and the excess impression material was removed using a surgical blade. Variations in the post length were eliminated by preparing all posts at the 10mm length prior to cementation. In this study, the posts in all the groups were cemented with self-adhesive resin cement following standard procedures. Studies have elucidated that the adhesion of self-adhesive resin cements to root dentin is comparable to that of conventional resin cements used with etch and rinse adhesive systems and is suitable for cementation of intra-radicular posts59.

Guzy and Nichollas reported that, for incisor teeth loading angle of 135 degrees was chosen to simulate a contact angle found in class 1 occlusion between maxillary and mandibular anterior teeth. In the present study, the cross-head speed was 1mm/min at an angle of 135 degrees to long axis of the tooth at the center of palatal fossa. However, submitting samples to cyclic loading and then establish their reaction to fatigue more accurately simulates intraoral conditions than increasing a single load until facture will occur[54].

In present study, Group 1 specimen (glass fiber post) exhibited the highest mean resistance to fracture with the most catastrophic fractures. Group 4, Ni-Cr cast post exhibited the lowest mean resistance to fracture followed by group 2 and group 3 which is prefabricated metal post and carbon fiber post (Table 1). One -way analysis of variance (ANOVA) test was carried out for comparison among four groups. P value less than 0.005 shows that there is significant difference observed among four groups. The different post systems significantly influenced the final fracture resistance ($p<0.05$). These results may explain how different post systems enhance the fracture resistance of ETT.

This finding is consistent with Jens T. Mangold and Matthias Kern and they reported that placement of glass fiber post had a significant influence on the fracture resistance when fewer than 2 cavity walls remained, but no significant influence when 2 or 3 walls were present11. This result also agreed with the findings of Giovani et al who conclude that the roots are restored with glass fiber post showed higher fracture resistance than cast post30. This finding is also consistent with Carlos Torres- Sanchez, Vanessa Montoya -Salazar et al-reported that the use of a glass fiber post and resin modified glass ionomer cement increased the fracture resistance of endodontically treated teeth[43]. Clarence J. Cormier et al concluded that fiber posts evaluated provided an advantage over a conventional post[10].

Conversely, these findings disagree with the result of Lili Zhou and Qing Wang in which they who concluded that cast post had higher fracture resistance than fiber post42. This finding is also disagreed with the result of Beck.et al, who reported significantly lower fracture load of glass fiber post than zirconia post[55]. Mavari Saritha et al concluded that zirconia had good fracture resistance compared with the carbon fiber post and glass fiber posts[40].

In Table 2, maximum stress is compared between four groups. Mean value observed for Ni-Cr cast post shows highest value (11.34) compared to other groups and lowest for glass fiber post (5.30). Stress measures the deforming force per unit area of the post which is lowest for the glass fiber post. This finding is agreed with that of Aggarwal et al and Madfa et al in which they reported that compared with other dental post glass fiber post generate least amount of stress concentration and best option for restoring badly decayed teeth (56,57). In Table 3, maximum strain is compared between four groups. Mean value observed for glass fiber post is highest which is 0.17 and lowest for gold plated prefabricated metal post (0.11). Strain measures the relative changes in length caused by deforming force.

With respect to glass fiber posts, the result indicated that the roots restored with longer posts (10 mm) had a greater resistance to fracture. Posts glass fiber post has modulus of elasticity similar to dentin. When submitted to a compressive load, it can better absorb the forces concentrated along the root, which may decrease the probability of fracture[30]. However, fracture test has certain limitation with regard to obtaining information on the internal behavior of the tooth -restoration complex before the failure. Therefore, it is important to combine destructive test with non-destructive methodologies, such as strain gauge measurement for root strain analysis and its relation to fracture resistance and failure mode[58].

In table 4, 5, 6, the maximum load, maximum stress and maximum strain in unfavorable mode were discussed. In table 4, the mean value of maximum load was observed for gold plated prefabricated metal post (316.52) is highest among the group. Mean value observed for carbon fiber post (232.46) is lowest among the groups. In table 5, comparison of maximum stress was observed. gold-plated prefabricated metal post was highest (16.39) and lowest for the glass fiber post (8.00). In table 6, comparison of maximum strain was measured in which I glass fiber post is highest 0.21 and cast post was lowest 0.07.

An important factor related to resistance is failure mode. All post systems have some percentage of clinical failure. However, some posts cause higher percentage of failures that result in teeth that are nonrestorable. For example, teeth restored with less rigid posts, such as fiber posts, tend to have failures that are more likely to be restorable (21,18,10,29). In the present study, Chi-square (X2) analysis indicated statistically significant differences in the failure modes among groups less than 0.05, which shows significant correlation between failure mode and post systems (Table7). Most specimens with glass fiber and prefabricated metal post showed followed by carbon fiber post and cast post showed favorable failure mode. The unfavorable or catastrophic failures were shown mostly with carbon fiber post and cast post.

Conclusion

Within the limitations of this study it can be concluded that

1.Endodontically treated teeth restored with glass fiber and prefabricated metal post are more resistant to fracture load than those restored with carbon fiber posts or cast posts and core.

2.Because of their rigidity, restoring endodontically treated teeth with carbon fiber posts or cast posts and core can lead to tooth fracture.

3.Presence of fiber posts changes the failure mode, and the fracture pattern was mainly favorable.

The fiber posts followed by prefabricated gold-plated metal post are readily retrievable after failure, whereas the remaining post systems tested are nonretrievable.

References

1. Himanshi karla, Urvashi sukhija, reena, Reena roy rassawat, Varsha rani. A review on post and core sch J Dent sci, March,2020;7(3):51-56
2. Georgios Maroulakos, William W. Nagy, Elias D. Kontogiorgos. Fracture resistance of compromised endodontically treated teeth restored with bonded post and cores: An in vitro study J Prosthet Dent 2015

3. C.Goracci, M Ferrari. Current perspectives on post systems: a literature review Australian dental journal 2011;56(1):77-83
4. Rajnish Aggarwal, Swati Gupta, Amrit Tandon, Narendra Kumar Gupta, Ravi Dwivwedi,Renu Aggarwal. Comparative evaluation of fracture resistance of various post systems using different luting agents under tangential loading. Journal of oral biology and craniofacial research 2013:63-67
5. R.Mosharraf, M. Sabouhi, M. Mahabadi, A. Behzadi, MR. Kalantar Motamedi.comparison of fracture resistanceof endodontically treated maxillary incisor restored with six different post and core systems 2017 ;29,4.
6. Didier dietschi, Olivier duc, ivo Krejci, avishai sadan biomechanical considerations of the restoration of endodontically treated teeth: A systematic review of the literature, Part II (evaluation of fatigue behavior, interface, and in vivo studies). Quintessence international 2008; 39:117-129.
7. Erico Braga Franco, Accacio Lins do Valle, Ana Lucia pompeia fraga de Almeida, Jose Henrique Rubo, Jefferson Ricardo Pereira.fracture resistance of endodontically treated teeth restored with glass fiber posts of different length.J prosthet dent 2014; 111: 30-34.
8. Paulo C.A Maccari, Ewerton N. Conceiicao, Mauro f. Nunes fracture resistance of endodontically treated teeth restored with three different prefabricated esthetic posts.J esthet restro dent 2003; 15: 25-31
9. Khetarpal ambica , Kavitha mahendran, sangeeta talwar, Mahesh verma, govindaswamy Padmini. Comparative evaluation of fracture resistance under static and fatigue loading of endodontically treated teeth restored with carbon fiber post, glass fiber post and an experimental dentin post system: an in vitro study. 2013; 39: 96-100.
10. Clarence J. Cormier, David R. Burns, Peter moon. In vitro comparison of the fracture resistance and failure mode of fiber, ceramic, and conventional post systems at various stages of restoration. J prosthodont 2001; 10:26-36.
11. Jens t. mangold, Matthias kern. Influence of glass fiber post on the fracture resistance and failure pattern on endodontically treated premolars with varying substance loss: an in vitro study. J prosthet dent 2011; 105:387-393.
12. Guido Heydecke, Med Dent, Mathilde c. Peters. The restoration of endodontically treated, single -rooted teeth with cast or direct post and cores: a systemic review. J.prosthet dent 2002; 87: 380-6.
13. Burak sagsen, Mustafa zortuk, Huseyin Ertas, Ozgur Er, Sezar Demirbuga,Hakun Arsalan. In vitro fracture resistance of endodontically treated roots filled with a bonded filling material or different types of posts.J Endod 2013;39:1435-1437.
14. Clarisse C.H. Ng, Herman B. Dumbrigue, Manal I.Al-Bayat, Jason a. Griggs,Wakefield Influence of remaining coronal tooth structure location on the fracture resistance of restored endodontically treated anterior teeth. J.prosthet dent 2006; 95: 290-6.
15. Chetana s. Makade, Ganesh Meshram, Manjusha Warhadpande Pravinkumar G.patil a comparative evaluation of fracture resistance of endodntically treated teeth restored with different post core systems – an in- vitro study. J adv prosthodont 2011; 3:90-5.
16. Mihaela chirila , Bogdan Dimitriu, Ruxandra loana Bartok, Oana Amza, Ana Maria Serban loana

suciu.fracture resistance of endodontically treated teeth restored with resin post reinforced with glass fiber. Journal of medicine and life 2021;14.

17. Abdulaziz samran, Mahmoud al-afandi, jad -alkareem kadour,Matthias kern.Effect of ferrule location on the fracture resistance of crowned mandibular premolars: an in vitro study.J prosthet dent 2015
18. Begum akkayan, med dent, turgut gulmez. Resistance of fracture endodontically treated teeth restored with different post systems. J prosthet dent 2002;87: 431-7.
19. Christophe G. Raygot, John Chai, Lee Jameson.fracture resistance and primary failure mode of endodontically treated teeth restored with a carbon fiber -reinforced resin post systems in vitro.2001;14:2
20. Dean JP, Jeansonne BG, Sarkar N.in vitro evaluation of a carbon fiber post.1998;24:12
21. Arturo Martinez insua, luis da silva, benito rilo,urbano santana. Comparison of the fracture resistance of pulpless teeth restored with acast poat and core or carbon fiber post with a composite core.j.prosthet dent 199;80:527-32.
22. Ahed al-wahadani, Sami Hamdan,Mahmoud Al-Omiri, Mohammad M. Hammad ,Muhanand m. Hatamleh. Fracture resistance of eeth restored with different post systems:in vitro study.oral surg oral med oral pathol oral radiol endod 2008;10:77-83.
23. Taha Özyürek, Can Topkara, İmran Koçak,Koray Yılmaz,Mustafa Gündoğar, Gülşah Uslu. Fracture strength of endodontically treated teeth restored with diferent fber post and core systems. Odontology 2019.
24. Pegoretti*, L. Fambri, G. Zappini, M. Bianchetti Finite element analysis of a glass fibre reinforced composite endodontic post. Biomaterials 2002;23: 2667–2682.
25. Haneef SHERFUDHIN, Joseph HOBEICH , Carlos Augusto CARVALHO , Moustafa N. ABOUSHELIB , Walid SADIG , Ziad SALAME Effect of different ferrule designs on the fracture resistance and failure pattern of endodontically treated teeth restored with fiber posts and all ceramic crowns. J Appl Oral Sci. 2 2011;19(1):28-33.
26. Jefferson Ricardo Pereira1 , Elias Manoel Ribeiro Neto2 , Saulo Pamato2 , Accácio Lins do Valle3 , Vitor Guarçoni de Paula4 , Hugo Alberto Vidotti Fracture resistance of endodontically treated teeth restored with different intraradicular posts with different lengths. Braz J Oral Sci.2012(1):1-4.
27. Arzu Civelek, Figen Kaptan, Ufuk Iseri, Oktay Dulger, Ender Kazazoglu, Yeditepe Universit Fracture Resistance of Endodontically Treated Teeth Restored with Fibre or Cast Posts. Balk J Stom, 2007; 11:196-200.
28. Rita Eid, Jelena Juloski, Hani Ounsi, Munir Silwaidi, Marco Ferrari, Ziad Salameh. Fracture Resistance and Failure Pattern of Endodontically Treated Teeth Restored with Computer-aided Design/ Computer-aided Manufacturing Post and Cores: A Pilot Study.The Journal of Contemporary Dental Practice, January 2019;20(1):56-63.
29. Marcela P. Newman, Peter Yaman, , Joseph Dennison, Mary Rafter,and Edward Billy. Fracture resistance of endodontically treated teeth restored with composite posts. J Prosthet Dent 2003;89:360-7.

30. Alessandro Rogério Giovani, Luiz Pascoal Vansan, Manoel Damião de Sousa Neto, and Silvana Maria Paulino. In vitro fracture resistance of glass fiber and cast metal posts with different lengths. J Prosthet Dent 2009;101:183-188.
31. Abdulrahman FADAG, Maged NEGM, Abdulaziz SAMRAN, Ahlam SAMRAN, Giraldine AHMED, Ali ALQERBAN, Mutlu ÖZCAN Fracture resistance of endodontically treated anterior teeth restored with different post systems: An in vitro study EUR Endod J 2018; 3: 00-0
32. Richard S. Schwartz, and James W. Robbins Post Placement and Restoration of Endodontically Treated Teeth: A Literature Review. Journal of Endodontics 2004;30:5.
33. Dimitrios Tortopidis1, Stefanos Kourtis2, Konstantinos Kountouras3 Restoration of Endodontically Treated Anterior Teeth with Cast Metallic Post or Prefabricated Fibre Post Placement: 2 Case Reports and Critical Literature Review Balk J Dent Med, 2015; 19:86-91.
34. Miguel Go´mez-Polo a , Blanca Llido´ b , Antonia Rivero b , Jaime del Rı´o b , Alicia Celemı´n b A 10-year retrospective study of the survival rate of teeth restored with metal prefabricated posts versus cast metal posts and cores. journal of dentistry 2010;38 :916–920.
35. Fabrıcio Eneas Diniz Figueiredo, DDS,* Paulo Ricardo Saquete Martins-Filho, PhD,† and Andre Luis Faria-e-Silva, PhD*Do Metal Post–retained Restorations Result in More Root Fractures than Fiber Post–retained Restorations? A Systematic Review and Meta-analysis. J Endod 2015;-:1–8.
36. Amer AlQahtani1, Abdulrahman Albargash2, Tariq Abduljabbar3, Fahad Bahmmam4, Siti Maraim AbGhani5, Mustafa Naseem6 ∗, and Fahim Vohra3Fracture Resistance of Maxillary Lateral Incisors Restored with Different Post Systems. Journal of Biomaterials and Tissue Engineering Vol.2017;7:1-5
37. Wietske A. Fokkinga, DDSa/Cees M. Kreulen, DDS, PhDb/Pekka K. Vallittu, DDS, PhDc/ Nico H. J. Creugers, DDS, PhD A Structured Analysis of In Vitro Failure Loads and Failure Modes of Fiber, Metal, and Ceramic Post-and-Core Systems. Int J Prosthodont 2004;17:476–482.
38. Joanna N. Theodosopoulou, DDS, MSc & Konstantinos M. Chochlidakis, DDS A Systematic Review of Dowel (Post) and Core Materials and Systems. Journal of Prosthodontics (2009);18: 464–472.
39. Shweta Sharma, George Attokaran1 , Kunwar S. Singh2 , Jeethu J. Jerry3 , Naima Ahmed4 , Nirban Mitra4 Comparative evaluation of fracture resistance of glass fiber reinforced, carbon, and quartz post in endodontically treated teeth: An in-vitro study. . J Int Soc Prevent Communit Dent 2016;6:373-6.
40. Mavari Karibasappa Saritha1 , Uttam Paul2 , Kiran Keswani3 , Ashu Jhamb4 , Swapnil Haribhau Mhatre5 , Pradyumna Kumar Sahoo6. Comparative Evaluation of Fracture Resistance of Different Post System . J Int Soc Prevent Communit Dent 2017;7:356-9.
41. Nadim Z. Baba, DMD, MSD,1 Gary Golden, DDS,2 & Charles J. Goodacre, DDS, MSD3. Nonmetallic Prefabricated Dowels: A Review of Compositions, Properties, Laboratory, and Clinical Test Results Journal of Prosthodontics (2009);18:527–536

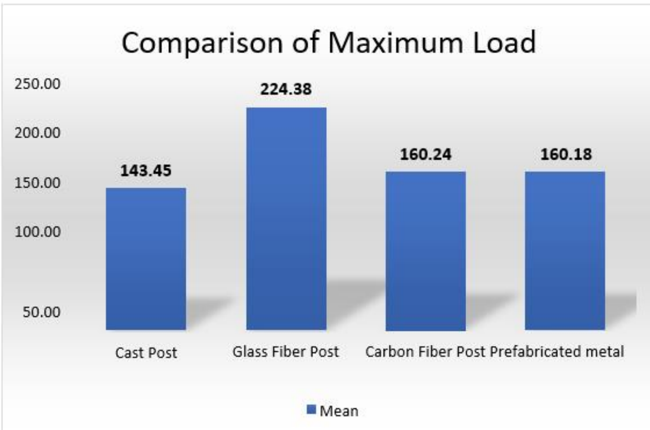
42. Lili Zhou and Qing Wang. Comparison of fracture resistance between cast posts and fiber posts: A meta -analysis of literature.j.endod 2013;39:11-15.
43. Carlos Torres-Sánchez,Vanessa Montoya-Salazar, Paola Córdoba, Claudia Vélez, Andrés Guzmán-Duran, José-Luis Gutierrez-Pérez, and Daniel Torres- Lagares. Fracture resistance of endodontically treated teeth restored with glass fiber reinforced posts and cast gold post and cores cemented with three cements.J prosthet dents 2013;110:127-133.
44. M.rosentritt, C.Furer, M.Behr, R.Lang and G.H andel Comparison of in vitro fracture strength of metallic and tooth coloured post and cores. Journal of oral rehabilitation 2000; 27:595-601.
45. Dean JP, Jeansonne BG, Sarkar N. In vitro Evaluation of a Carbon fiber post American association of endodontists 1998; 24:12.
46. Guido Heydecke,Dr med Dent,Frank Butz,Amr Hussein and jorg R. Strub Fracture strength and survival rate of endodontically treated maxillary incisors with approximal cavities after restoration with different post and core systems: an in vitro study. Journal of dentistry 2001; 29: 427-433.
47. Oliver Pontius, Dr med dent, MSD, and Jeffrey W. Hutter, DMD, MEd Evaluated the survival rate and fracture resistance of maxillary central incisors restored with different post and core systems.american association of endodontists 2002; 28: 10.
48. Guido Heydecke,Dr med Dent,Frank Butz,Amr Hussein and jorg R. Strub. Fracture strength after dynamic loading of endodontically treated teeth restored with different post and core systems.J Prosthet Dent 2002;87:438-45.
49. Sonthi Sirimai, DDS, MSD,a Douglas N. Riis, DMD, MS,b and Steven M. Morgano, DMDc. An in vitro study of the fracture resistance and the incidence of vertical root fracture of pulpless teeth restored with six post and core systems.j prosthet dent 1999; 81: 262-9.
50. X.-H. GU, M. Kern. Fracture resistance of crowned incisors with different post systems and luting agents. Journal of oral rehabilitation 2006; 33: 918-923.
51. Hai Qing, DDS, MMed,a ZhiMin Zhu, DDS, PhD,b YongLie Chao, DDS, MMed,c and WeiQun Zhang, DDS, MMedd.In vitro evaluation of the fracture resistance of anterior endodontically treated teeth restored with glass fiber and zircon posts.J. Prosthet Dent 2007; 97: 93-8.
52. Ziad Salameh, Roberto Sorrentino, Hani.F. Ounsi, Cecilia Goracci, Esam Tashkandi, Franklin R. Tay. Effect of different all- ceramic crown systems on fracture resistance and failure pattern of endodntically treated maxillary premolars restored with and without glass fiber posts. J. Endod.2007;33:848-851.
53. Michael Naumann Felix Blankenstein , Saskia Kiebling, Thomas Dietrich. Risk factors for failure of glass fiber-reinforced composite post restorations: a prospective observational clinical study.european journal of oral science 2005;113:519-52
54. Guzy GE, Nicholls ji.In vitro comparison of intact endodontically treated teeth with and without end-post reinforcement. J Prosthodont dent 1979; 42:39-44.
55. Beck N, Graef F, Wichmann M, Karl M.In vitro fracture resistance of copy-milled zirconia ceramic posts.J Prosthet Dent 2010;103(1): 40-4

56. Aggarwal S,Garg V. finite element analysis of strees concentration in three popular brands of fiber post systems used for maxillary central incisor teeth. J Conserve dent 2011;14(3):293-6.
57. Madfa AA,Kadir MR, Kashani J,Saidin S, SulaimanE,Marhazlinda J,et. al Stress distribution in maxillary central incisor restored with various types of post materials and design. Med eng phys 2014;36(7):962-7.
58. Gisele Rodrigues da SILVA,Paulo cesar de Freitas SANTOS-FILHO,Paulo Cezar SIMAMOTO-JUNIOR,Luis Roberto Marccondes MARTINS, Aderito Soares da MOTA, Carlos Jose SOARES. Effect of post type and restorative techniques on the strain and fracture resistance of flared incisor roots.braz dent j 2011;22(3):230-237.
59. Shahnaz Khadar, Kishore sapkale, pravinkumar G. patil, sayed abrar, manoj ramugade and febel huda. Fracture resistance and stress distribution pattern of different posts-core systems in immature teeth: an in vitro study and 3D finite element analysis.
60. Mendoza DB, Eakle WS, Kahl EA, Ho R.Root reinforcement with a resin -bonded performed post.journal of prosthetic dentistry 1997;78:10-14
61. Guido Heydecke, Dr Med Dent, and Mathilde C.Peters.the restoration of endodontically treated, single rooted teeth with cast or direct posts and core: a systematic review.journal of prosthetic dentistry 2002;87:349-467.
62. Paulo C.A. Maccari, Ewerton .N. Conceicao , Mauro F. Nunes. Fracture resistance of endodontically treated teeth restored with three different prefabricated esthetic post. Journal of esthetic and restorative dentistry. 2003; 15:1(25-31).
63. John D. McLaren, Charles I. McLaren, Peter Yaman,, MS,c Mohammed S. Bin- Shuwaish, Joseph D. Dennison, Neville J. McDonald. The effect of post type and length on the fracture resistance of endodontic treated tooth. The journal of prosthetic dentistry 2009;101(3):174-82.
64. Roshan Uthappa, Deepika Mod1, Pranav Kharod1, Pavitra S.2, Kavita Ganiger3, Hiral Kharod3. Comparative evaluation of the metal post and fiber post in the restoration of the endodontically treated teeth. Journal of dental research and review 2015; 2:2
65. Emel Uzunoglu-Özyürek , 1* Selen Küçükkaya Eren ,1 Oğuz Eraslan , 2 Sema Belli. Critical evaluation of fracture strength testing for endodontically treated teeth: a finite element analysis study. Restorative dentistry and endodontics 2019 ;44(2):15.
66. Gisele Rodrigues da SILVA1 Paulo César de Freitas SANTOS-FILHO1 Paulo Cézar SIMAMOTO-JÚNIOR1 Luis Roberto Marcondes MARTINS2 Adérito Soares da MOTA1 Carlos José SOARES. Effect of Post Type and Restorative Techniques on the Strain and Fracture Resistance of Flared Incisor Roots. Braz Dent J (2011) 22(3): 230-237
67. Schmitter M, Lippenberger S, Rues S, Gilde H, Rammelsberg P.fracture resistance of incisor teeth restored using fibre-reinforced posts and threaded metal posts: effect of post length,location, pretreatment and cementation of the final restoration. Journal of endodontics 2010;43 (5): 436-42.

Legend Tables and Figures

Maximum Load	N	Mean	SD	SE	F-Value	P-Value	Remark
Cast Post	20	143.45	27.70	6.19	37.634	0.000	Sig
Glass Fiber Post	20	224.38	29.27	6.54			
Carbon Fiber Post	20	160.24	30.78	6.88			
Pre-fabricated metal post	20	160.18	12.13	2.71			

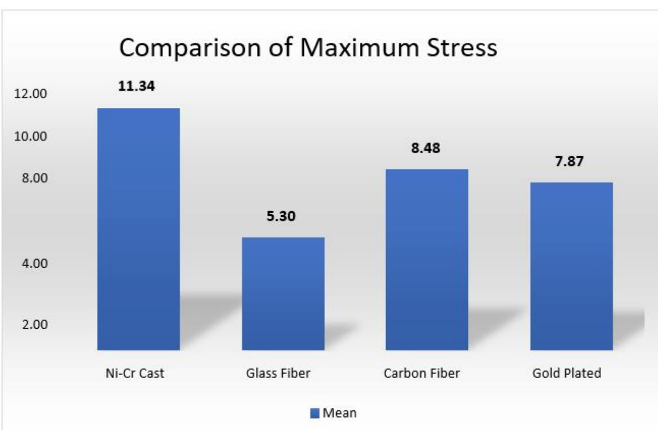
Table1: Comparison of maximum load (Favourable)



Graph1: Comparison of maximum load (favourable)

Maximum Stress	N	Mean	SD	SE	F- Value	P-Value	Remark
Ni-Cr Cast	20	11.34	1.79	0.40	29.576	<0.001	Sig
Glass Fiber	20	5.30	1.80	0.40			
Carbon Fiber	20	8.48	2.13	0.48			
Gold Plated	20	7.87	2.37	0.53			

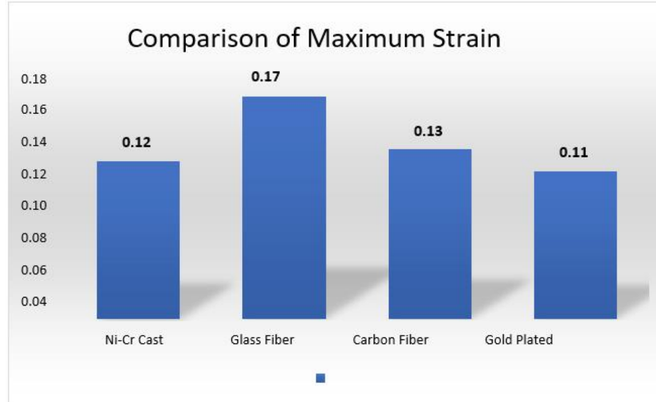
Table 2. Comparison of maximum stress(favourable)



Graph 2: Comparison of maximum stress(favourable)

Maximum Strain	N	Mean	SD	SE	F-Value	P-Value	Remark
Ni-Cr Cast	20	0.12	0.10	0.02	3.066	0.033	Sig
Glass Fiber	20	0.17	0.07	0.02			
Carbon Fiber	20	0.13	0.07	0.01			
Gold Plated	20	0.11	0.08	0.02			

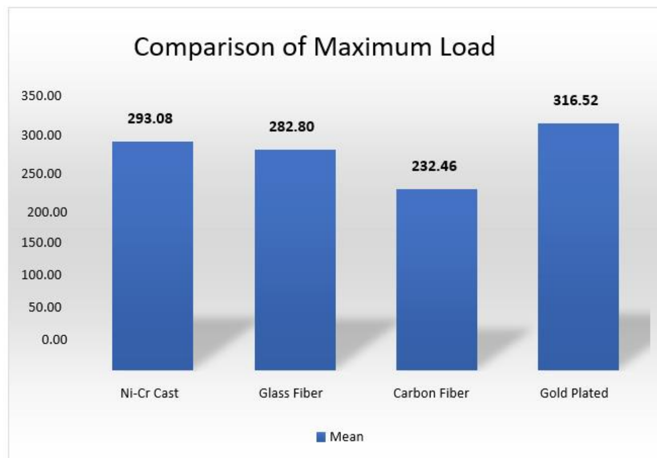
Table 3: Comparison of maximum strain (favourable)



Graph 3: Comparison of maximum strain

Maximum Load	N	Mean	SD	SE	F-Value	P-Value	Remark
Ni-Cr Cast	20	293.08	62.18	13.90	6.573	0.001	Sig
Glass Fiber	20	282.80	39.01	8.72			
Carbon Fiber	20	232.46	64.15	14.34			
Gold Plated	20	316.52	76.02	17.00			

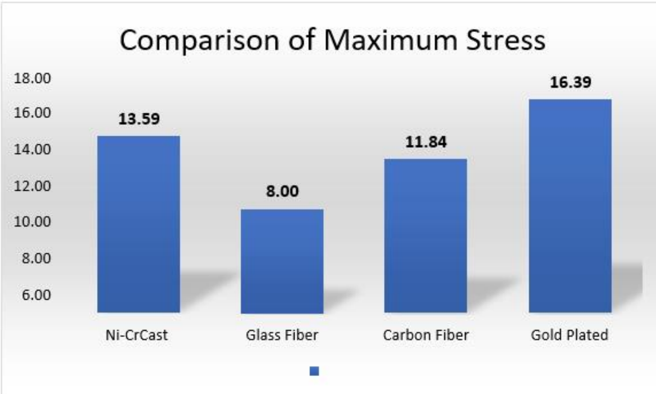
Table 4: Comparison of maximum load (unfavourable)



Graph 4: Comparison of maximum load(unfavourable)

Maximum Stress	N	Mean	SD	SE	F-Value	P-Value	Remark
Ni-Cr Cast	20	13.59	3.50	0.78	22.190	0.000	Sig
Glass Fiber	20	8.00	2.34	0.52			
Carbon Fiber	20	11.84	3.38	0.75			
Gold Plated	20	16.39	3.91	0.87			

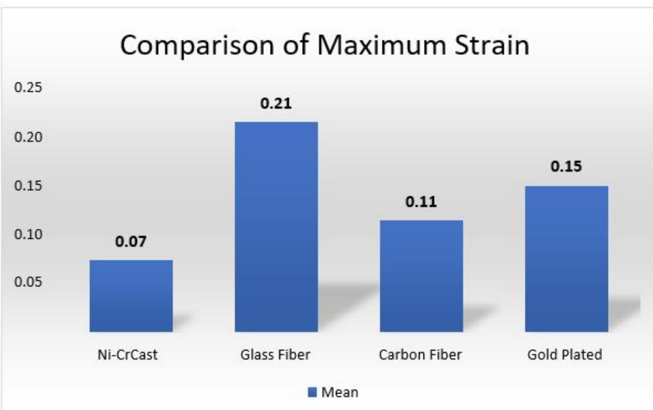
Table 5: Comparison of maximum stress (unfavourable)



Graph 5: Comparison of maximum stress(unfavourable)

Maximum Strain	N	Mean	SD	SE	F-Value	P-Value	Remark
Ni-CrCast	20	0.07	0.06	0.01	5.629	0.002	Sig
Glass Fiber	20	0.21	0.09	0.02			
Carbon Fiber	20	0.11	0.05	0.01			
Gold-plated	20	0.15	0.20	0.04			

Table 6: Comparison of maximum strain(unfavourable)



Graph 6: Comparison of maximum strain

Fracture Mode	Groups			
	Glass Fiber Post	Pre-fabricated metal post	Carbon Fiber Post	Cast Post
Favourable	16(80%)	14(70%)	12(60%)	12(60%)
Unfavourable	4(20%)	6(30%)	8(40%)	8(40%)

Table7: Failure mode