Khalij-Libya Journal
of Dental and Medical Research
http://journals.khalijedental.com.ly/index.php/ojs/index eISSN:2708-888X

Original Article

Influence of Intraradicular post Lengths and Surface characteristics on Fracture Resistance of Endodontically Treated Teeth

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ABSTRACT

***Objectives**. The purpose of this in vitro study was to evaluate the fracture resistance of endodontically treated teeth that were prosthetically restored with two fiber post Surface characteristics with different lengths (8,10 and 12mm). **Material and methods**. A total of thirty intact upper central incisors were collected and decoronated 2mm above to the cemento –enamel junction. Then prepared with 2mm a circumferential ferrule and a chamfer finish line of 0.5 mm. The teeth were embedded in epoxy resin blocks using a centralizing device. Root canals were performed then post holes were prepared with the corresponding drill using the drilling machine. The thirty samples were divided into 2 main groups according to the post surface characteristics Group I: parallel smooth glass fiber post. (n=15). Group II: parallel serrated glass fiber post. (n=15). The samples of each group were further subdivided into three sub-groups(n=5) according to different post lengths as follows: Sub Group A: 8mm length. Sub Group B: 10 mm length. Sub Group C:12mm length. All posts were cemented with a-self-adhesive resin cement using a load applicator device. Metal crown coping was constructed and cemented to the post and core assembly. Each specimen was then subjected to a compressive test in a universal testing machine where load was applied on palatal side at angle of 135 degrees in relation to long axis of the root at across head speed of 1mm/min until failure occurred. **Results.** There was no statistically significant difference between the tested post Surface characteristics, and there was a statistically significant difference between the three post lengths. **Conclusion.** The increased in post length showed significant increase fracture resistance of endodontically treated maxillary central incisor teeth, while Surface characteristics of post showed non-significant influence to fracture resistance.*

Keywords: Post, Length, Surface Characteristics, Fracture Resistance

Citation: Elkawash H, Eshah M. Influence of Intraradicular post Lengths and Surface characteristics on Fracture Resistance of Endodontically Treated Teeth. Khalij-Libya J Dent Med Res. 2022;6(2):144–151. https://doi.org/10.47705/kjdmr.226209

Received: 22/10/22; **accepted**: 20/11/22; **published**: 1/12/22

INTODUCTION

Restoration of endodontically treated teeth is still a controversial subject nowadays. It is well known that those teeth are generally weaker due to decay, previous restorative procedures and endodontic access preparation [1-3]. or loss of moisture supplied by a vital pulp. The restoration of such teeth is commonly accomplished using post and core, to prevent further destruction and create retention and resistance, before the placement of a crown or a fixed partial denture. [2,4]. Some reports suggest that the correct post length should be for conventional posts, which includes the following: (a) the post length should equal the clinical crown; (b) the post should be longer than the clinical crown; (c) the post should be half the root length; (d) the post should be two-thirds the root length; (e) the post should be four-fifths the root length and (f) the post should be as long as possible without disturbing the apical seal. These statements were related to cast metal posts, which have a high elastic modulus and only frictional retention in the root canal. However, these statements have been transferred to use of prefabricated metal posts and fiber posts, without taking into consideration the different mechanical properties, and the capacity shown by some of these intra-radicular posts of bonding to dentine with the use of adhesive systems and resin cements (5).Therefore, purpose of this in vitro study was to evaluate the fracture resistance of roots that were prosthetically restored with two glass fiber post Surface characteristics with different lengths. However, in this research hypotheses there is a significant difference in the effect of post length on the fracture resistance, and that there is a significant difference between post designs.

MATERIALS AND METHODS

Materials

Materials used in this study were as follows: A-Glass fiber post (ilumi super fiber post) with two different designs tapered serrated body and tapered smooth body (ilumi science, inc, USA). Rely x unicem: self-adhesive resin cement 3M ESPE company USA). Core-BULID- up material, Dual cure-auto mix (Quala dental products USA). normal saline solution (0.9% concentration), temporary filling eugenol free (Cavit , 3M company).

Methods

A-Teeth selection and preparation:

Thirty maxillary human central incisors were selected, freshly extracted for periodontal reasons, with straight root canals, anatomically similar root segments, and fully developed apices, used for this study. Soft tissue and calculus were mechanically removed from these teeth. Mesiodistal and buccopalatal dimensions and root lengths of all selected teeth were measured using digital calipers. The collected teeth were divided into two main experimental groups according to post surface designs as follows: Group I: parallel smooth glass fiber post (15 samples). Group II: parallel serrated glass fiber post (15 samples). The samples of each group were further subdivided into three subgroups according to different post lengths as follows: Sub Group A: 8mm length, Sub Group B: 10mm length and Sub Group C: 12mm length.

Teeth were mounted in acrylic resin block perpendicular to their long axis by aid of dental surveyor then decoronated 2mm coronal to most apical point of the proximal cemento-emamaljunction (CEJ) by diamond disc (syndent company) with straight hand pice using diamond rotary disc. Standardized preparation was performed with tooth length 15mm.(2mm ferrule and 13 root length) Teeth diameter were standardized to 4.5 mm and 2mm ferrule length with chamfer finish line 0.5mm and 6° degree convergence angle by aid of milling machine (Universal Milling Machine ,Vanguard company) leave space of post (diameter 1.47mm. After preparation was completed, teeth were demounted by sectioning of acrylic resin block**.** The coronal access opening was sealed with temporary filling eugenol free (Cavit, 3M company) and the teeth were stored in normal saline solution (0.9% concentration) for 1 week.

Endodontic Procedures:

The pulp chamber of each tooth was accessed and pulp extirpation was performed following the standard procedures. The working length was determined by inserting a number 10 k- file into the canal until its tip appeared at the apex then subtracting 0.5 mm. Root canals were prepared using crown down technique with nickel-titanium rotary system (Protaper endodontic system). Eugenol free sealer (Roeko seal) was introduced into canal using lentulo spiral (denstply) at low speed. The cone was lightly coated with the sealer and the root canals were filled using lateral condensation technique.

Teeth mounting in acrylic block

A specially designed centralization device was used, to allow accurate centralization of the teeth in acrylic block for standardize post space preparation and angulations, Teeth were demarcated and fixed at level 2mm apical to most coronal labial cemento-enamel junction in order to imitate the biological width .Root surfaces were covered with 2 layers of 0.1 mm tin foil in order to simulate and maintain human periodontal space(6) .The mixed acrylic resin was poured manually into a specially designed from its bottom after being coated with vaseline to facilitate the removal of moldacrylic block after setting.

This acrylic block would simulate the alveolar bone. When first signs of polymerization were observed, the tooth was removed from the resin block by moving the rod in an upward direction and then unwrapped from the foil spacers, vinyl polysiloxane impression material (Imprint 3M) light body automixwas injected into acrylic resin alveolus (7). The tooth was reinserted into test block by aid of reseating marks and excess set impression material was removed using a sharp scalpel. This layer of silicon material simulated the periodontal ligament.

Post space preparation and cementation

For post space preparation, the coronal gutta –percha was removed to required depth using size 2 Gates-Glidden drill mountedto drill press device (drilling machine) by guided by a rubber stopper. After which, each root canal was prepared by using instruments specified by manufacture for each post system as follows: super fiber serrated post size 3 (diameter 1.47mm) by using the special Matching parallel drill (1.5mm diameter blue color) and same drill was used for pa smooth post super fiber. The drill of post system was mounted to drill press device to ensure the post space was prepared parallel to long axis of the root and to prepared post space with different lengths (8mm, 10mm, 12mm) by the guiding rubber stopper and endodontic ruler. A self-adhesive resin cement used for the cementation of both post types. The post space was cleaned by17% EDTA followed by rinsing with 2.5% sodium hydrochloride for 30 seconds and normal saline and then dried by paper point (8).

The elongation tip was kept immersed in the resin cement until the root canal was completely filled, then the tip was slowly removed. The post was seated immediately and inserted into the root canal in a pumping action to prevent entrapment of air bubbles while excess cement was removed with a cotton pellet. Each post sample was maintained under constant load 1 kg for 5 minutes, before setting, excess cement was removed and each side was light cured for 20 seconds.

Core building

In order to standardize the shape and dimension of the core in all the samples a specially designed Teflon mold core former was fabricated. First, tooth structure was conditioned by applying phosphoric acid 37% to the tooth dentine surface for 15 second then washing it by water and then dried with compressed air. Then two coats of adhesive bond were applied with a brush to the etched surface and gently air blown according to the manufacturer's instruction and light cured for 10 second. The core former was positioned over the prepared tooth, and the dual cure composite was injected into mold hole by an auto mixing tip which was inserted in to former hole.

Composite was light cured for 40 second. Then the assembling ring was removed and two halves of the molds were separated and the composite core was light cured again from each side for 20 second. The resulting total abutment height was 7 mm composed of 5 mm of core material and 2mm ferrule with convergence.

Crown construction

In order to standardize the thickness and dimensions of the full metal crowns of the different groups was constructed using the lost wax technique as follows: A specially designed copper perforated tray with a top handle was constructed in the form of cylinder of 2.5 cm diameter and 2cm length. Tray were used to make single poly vinyl siloxane impression for each sample. Each impression was poured in die stone (type V) to produce a single die then two layers of die spacer were applied 1mm shorter from the finish line.

Wax pattern was fabricated on the first die which was sprued by wax sprue attached to sample at the incisal edge. Vacuum investing was carried out and invested by a phosphate bonded material according to manufacturer's instructions. On the finished crown coping a silicon impression mold was constructed to serve as an index for the other crown coping samples.

Finally, a total of thirty crown copings were obtained. The fitting surface of the metal copings were sandblasted and washed with water and dried with oil free air spray. The self-adhesive cement was applied to the internal surface. Each crown was seated on its corresponding sample with finger pressure then maintained under a constant pressure of 1 Kg for 5 minutes using the previously used loading device. Light curing of margins for 20 seconds per surface.

Testing of samples

All samples were subjected to a compressive loading using a universal testing machine (Model LRX.plus, UK) with load cell of 5 KN through a round tip load applicator with cross speed of 1mm/min at an angle of 135 degrees to the long axis of teeth until failure, load was applied 3mm below the incisal edge on the palatal surface of the crown until the failure. The load was measured in newton (N).

RESULTS

The results showed that Surface characteristics had no statistically significant effect on mean fracture resistance. Post length and the interaction between the two variables had a statistically significant effect on mean fracture resistance

Table (1): The mean, standard deviation (SD) values and results of comparison between post surface characteristics

Smooth		**Serrated**		**P - value**
Mean	**SD**	**Mean**	**SD**	
530.3	28.7	520.2	28.9	0.422

*Significant at $P \leq 0.05$

Effect of post surface characteristics

Two-way ANOVA test showed that there was no statistically significant difference between the tested post Surface characteristics Table 1.

Effect of post length

Two-way ANOVA results showed that there was a statistically significant difference between the three post lengths.

Pair-wise comparisons between the lengths revealed that there was no statistically significant difference between 12 mm and 10 mm post lengths; both showed the statistically significant highest mean fracture resistance values, while 8 mm length showed the statistically significant lowest mean fracture resistance value resistance values.All data were represented numerically in Table (2) and graphically in Figure (1) .

Table (2): The mean, standard deviation (SD) values and results of comparison between post lengths with each post Surface characteristics at each root segment

Post length / post Surface characteristics	12 mm		10 mm		8 mm		P-value
	Mean	SD	Mean	SD	Mean	SD	
Serrated	540.3 a	18.2	530.1	24.5	490.2 b	17.2	<0.001*
Smooth	549.1 a	22.5	540.3	23.6	501 b	15.4	<0.001*

** Significant at P ≤ 0.05, Different letters are statistically significantly different*

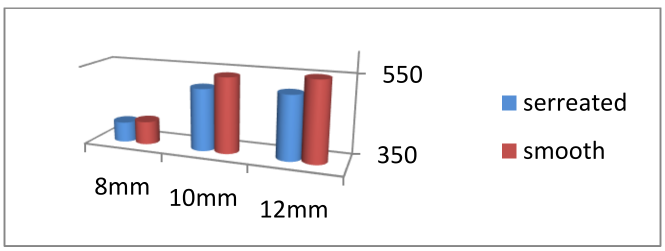

Figure (1): Mean fracture resistance of the three post lengths with each post Surface characteristics

In this study, all samples demonstrated oblique root fractures Figure (2).

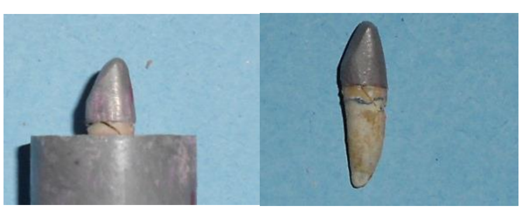

Figure 2. Oblique root fractures

DISCUSSION

Many authors recommended the use of fiber post and composite core and stated that they have higher fracture resistance than teeth restored with more rigid material such as cast post and core. Because of the elastisty of the post material, composite, resin cement luting material and dentin demonstrated similar structural deformations under load (Balkaya and Birdal 2013; Goracci and Ferrari 2011). (8,9),

Self-adhesive cements dual cure was used because it's simplicity technique and clinically time saving and it eliminated the inconsistent results encountered by the use of traditional etch and rinse bonding agents as proven by Torbjörner et al (10).

All the teeth were restored with complete coverage crown copings before subjecting them to mechanical testing where they act to distribute the applied loads more evenly over core; in addition, they prevent fracture of tooth substance by providing an extra coronal bracing. This was in accordance by Heydeck et al (11) who advocated that testing post and core preparation without placement of a crown would not reflect common clinical practical case.

The result of the current study accepted the first hypothesis because they showed that the increased in post length showed significant increase fracture resistance while second hypothesis was rejected because there no significant difference between post different surface characteristics.

The result of the present study related to length, demonstrated that 12 mm long post had highest fracture resistance strength followed by 10mm long post with no statistically significant difference between them, while 8mm short post had lowest fracture resistance with statistically significant. The result suggested that post with a modulus of elasticity similar to dentine can better absorb the forces concentrated along the root, with the longer posts, where their larger mass volume, possessed the capacity to absorb a greater amount of stress, rather than transferring stress to the dentine, However, the shorter posts 8mm appeared to concentrate the stress in the smaller area of radicular dentine, with a greater susceptibility to fracture as was explained by Giovani et al (12)

The findings of this study are in agreement with Giovani et al (12) and Adanir et al (6) they pointed out that longer glass fiber groups demonstrated significantly higher values of fracture resistance, while shorter post groups showed the lowest values and were significantly different from each other.

On other hand , these finding are not in agreement with Thakur and Ramarao ,aNissan et al (13 , 14) , who found that post length did not influence the fracture resistance as their explanation was that crowned endodontically treated teeth with 2mm ferrula becomes the equalizer and it changes the force distribution to the root and the post and core complex. Whereas, Filho et al (15), Sebastià et al (16) and Al-Laham et al (17) found that different length of glass fiber post did not increase the fracture resistance of teeth as their explanation was that similarity of the mechanical properties between fiberglass and dentine. More ever Cecchin et al (18) stated that increased length of glass fiber post did not consistently increase fracture resistance of tooth. Their explanation is that the post space preparation may weaken the tooth rather than reinforcing it.

For the results of post surface configuration; the smooth glass fiber post had higher fracture resistance value than serrated post with no statistically significant difference. This result could be explained that crowned endodontically treated teeth with 2mm ferrula becomes the equalizer and it changes the force distribution to the root and the post and core complex as suggested by Assif et al (19), Nissan et al (13).While, high value of smooth post than serrated post can explained by Soares et al(20) and Love et al (21) is serrations significantly reduce the rigidity of the post and serration may increase stress concentration on fiber that were sectioned during post fabrication .

On the contrary Santini et al (22), showed that serration at coronal part of the fiber post can damage the fracture resistance in thinner fiber post after fatigue cycling loading in compared with smooth surface post. There explanation was that serration damages the superficial and middle fibers of the post, which are able to transmit the stress lead to insufficient to withstand a masticatory force.

In this present study, the mode of failure of teeth restored with short post groups showed more irreparable fracture compared with other post groups showed predominant restorable fracture pattern. This result is in accordance with Giovani et al (12) and Cecchin et al (18) and Adanir et al (6) as they documented that mode of failure for long glass fiber posts were more repairable compared with short length post.

An explanation to the mode of failure observed in this study could be clarified by Giovani et al (12) and Chuang et al (23), who stated that the fracture locations for the longer glass fiber posts 10-12mm were predominantly in the cervical region at crown margin, which may result from a greater concentration of forces in this region due to significant material property difference between the crown and dentine. As for the 8mm posts there was a greater incidence of fracture in the middle of root, probably because of the smaller mass volume of these posts, which resulted in a lower absorption of forces and their more efficient transfer to the dentine, and simulated crowns and ferrules also reported that the stress field in teeth restored with fiber post and composite resin cores were generally homogenous, except in cervical region. Adanir et al (6) reported that when the post length was shorter than clinical crown, stress accumulation was increased on cervical buccal area. Cecchin et al (18) who found that lower clinical incidence of root fracture in teeth restored with glass fiber post, when compared with teeth restored with metal posts due to modulus of elasticity of glass fiber similar to that dentine, thus diminishing the stress transmitted to dental structure and reducing the possibility of root fracture.

On the other hand, our study is in controversy to Zicari et al (24) who found that fracture patterns associated with shorter posts appeared to be more favorable than longer post as their explanation was that fracture patterns do not depend on the rigidity of the post and importance of preventing

unnecessary removal of sound tooth structure surrounded the root canal. While Palepwad and Kulkarni (25) showed Zirconia and GFP groups had a greater percentage of favorable fractures than the CP group.
In this study, all samples demonstrated oblique root fractures. The oblique direction of the fracture line is characteristic for failure in shear caused by angled loading (26). When a central incisor is subjecting to oblique loading, significant bending occurs in the cervical and middle regions of the root, high compressive stresses were observed on the facial side of the root, while high tensile stresses were observed palatably, that may initiate cracking on the palatal side of the restoration (27).

CONCLUSIONS

The results indicate that the use of long post has better stress distribution and more favorable fracture. The failure mode was catastrophic in short post and effect of surface characteristic was non-significant.

REFERENCES

1. Reeh ES, Messer HH, Douglas WH. Reduction in tooth stiffness as a result of endodontic and restorative procedures. *J Endod.* 1989;15:512–516
2. Sedgley CM, Messer HH. Are endodontically treated teeth more brittle? *J Endodon.* 1992;18:332–335
3. Hudis SI, Goldstein GR. Restoration of endodontically treated teeth: a review of the literature. *J Prosthet Dent.* 1986;55:33–38
4. Assif D, Gorfil C. Biomechanical considerations in restoring endodontically treated teeth. *J Prosthet Dent.* 1994;71:565–567.
5. Santos-Filho PC, Castro CG, Silva GR, Campos RE and Soares CJ: Effects of post system and length on the strain and fracture resistance of root filled bovine teeth. IntEndo d J 2008; 41:493-501; .
6. Adanir N and Belli S: Evaluation of different post lengths' effect on fracture resistance of a glass fiber post system. Eur J. Dent 2008;2:23-8;.
7. Akkayan B and Gülmez T: Resistance to fracture of endodontically treated teeth restored with different post systems. J Prosthet Dent 2002;87:431-7;.
8. Balkaya MC, Birdal IS.. Effect of resin-based materials on fracture resistance of endodontically treated thin-walled teeth. J Prosthet Dent 2013; 109(5):296- 303
9. Goracci C, Ferrari M.. Current perspectives on post systems: a literature review. Aust Dent J. Jun 2011;56 Suppl 1:77-83.
10. Torbjörner A, Karlsson S and Odman PA: Survival rate and failure characteristics for two post designs. J Prosthet Dent1995;73:439-44;.
11. Heydecke G, ButzF , Hussein A and Strub J.R :Fracture strength after dynamic loading of endodontically treated teeth restored with different post-and –core systems. J Prosthet Dent 2002;87; 438-45;.
12. Giovani AR, Vansan LP, de Sousa Neto MD and Paulino SM: In vitro fracture resistance of glass-fiber and cast metal posts with different lengths. J Prosthet Dent 2009;101:183-8;.
13. Acomparative evaluation of fracture resistance of endodontically treated premolar teeth reinforced with different prefabricated and custom-made fiber-reinforced post system with two different post lengths: An in vitro study Anamika Thakur and Sathyanarayanan Ramarao1J Conserv Dent. Jul-Aug; 2019 : 22(4): 376–380 ;.
14. Nissan J, Barnea E, Carmon D, Gross M and Assif D: Effect of reduced post length on the resistance to fracture of crowned, endodontically treated teeth. Quintessence Int 2008;39:79-82;.
15. Santos-Filho PC,verissimo C, soares PV, saltarelo RC, soares CJ marcondes martins LR .influence of ferrule , post system , and length on biomechanical behavior of endodontically treated ante endorior teeth , j
    a. . jan 2014;40(1) :119-23
16. Ramírez-Sebastià A, Bortolotto T, Cattani-LorenteM,GinerL, Roig M, Krejci I. Adhesive restoration of anterior endodontically treated teeth: influence of post length on fracture strength. Clin Oral Investig 2014;18(2):545-54.
17. Badr Al-Laham, Esam Osman, Mohammad Rayyan, Ehab A. Farghaly and Sahar Mokhtar ,fracture resistance of endodonticallytreated teeth

restored with different fiber post lengths EDJ . July; 2018 :64, 2579:2584,
18. Cecchin D, Farina AP, Guerreiro CA and Carlini-Júnior B:Fracture resistance of roots prosthetically restored with intra-radicular posts of different lengths. J Oral Rehabil 2010;37:116-22.
19. Assif D, Bitenski A, Pilo R and Oren E: Effect of post design on resistance to fracture of endodontically treated teeth with complete crowns. J Prosthet Dent1993;69:36-40;
20. Soares CJ, Pereira JC, Valdivia AD, Novais VR and Meneses MS: Influence of resin cement and post configuration on bond strength to root dentine. IntEndod J 2012. 45:136-45;.
21. Love RM and Purton DG: The effect of serrations on carbon fibre posts-retention within the root canal, core retention, and post rigidity. Int J Prosthodont. 1996 :9:484-8;.
22. Santini MF, Wandscher V, Amaral M, Baldissara P and Valandro LF:Mechanical fatigue cycling on teeth restored with fiber posts: impact of coronal grooves and diameter of glass fiber post on fracture resistance. Minerva Stomatol. 2011: 60:485-93;.
23. Chuang SF, Yaman P, Herrero A, Dennison JB and Chang CH: Influence of post material and length on endodontically treated incisors: an in vitro and finite element study .J Prosthet Dent. 2010 :104:379-88;.
24. Zicari F, Van Meerbeek B, Scotti R and Naert I: Effect of fibre post length and adhesive strategy on fracture resistance of endodontically treated teeth after fatigue loading. J Dent. 2012 :40:312-21;.
25. In vitro fracture resistance of zirconia, glass-fiber, and cast metal posts with different lengths Ashutosh B. Palepwad and Rahul Shyamrao Kulkarni J Indian Prosthodont Soc. Apr-Jun; 2020 :20(2): 202–207.
26. Ghoneim M. and EL-Mihily M: Design of reinforced concrete structures. 1st. Cairo: 148; 2005.
27. Al-Wahadni AM, Hamdan S, Al-Omiri M, Hammad MM and Hatamleh MM: Fracture resistance of teeth restored with different post systems: in vitro study. Oral Surg . 2008: 106:77-83;.