Fracture Resistance Of Endodontically Treated Maxillary Central Incisor With Five Different Post And Core Systems-An In-Vitro Study

C Dhanavel, K Madhuram, V Naveenkumar, R Anbu

Citation

C Dhanavel, K Madhuram, V Naveenkumar, R Anbu. *Fracture Resistance Of Endodontically Treated Maxillary Central Incisor With Five Different Post And Core Systems-An In-Vitro Study*. The Internet Journal of Dental Science. 2010 Volume 10 Number 1.

Abstract

Aim: The purpose of this study was to evaluate the fracture resistance and the mode of failure of endodontically treated teeth with five different post and core systems. Materials and Methods: Thirty intact human maxillary central incisors were randomly divided into five groups of six each. Teeth from each group received endodontic therapy and one of the five post and core systems1. Carbon Fiber post [Mirafit, Hager Worldwide, Inc, Odessa, USA] and resin composite core 2.Luscent Anchor post [Dentatus USA ltd, NY, USA] and resin composite core 3.Stainless Steel spilt Shank post [Flexi post, Essential Dental Systems, Inc, NJ] and resin composite core 4.Titanium post [Dentatus Classic System, Charles B.Schwed co, Inc, NJ] and resin composite core 5.Cast post and core. A full coverage metal crown was fabricated and cemented onto each tooth. Each specimen was subjected to compressive load at a 130-degree angle to its axis until fracture. The failure load was recorded and compared statistically. The mode of failure of the specimens was analyzed. Results: Cast post and core showed the highest fracture threshold and Titanium post showed the lowest fracture threshold. Cast post and core and titanium post showed evidence of root fracture, which comes under unfavorable fractures. Carbon fiber, Luscent Anchor and Stainless Steel spilt shank post showed either core fracture or a coronal tooth fracture, which comes under favorable fracture, which are restorable. Conclusion: Groups, which have modulus of elasticity close to that of dentin like Carbon fiber post, Luscent Anchor post produced favorable tooth fractures, which are restorable.

INTRODUCTION

The restoration of endodontically treated teeth is a challenging aspect of restorative dentistry. There has been a notable increase in the retention of endodontically treated teeth, which can be attributed to present state of art and science of endodontics [1]. After root canal treatment, the tooth becomes weaker because sound tooth structure has been removed to properly clean and shape the canal [1]. The tooth structure that remains after endodontic treatment has already been undermined and weakened by all of the previous episodes of caries, fracture, tooth preparation and restoration. Endodontic manipulation further removes important intra coronal and intra radicular dentin [2]. The combined result of these changes further increases the fracture susceptibility of endodontically treated teeth.

The post and core system should both reinforce the tooth and provide retention for the crown. Studies have reported that design, length and type of endodontic post also play a role in the behavior of the post. The use of posts of various designs and materials can unfortunately create inordinate stresses that lead to damage during post installation or function. The damage varies from core fracture, coronal tooth fracture, post dislodgement and root fracture [3].

The aim of this study is to compare fracture resistance and primary mode of failure of five different posts system [Carbon Fiber post, Luscent Anchor post, Titanium post, Stainless Steel spilt shank post and Cast post and core] with composite as a core by applying compressive load using universal testing machine.

MATERIALS AND METHODS

Thirty recently extracted, intact, human maxillary central incisors were collected and stored in de-ionized water. Teeth with caries, restoration and cracks were discarded. Teeth with excessively wide or constricted root canals or dilacerations at the apex were excluded. Teeth were kept in a

moist environment throughout the experiment except during placement of post and core. A custom mold of poly vinyl siloxane material [Affinis precious, Coltene/whaledent, Burlingame, CA] was made for each tooth and preserved to facilitate the fabrication of full veneer crown to its original coronal contour.

The radicular portion of each tooth was embedded in clear auto polymerizing acrylic resin [Epo-Kwick, Buehler] such that only 2mm of the tooth is exposed. Each tooth received endodontic therapy that included instrumentation till 55-size k- file files (Maillefer, Dentsply, Ballaigues, Switzerland) 1mm short of the working length. The cleaning and shaping was done by step back technique. Canals were recapitulated using smaller size files. Saline (Baxter, Alathur, TamilNadu, India) and 5.2% sodium hypochlorite (NaOCl) (Prime Dental products pvt ltd, Mumbai, India) were used as irrigant. No.55 Gutta percha point (Maillefer, Dentsply) was selected as master cone. After instrumentation the roots were dried using paper cones. Obturation was done by lateral condensation technique using Gutta percha and Seal Apex [Sybron Endo] as root canal sealer. The teeth were stored in saline at room temperature.

After 48 hours of Obturation, Gutta percha was softened by hot vertical plugger and removed by Gates gliden drill [Mani INC, Tochigi, Japan] to a depth of 4mm coronal to the root apex. The post spaces were irrigated with and 17% Ethylene Diamine Tetra Acetic acid (EDTA) (Glyde, Maillefer, Dentsply, Ballaigues, Switzerland) followed by5.2% sodium hypochlorite (NaOCl)(Prime Dental products pvt ltd, Mumbai, India). The post space was dried with paper point and compressed air. Each tooth was prepared for a full veneer crown with 1.2mm wide rounded shoulder at Cemento Enamel Junction. After finishing the margin and tooth surface, the coronal tooth structure was removed horizontally with water spray- cooled diamond abrasive point [Mani DIA burs, Tochigi, Japan] at high speed, creating a flat coronal surface perpendicular to the long axis of the tooth and only 1mm tooth structure above Cemento Enamel Junction was retained. All the prepared teeth were randomly divided into five groups of six specimens each.

In-group I, each tooth was restored with Carbon Fiber post [Mirafit, Hager Worldwide, Inc, Odessa, USA] with 2mm diameter .The posts was trial inserted into the respective analogue. The post was luted with dual cured resin luting cement [Panavia 21, Kuraray America, Inc, NJ] after the dentin was etched and then coated with dentin bonding agent according to manufacturer's direction [3M-Rely X Arc]. The core was subsequently built up in resin composite [Tetric ceram, shade A2, Ivoclar vivadent, Schaan, Liechtenstein]. Teeth in groups II, III& IV received treatment similar to group I, except for change in posts. Group II utilized Luscent Anchor post [Dentatus USA Ltd, NY, USA] Group III received Stainless Steel spilt shank post [Flexi post, Essential Dental Systems, Inc, NJ]. Group IV used Titanium post [Dentatus Classic System, Charles B.Schwed co, Inc, NJ]. In-group V, teeth were restored with cast post and core.

The crowns were fabricated after 24 hours. The crown patterns were directly waxed on the respective post and core and cast in a predominately base metal alloy [Sankin CB 80]. The individual impression of each tooth, which was taken with poly-vinyl siloxane material [Affinis precious, Coltene/whaledent, Burlingame, CA] during the initial stages, helped us maintain the original coronal contour of respective teeth. The crowns were finished polished and cemented with luting GIC Type I [GC corporation, Tokyo, Japan]. Specimens were stored in normal saline at room temperature for 1 week

The specimens were mounted on a universal instron testing machine [AG-1000E, Shimadzu] and subjected to a compressive load on the lingual ledge of the crown at an angle of 130 to the long axis of the tooth. The load was applied at a crosshead speed of 2.5mm/min until there was a sudden drop of the stress strain curve. The readings were recorded. The predominant modes of failure of each specimen were classified as: core fracture, coronal tooth fracture, post dislodgement and root fracture according to its location.

RESULTS

The mean failure load for each group was as follows Group 1(Carbon fiber post): 27.43Kg(Standard deviation SD 2.03]; Group2 (Luscent Anchor post): 28.65 Kg (SD 2.09); Group 3 (Stainless Steel spilt shank post): 29.63 kg (SD 1.22); Group 4 (Titanium post): 26.64 kg (SD 1.66); Group 5 (Cast post and core): 30.64kg (SD 1.99).

Figure 1

Table 1

Group name	Core fracture	Post dislodgement	Coronal tooth fracture	Root fracture
Group I [CFP]	6	2	0	0
GROUP II [LUSCENT]	6	1	1	0
GROUP III [FLEXI-SS]	5	1	2	0
GROUP IV [TITANIUM]	6	0	2	2
GROUPIV [CAST POST]	0	4	5	3

Figure 2

Table 2

	GROUP I	GROUP II	GROUP III	GROUP IV	GROUP V
GROUP I	_	NS	NS	NS	NS
GROUP II	NS	_	NS	NS	NS
GROUP III	NS	NS	_	NS	NS
GROUP IV	NS	NS	NS	_	S
GROUP V	NS	NS	NS	S	_

DISCUSSION

The result of the present study showed that there is a statistical difference in fracture threshold between group IV and V. This shows that the fracture threshold for cast post and core groups was significantly higher than the titanium post. Cast post and core has the highest fracture threshold. This could be due increased rigidity. Titanium post has the lowest threshold due to its inherent low fracture strength [4].Group I when compared to group II, III, IV and V were not statistically significant. The same way groups II, III, IV, V when compared with other groups were statistically insignificant except group IVand V. The statistically insignificant within groups denote that the mean difference in fracture threshold among them were not considerably high.

In Group I (Carbon fiber post, Mirafit, Hager Worldwide, Inc, Odessa, USA) there was no evidence of any tooth fracture. There is mere breakage of core thereby reducing the tooth fracture. This can be attributed to their longitudinal arrangements of fibers [5] and the modulus of elasticity matches with that of dentin [6] possessing high tensile strength [5]. This will distribute the forces away from the shoulder. This results in likely hood failure of post or post tooth interface instead of tooth fracture. The Carbon fiber adhesively bonds to composite. It is claimed that when the post is used with adhesive luting agents and composite resin core materials, the system can form an adhesively retained homogenous restoration, which will distribute the force more uniformly along the long axis of the tooth, which could reduce stress concentration and thus reduce the rate of failure [7].

In Group II (Luscent Anchor, Dentatus USA Ltd, NY, USA) almost all specimens showed core fracture except with one specimen showing post dislodgement and one tooth fracture. These posts have ability to absorb and distribute occlusal and functional stresses that are applied to bonded post crown complex and redirect them along the long axis of the root [8]. If failures occur they might result in teeth that are less severely damaged and ultimately could be restorable. This post has glass particles, which conduct light, and helps in complete polymerization of resin cement [8] making it a homogenous restoration along with the composite core. This homogenous restoration can uniformly transfer the stress along the long axis of the tooth, which could reduce stress concentration and thus reduce the rate of failure [7,8]. The root fracture in this group may be due its modulus of elasticity twice that of dentin which is higher than carbon fiber posts [9]. The fracture threshold observed in this group is higher compared to other groups, which may due to difference in the rigidity [10].

Group III [Flexi post, Essential Dental Systems, Inc, NJ] showed more evidence of coronal tooth fracture. The spilt shank may provide a stress breaking function by collapsing during the development of threaded post space and minimizing hydrostatic backpressure during insertion [11]. The improved failure rate could also be related to the minimal thread penetration into the dentin. Flexi post binds primarily in the coronal dentin. Compressive loading of flexi post causes high stress concentration in the coronal half of the post channels. This stress concentration can cause coronal tooth fracture [3,12,13]. The modulus of elasticity of stainless steel is twenty times greater than that of dentin [7]. This increase in modulus of elasticity can be attributed to its increased fracture threshold.

Group IV (Titanium post, Dentatus Classic System, Charles B.Schwed co, Inc, NJ) exhibits the lowest fracture threshold among all the other groups with two-specimen showing root fracture. This post incorporates retention by interlocking the

cement between the undercuts found on the post surface and grooves created in the canal wall during post space preparation. This surface design produces wedge like action of which is responsible for increased stress concentration at the tapered apical end resulting in root fracture [14]. For Titanium, the modulus of elasticity is ten times greater than dentin [7]. Titanium posts with high modulus of elasticity do not flex with tooth under loading and are believed to cause root fracture. Titanium alloys have low fracture strength, which might have caused it to fracture at low fracture threshold [4]. Further due to its low fracture strength these posts break while retrieving for re-treatment[4].

Group V (Cast post) showed highest fracture threshold. Maximum samples in this group showed tooth fracture because of its increased rigidity. Cast post is made up of rigid metal with a much high modulus of elasticity than tooth material and has the potential to create apical stresses and fractures in root dentin as the result of crushing forces. This may be the cause for high root fracture in cast post [15]. The other causes for root fracture in cast post can also be minute nodules on the cast post that can cause wedging stresses which can precipitates root fracture [16]. The highest fracture threshold in this group can be attributed to its rigidity. Sidoli.G et. al [17] reported higher fracture resistance for cast post, which also correlates with this study.

Sidoli.G and Cormier .M classified fractures into favorable and unfavorable fractures .If the tooth fractured below the surrounding acrylic resin, the fracture was considered to have been unfavorable and all other types of fracture were considered to have been favorable [18]. In this study except group IV and V all other failures were considered to be favorable. The variables in fracture threshold among the groups may be due to variations in rigidity of post materials used, variations in dentinal quality because of the age of the patient, time lag between extractions and percentage of cyclic fatigue tooth received before extraction [16].

CONCLUSION

Within the parameters of the experimental model used in this in-vitro study concludes that groups, which have modulus of elasticity close to that of dentin like Carbon Fiber post, Luscent Anchor post, fared well. They produce favorable tooth fracture, which is restorable. In contrast groups those have modulus of elasticity more then dentin can cause unfavorable root fractures, which have a bad prognosis. The fracture threshold was highest for Cast post and core and lowest for Titanium post.

Data from previous studies can help in understanding the clinical problems, but must be appropriately analyzed to ensure that the conclusions are not misleading. Additional well-designed longitudinal, in vivo investigations of various posts with increased specimen numbers are needed to clarify the specific indications and prognosis for various posts.

References

1. Milot.P, Stein. R.S. Root fracture in endodontically treated teeth related to post selection and crown design. Journal of prosthetic dentistry. September 1992; Vol 68(5); 428-435.
2. Cohen. S, Burns C.R. Pathways of pulp. Eighth edition 2002.
3. Burns A.D, Krause. R.W, Douglas.P and Burns. R.D. Stress distribution surrounding endodontic posts. Journal of prosthetic dentistry. October 1990; 6(4):412-424.
4. Schwartz .S.R and Robbins. W.J. Post placement and restoration of endodontically treated teeth: A literature review. Journal of Endodontics. May 2004; 30 (5): 289-301.
5. Raygot.C.G, Chai.J and Jameson.L. Fracture resistance and primary failure mode of endodontically treated teeth restored with carbon fiber- reinforced resin post system- in vitro. The International Journal of Prosthodontics. 2001; 14 (2): 141-145.
6. Tidarmarsh.Restoration of endodontically treated posterior teeth, Journal of endodontics .1976; 2:374-375.
7. Cormier.C.J Burns. D.R and Moon .P. In vitro comparison of fracture resistance and failure mode of fiber, ceramic, and conventional post systems at various stages of restoration journal of prosthodontics. March 2001; 10 (1): 26 -36.
8. Maccari C.A.P, Conceicao. N, Nunes F.E.M. Fracture resistance of endodontically treated teeth restored with three different prefabricated esthetics posts. Journal of esthetic and restorative dentistry.2003; 15(1): 25-30.
9. Richard S.Schwartz, James B.Summit, J.William Robbins, Jose Dos Santos [Illustrator]. Fundamentals of Operative dentistry. Quintessence publishing company .Jan 1996.
10. Isidor .F, Odman.P and Brondum .K. Intermittent loading of teeth restored using pre fabricated carbon fiber posts. Intl J prosthodont. 1996; 9:131-136.
11. Greenfeld .S.R, Roydhouse .H.R, Marshall. F. J and Schoner .B. A comparative study of two post systems under applied compressive shear loads. Journal of prosthetic dentistry January 1989; 61 (3): 17- 24.
12. Standlee.P.J and Caputo. A.A.The retentive and stress distributing properties of spilt threaded endodontic dowels. Journal of prosthetic dentistry. September 1992; 68: 436-442.
13. Stockton .L.W, Williams P.T and Clarke C.T. Post retention and post/core shear bond strength of four post systems. Operative dentistry. 2000; 25: 441-447.
14. Akkayan Begum and Turgut Gulmez.Resistance to fracture of endodontically treated teeth restored with different post systems. Journal of prosthodontics, April 2002; 87(4): 431-437.
15. Assif. D, Oren.E and Marshak.B.L and Aviv. I. Photoelastic analysis of stress transfer by endodontically treated teeth to the supporting structure using different restorative techniques. Journal of prosthetic dentistry. May 1989; 61 (3): 535-542.
16. Morgano.M.S and Milot.P. Clinical success cast metal and posts and cores. Journal of prosthetic dentistry. July

1993;CD-ROM: 11-16.
17. M. Sadeghi. A Comparison of the Fracture Resistance of Endodontically Treated Teeth using Three Different Post Systems. Journal of dentistry .Feb 2006; 3(2): 69-76.
18. Sidoli.E.G, King .A.P and Sctchell. J.D. An in vitro evaluation of a carbon fiber-based post and core system. Journal of prosthetic dentistry. July1997; CD-ROM: 5-9.

Author Information

C. Dhanavel, M.D.S [Conservative Dentistry& Endodontics]
Department Of Conservative Dentistry& Endodontics, Karpaga Vinayaga Institute Of Dental Sciences

K. Madhuram, M.D.S [Conservative Dentistry& Endodontics]
Department Of Conservative Dentistry& Endodontics, Karpaga Vinayaga Institute Of Dental Sciences

V. Naveenkumar, M.D.S [Conservative Dentistry& Endodontics]
Department Of Conservative Dentistry& Endodontics, Karpaga Vinayaga Institute Of Dental Sciences

R. Anbu, M.D.S [Conservative Dentistry& Endodontics]
Department Of Conservative Dentistry& Endodontics, Karpaga Vinayaga Institute Of Dental Sciences