

Evaluation the Fracture Resistance of Endodontically Treated Teeth Restored With Different Post and Core Materials

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Key words

fracture resistance, fiber post, titanium post, core materials.

Abstract

Widespread use of prefabricated post that provides retention and support for core and the final crown has caused manufacturers to produce different types of post materials. The aim of this study was to evaluate the fracture resistance of two types of post materials and two types of core material. Forty extracted human mandibular premolar were selected. After root canal preparation and obturation with gutta percha the roots were divided into two groups according to the type of post material, group F restored with fiber post and group T restored with titanium post then each group was subdivided into two subgroup according to the type of core materials which include composite and amalgam restorative materials. Then all the teeth were subjected to compressive load at 130° angle from the horizontal plan at a 5mm/min crosshead speed until fracture. Results showed that there was significant different between groups in term of fracture loads ($P= 0.0156$). Also the fracture loads of teeth restored with titanium post and composite core has highest mean fracture load (812N), whereas teeth restored with fiber post and amalgam core demonstrated the lowest mean fracture load (643.1N). The study concluded that the teeth restored with metal titanium post were more fracture resistant than those restored with fiber posts. But the combination of a fiber post and composite core has the favorable mode of fracture that considered repairable, while considered unfavorable when restored with titanium post.

Introduction

Endodontically treated teeth show a lower fracture resistance to intraoral forces. Post endodontic tooth fractures usually occur as a result of weakened tooth structure, large dental caries, tooth wear, and physical

changes in tooth structure caused by aging, vital pulp tissue loss, and endodontic therapy procedures ^(1,2). The fracture susceptibility of teeth restored with posts may be related to factors such as the amount of remaining tooth structure, which provides resistance to the fracture of the tooth, as well as the characteristics of the post, such as the material composition, modulus of elasticity, diameter and length. A post fracture is the most serious type of failure

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in post restored teeth. To avoid root fractures, a post having a modulus of elasticity similar to that of dentin helps in distributing the stress of occlusal load in a uniform pattern ⁽³⁾. In cases of considerable hard tissue loss, posts are used as an element supporting core foundation when there is insufficient coronal tooth structure. Clinicians usually choose the post and core system that provides best retention, support, and reduces the possibility of root ^(4,5). Non metal posts were developed as a result of advances in biomaterials, development in bonding and adhesive systems, and enhancement of aesthetic characteristics of dental restorations. Non metal posts include composites and ceramics. Composite posts include carbon fiber, silica fiber, ribbon fiber, and light transmitting posts. Non metal posts have superior aesthetics, biocompatible, more color stable, corrosion free, and some have similar stiffness to dental tissues thus improving stress distribution ⁽⁶⁾. Ready-made or prefabricated metal posts are associated with higher risk of root fracture due to the high stiffness and modulus of elasticity of the metal when compared to tooth structure, which might lead to increased stress concentration ⁽⁷⁾. Although the science of fiber reinforced post is well-established, the application of these materials is still new, and the physical characterization of these materials needs to be further evaluated. Woven fibers embedded in composites are widely used in periodontal splints, orthodontic retainers, endodontic posts, and fixed partial dentures for reinforcement. These fibers vary in their chemical and physical properties as well as in their fabric configurations. The reinforcing ability of the fibers is influenced by the orientation of the fibers, adhesion between the fiber and resin, and impregnation of fibers with the resin ⁽⁸⁾. The aim of this study is to evaluate the fracture resistance and mode of failure of endodontically treated teeth restored with different materials post including fiber post and titanium post with use of two different core materials including composite and amalgam core materials.

Materials and Methods

Forty mandibular premolar extracted for orthodontics reason free from caries or previous restoration were selected for this study. Teeth were restored in normal saline at room temperature during the study. All teeth were carefully debrided from soft tissue with periodontal curette, followed by cleaning with rubber cup and pumice; teeth were examined by transillumination for presence of cracks. Teeth of similar dimensions and shapes were selected for this study, with as close as possible of the following dimensions: root length 14 mm from cemento enamel junction (CEJ) to the apex and with width dimension faciolingually and mesiodistally of 6-8 mm and 4-6 mm respectively. The clinical crowns of all teeth were removed at the (CEJ) with a diamond disc rotary instrument (Topdent, Switzerland) under water coolant. The working length of each canal was calculated to be 1 mm shorter to the root length. Root canals were prepared with nickel-titanium hand instrument (ProTaper, Dentsply-Maillefer, Ballaigues, Switzerland) and Glyde (Dentsply-Maillefer, Ballaigues, Switzerland), for standardization all roots were prepared to file F3, roots were irrigated between instrumentation with 5% sodium hypochloride. The prepare canals were obturated with a single F3 gutta percha cone (Dentsply-Maillefer, Ballaigues, Switzerland) and AH26 sealer (Dentsply-Maillefer, Ballaigues, Switzerland), then roots were stored in saline solution at 37⁰C for one week^(1,9,10). Each root was embedded in 2.8 x 2.8 x 2.8 cm³ individual block of self-curing acrylic resin (Acromed, Modern Medical, UAE) with long axis perpendicular to the base of the block and with acrylic ending at 2mm below the cemento enamel junction. Before embedding, a thin layer of glycerin was first applied with microbrush on the roots, and after polymerization of acrylic resin the root was carefully removed. Siloxane impression material (Zhermach Oranwash L, Badia Polesin, Italy) was mixed according to the manufacturer instruction and injected into the acrylic resin molds to



simulate the periodontal ligament and the root was reinserted again and excess silicone impression material removed. The roots were randomly distributed into two groups. Group F (twenty teeth) was restored with Fiberapost plus (PD, produits dentaires Vevey, Switzerland) and Group T (twenty teeth) was restored with prefabricated Titanium post (Unimetric titanium post, Dentsply-Maillefer, Ballaigues, Switzerland). For each group the post preparation was started with the removal of root gutta percha with Peeso reamer (Dentsply-Maillefer, Ballaigues, Switzerland) to a point 4mm from root apices to preserve the apical seal. Post spaces were prepared with low-speed drills supplied by each manufacturer. All posts were shortened to total length of 14mm, so that 10mm of the post could be placed in the root and the remaining 4mm in to core components^(9,11-13). All posts were cemented with self cure resin modified glass ionomer luting cement (Riva luting plus, SDI, Australia) according to the manufacturer instruction which include irrigation the post space with saline and dried with cotton paper point (Absorbent paper point, MetaBiomed, South Korea). The walls of the root canal were acid etch for 10 second using 37% phosphoric acid (Super etch, SDI, Australia), then the root canal washed with water spray and dried with paper point. A thin layer of cement was placed in the post space by cotton paper point also cement was placed on the post surface; the post was inserted in the canal. The cement allows to set for 1 hour, and then the access cement was removed with an explorer. After the cementation procedure was completed, the teeth in each group were divided into two subgroups (10 teeth for each subgroup) according to the type of core materials. Group F divided into: subgroup (Fc), the core material was fabricated from tetric ceram (ivoclar vivadent, Shaan, Liechtenstein), a cellulose mold 6mm height (PD, produits dentaires Vevey, Switzerland) was used during core build up for each tooth to ensure standardized core size as well as to exclude voids and deficiencies within the core material. A small indentation was included at the

middle third of the inner surface of the cellulose mould to provide a standardized point of load application. First, coronal tooth surface was etched for 15 seconds with 37% phosphoric acid (Super etch, SDI, Australia), then rinsed with water for 10 seconds and dried with air syringe for 5 seconds. A bonding agent (Alpha-dent bonding adhesive. Dental Technologies. 6901. N. Avenue LINCOLNWOOD. ILLINOIS 60712 USA) was applied to the etched dentin surface and the 4mm of exposed post and polymerized with light cure for 20 seconds the tetric ceram was applied in increment of 2 mm and light activated with light cure machine (Halogen light curing unit Dentsply, Switzerland). Subgroup (Fa), the core material was fabricated with silver amalgam (SDI, Bayswater, Victoria, Australia), Copper bands 6mm height (soft, PD produits dentaires, Vevey, Switzerland) were used to form cores around the prefabricated posts to ensure standardized core size as well as to exclude voids and deficiencies within the core material. A small indentation was included at middle third of the inner surface of the copper band to provide a standardized point of load application. The activated amalgam capsules were mixed according the manufacture instruction and condensed in to the prepared copper band. For all subgroup the core materials were cover the prefabricated post with the total height of the core was 6 mm for all subgroups. Group T divided into: Subgroup (Tc) the core material was restored in same manner as in subgroup (Fc). Subgroup (Ta) also restored in same manner as in subgroup (Fa). Each specimen was mounted within an Instron testing machine (computerized instron H5KT Tinius Olsen testing machine, England), which fixed by a specially designed retaining arm of Instron machine, which was used to hold the specimen during testing. Then the load was set at 130° from the horizontal plane onto a standard point at the middle of the lingual occlusal line angle of the core, at level of the small indentations. The compressive load was applied on the specimens at a 5mm/min crosshead speed until fracture. The point of fracture was determined by

sudden drop of the applied force and an audible crack sound would be heard. The fracture load in kilogram was recorded and later converted to newtons. The mode of failure of each specimen was categorized either a core failure (noncatastrophic or favorable) or root fracture only, or core and root fracture (catastrophic or unfavorable).

Results

The mean failure loads and standard deviations were calculated for all subgroups Table (1). ANOVA test Table (2) showed that there was significant difference between groups in term of fracture loads ($P= 0.0156$). Further analysis with LSD test showed that there was only significant differences in group T between subgroup Tc and Ta ($P= 0.039$), while t-Test showed that there was no statistically difference ($P> 0.05$) between group Fc and group Tc and between group Fa and Ta. Figure (1) shows that fracture loads of teeth restored with titanium post and composite core has highest mean fracture load (812N), whereas teeth restored with Fiberapost plus and amalgam core demonstrated the lowest mean fracture load (643.1N). Table (3) shows the failure mode of the study groups, a magnifying eye lens 10X (China) were used for inspection of these failure modes.

Discussion

Posts should have the ability to allow force and stress transfer and distribution to prevent root fracture. This study gives the idea on the fracture resistance of endodontically treated teeth restored with 2 different dowel systems: glass fiber post and titanium post and with 2 core materials: composite and amalgam restoration. The selection of the fiber post and titanium post with composite and amalgam restorations are due to the wide use of these materials. To simulate clinical conditions, natural teeth of similar dimensions and shapes were used in the study. Thus, the faciolingually and mesiodistally dimensions of each tooth

were recorded at the level of the cervical margin to ensure that each experimental group contained teeth of similar dimension. On the other hand, artificial teeth do not simulate natural dentin, and they unrealistically adhere to the post, which does not resemble the clinical situations. Furthermore, natural teeth have higher fracture resistance than artificial ones. This method was adopted in many studies^{(1,12),(14-18)}. Teeth were embedded in acrylic resin block leaving 2mm above the acrylic resin surface to simulate the position of root within the bone in clinical situation and allow good vision to the mode of failure during testing, while using Siloxane impression material was to simulate PDL to provide a cushioning effect that would resemble clinical conditions^(1,11,19, 20). This material was also selected because its width and modules of elasticity were similar to those of natural ligament. The fracture strengths of restored teeth without artificial ligaments were approximately two times greater than those with ligament, this might be because that the restored teeth were directly held by acrylic resin when testing without the artificial ligament and the acrylic resin acted as a ferrule, which showed a significant effect in preventing root fracture. Therefore, in the current situation, the usage of artificial ligament was the most appropriate method, even though it was not a natural one⁽¹⁶⁾. Loading was applied directly on the core, as no crown was used, for simplification purposes and to exaggerate the load effect on the tooth^(4,21). The load was set to 130° angle from the horizontal plane and continuous compressive loading was applied to resemble the mastication procedure, many previous studies has been adopted this angle for load application^(9,11,13,19,20). Composite was the material of choice for core build up because of its good bond strength, easy controlled and quick setting, good aesthetics and had adequate compressive strength^(4,21). This study showed that composite resin core has higher fracture resistance than amalgam core. Also, finding has been reported that failure modes were favorable with composite core, while with amalgam cores the failure

mode was unfavorable. Amalgam is not only the most widely used materials, but also one of the most tested ones in restorative dentistry. It has a good compressive strength but less adequate tensile and shear strengths, many studies concluded that silver amalgam was more resistance to tensile and shear strengths when an adhesive agent was used^(9, 22). In present study no bonding agent was used between amalgam and tooth surface and this could explain the low resistance of amalgam when it compare with composite material during the test. Moreover, composite is considered a good core material to use, especially with fiber posts⁽²²⁾. Statistical analysis showed that teeth restored with titanium posts had statistical significant fracture resistance than teeth restored with fiber post, this was in agreement with Al-Wahadni et al.,⁽⁴⁾ and Mitsui et al.,⁽²³⁾. This could be explained that titanium post have high modulus of elasticity, which allow the post to withstand large amounts of stress before bending and transmitting the load to the root, this mechanism makes the tooth more resistance to fracture. Previous studies showed that stiffer posts have been associated with better stress distribution and greater fracture resistance. According to manufacturers, fiber endodontic post, were introduced to the dental profession in order to allow homogenous mechanism and chemical bonding between the post and dentin to reinforce the tooth^(20,24). Salameh et al.,⁽²⁵⁾ reported that the use of fiber post to restore endodontically treated maxillary premolars improved the biomechanical performance loading, implying that the posts significantly contributed to the reinforcement and strengthening of endodontically treated tooth by supporting the remaining tooth structure against compressive stresses. It should be noted that under load, teeth behave mechanically like a cantilever. The recorded failure loads would primarily represent the bending resistance of the cantilever, which is in this case a hybrid structure including the root, the post and core. Mikako et al⁽¹⁶⁾. Under the condition of oblique loading, the majority of fractures in the titanium post-core group were propagated over the

middle portion of the roots, while in the fiber post subgroups were limited to the cervical portion. This difference in fracture propagation can be explained by the stress distribution in pulpless teeth restored with post-core systems reported in recent finite element analysis studies. When a 45-degree oblique load was applied to teeth restored with a metallic post-core, the stress distributed inside the post, all over the interface between the post and root dentin, and in the apex of the post. Reflecting this stress distribution, fractures propagated along the metallic post over the middle portion of the root including the post apex. This indicates that most of the fractured teeth restored with metallic post-cores were not reparable. In contrast, the majority of fractures in the fiber post group were limited to the cervical portion of the root including the core-dentin interface, since the stress was concentrated in the cervical area and the outer root surface. This type of fracture is most easy for repeated repair.

Conclusions

Within the limitation of this study it can be concluded that the teeth restored with metal titanium post were more fracture resistant than those restored with fiber posts. But the combination of a fiber post and composite core has the favorable mode of fracture that considered reparable, while considered unfavorable when restored with titanium post.

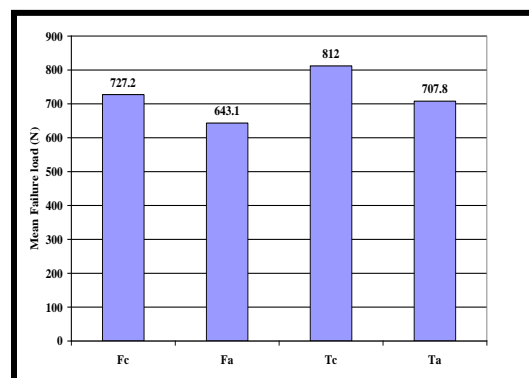


Fig.(1):- Mean fracture loads of teeth in the four subgroups.

Table (1):- Descriptive statistic of groups.

Fracture resistance N				
Subgroups	Fc	Fa	Tc	Ta
Mean (N)	727.2	643.1	812	707.8
SD	118.2	142.9	127.2	113.1
Maximum load (N)	871	866	982	840
Minimum load (N)	451	421	516	443

Table (2):- ANOVA test for all tested group.

	F-test	P-value
Between groups	4.131	0.0156

P<0.05 Significant

Table (3):- Mode of fracture of the study subgroups.

Fracture mode	Fc	Fa	Tc	Ta
Favorable fracture (noncatastrophic)	8	6	3	2
Unfavorable fracture (catastrophic)	2	4	7	8
Total teeth No.	10	10	10	10

References

- 1-Bilge Hakan S, en, Senem Yigit Ozer, Sadullah Kaya, Ozkan Adiguzel. Influence of Fiber-reinforced Composites on the Resistance to Fracture of Vertically Fractured and Reattached Fragments. *J Endod* 2011; 37:549–553.
- 2-Kishen A. Mechanisms and risk factors for fracture predilection in endodontically treated teeth. *Endod Topics* 2006; 13:57–83.
- 3-Peroz I. Blankenstein F., Lange KP., Naumann M. Restoring endodontically treated teeth with posts and cores a review. *Quintessence Int.* 2005 Oct;36(9):737-46
- 4-Ahed M. AL-Wahadni, Sami Hamdan, Mahmoud Al-Omiri, Mohammad M. Hammad, Muhanad M. Hatamleh. Fracture resistance of teeth restored with different post systems: in vitro study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2008; 106:e77-e83.
- 5-Dikbas I, Tanalp J, Ozel E, Koksall T, Ersoy M. Evaluation of the effect of different ferrule designs on the fracture resistance of endodontically treated maxillary central incisors incorporating fiber posts, composite cores and crown restorations. *J Contemp Dent Pract* 2007; 8:62-9.
- 6-Nakamura T, Saito O, Fuyikawa J, Ishigaki S. Influence of abutment substrate and ceramic thickness on the colour of heatpressed ceramic crowns. *J Oral Rehabil* 2002; 29:805-9.
- 7-Ferrari M, Vichi A, Garcia-Godoy F. Clinical evaluation of fiber-reinforced epoxy resin posts and cast post and cores. *Am J Dent* 2000; 13:15B-8B.
- 8-Karbharia VM, Strassler H. Effect of fiber architecture on flexural characteristics and fracture of fiber-reinforced dental composites. *Dent Mater* 2007; 23:960–8.
- 9-Filiz Aykent, Mustafa Kalkan, Munir Tolga Yucel, Atilla Gokhan Ozyesil. Effect of dentin bonding and ferrule preparation on the fracture strength of crowned teeth restored with dowels and amalgam cores. *J Prosthet Dent* 2006;95:297-30.
- 10-Polly S. Ma, Jack I. Nicholls, Thomas Junge, Keith M. Phillips. Load fatigue of with different ferrule length, restored with fiberposts, composite resin-cores, and all ceramic crowns. *J Prosthet Dent* 2009;102:229-234.
- 11-Sung-Ho Jung, Kyung-San Min, b Hoon-Sang Chang, Sung-Do Park, Soon-Nyu Kwon, Ji-Myung Bae. Microleakage and fracture patterns of teeth

restored with different posts under dynamic loading. *J Prosthet Dent* 2007; 98:270-276.

12-Ottl P, Hahn L, Lauer H, Fay M. Fracture characteristics of carbon fibre, ceramic and non-palladium endodontic post systems at monotonously increasing loads. *J Oral Rehabil* 2002;29:175-83.

13-Albuquerque Rde C, Polleto LT, Fontana RH, Cimini CA. Stress analysis of an upper central incisor restored with different posts. *J Oral Rehabil* 2003;30:936-43.

14-Al-Wahadni A, Gutteridge DL. An in vitro investigation into the effects of retained coronal dentine on the strength of a tooth restored with a cemented post and partial core restoration. *Int Endod J* 2002; 35:913-8.

15-Strub JR, Pontius O, Koutayas S. Survival rate and fracture strength of incisors restored with different post and core systems after exposure in the artificial mouth. *Journal of Oral Rehabilitation* 2001;28, 120-4.

16-Mikako Hayashi, Yutaka Takahashi, Satoshi Imazato, Shigeyuki Ebisu. Fracture resistance of pulpless teeth restored with post-cores and crowns. *J Dental Materials* 2006; 22, 477-485.

17-Ziad S, Roberto S, Hani F. O, Walid S, Fadi A, Marco F. The Effect of Different Full-coverage Crown Systems on Fracture Resistance and Failure Pattern of Endodontically Treated Maxillary Incisors Restored with and without Glass Fiber Posts. *J Endod* 2008;34:842- 846.

18-M. I. Reill, M. Rosentritt, M. Naumann, G. Handel. Influence of core material on fracture resistance and marginal adaptation of restored root filled teeth. *International Endodontic Journal* 2008;41, 424-430.

19-M. Schmitter, S. Lippenberger, S. Rues, H. Gilde & P. Rammelsberg. 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. *International Endodontic Journal* 2010; 43:436-442.

20-Begum Akkayan. An in vitro study evaluating the effect of ferrule length on fracture resistance of endodontically treated teeth restored with fiber-reinforced and zirconia dowel systems. *J Prosthet Dent* 2004; 92:155-62

21-M. K. AL-Omiri, A. M. AL-Wahadni. An ex vivo study of the effects of retained coronal dentine on the strength of teeth restored with composite core and different post and core systems. *International Endodontic Journal* 2006: 39, 890-899.

22-Pilo R, Cardash HS, Levin E, Assif D. Effect of core stiffness on the in vitro fracture of crowned, endodontically treated teeth. *Journal of Prosthetic Dentistry* 2002: 88, 302-6.

23-Mitsui FH, Marchi GM, Pimenta LA, Ferraresi PM. In vitro study of fracture resistance of bovine roots using different intraradicular post systems. *Quintessence Int* 2004;35:612-6.

24-Stockton G, Peters MC. The restoration of endodontically treated single-rooted teeth with cast or direct posts and cores: a systematic review. *J Prosthet dent* 2002;87:380-5.

25-Salameh Z, Sorrentino R, Ounsi HF, et al. Effect of different all-ceramic crown system on fracture resistance and failure pattern of endodontically treated maxillary premolars restored with and without glass fiber posts. *J Endod* 2007; 33:848 -51.