Laboratory Assessment of Fracture Resistance of Endodontically Treated Teeth Restored With Three Different Post and Core Systems

L. Ranjbar Omrani [1], E. Yassini [2], M. Mirzaei [1], M. Abbasi [1], N. Baniasad [3], H. Kermanshah [1]✉

[1]Assistant Professor, Department of Operative Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[2]Professor, Department of Operative Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[3]Dentist

Abstract

Background and Aim: Prefabricated posts are advantageous in restoring endodontically treated teeth because of their lower cost and operation time. Since selecting a suitable restoration is important in the survival of these teeth, in this study fracture resistance and the mode of failure of endodontically treated teeth restored with three different post and core systems were evaluated.

Materials and Methods: In this in vitro study, 36 human premolars were divided into three groups; namely, group 1, non precious cast post and core; group 2, prefabricated metal post with amalgam core; group 3, FRC post and composite core. All groups received crowning. Specimens were thermocycled and loaded until definite failure. The fracture resistance and failure modes were analyzed with one way ANOVA and Fisher Exact tests.

Results: The mean failure load for the three groups was 794, 647 and 724 N, respectively. Statistical analysis did not show any significant differences between the fracture resistance of the three experimental groups (P=0.0579). All failures in group 1, eight in group 2 and three in group 3, were unrestorable. Fisher's Exact test showed significant difference between group 3 and the two other groups (P<0.05).

Conclusion: If there is a 2-mm ferrule, the type of post and core does not have a significant effect on the fracture resistance, but it has a significant effect on the failure mode.

Key Words: Reconstruction, Endodontically treated teeth, Post and core, Fracture resistance

✉ **Corresponding author:**
Kermanshah H., Assistant Professor, Department of Operative Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
kermanshahhamid@yahoo.com

Introduction

The need for an appropriate restoration has increased in root canal treated teeth [1-3]. Clinical studies show that the major cause of failure in endodontically treated teeth is the low quality of restoration [4-9]. Fracture resistance of these teeth following restoration with post and core is a matter of continuous debate. Controversial issues have been declared by the literature about the effect of posts on fracture resistance of endo-

dontically treated teeth. Sidoli et al [10] stated that fracture resistance of root canal treated teeth restored by cast metal, stainless steel, and fiber-reinforced posts are not significantly different while using a one-millimeter ferrule and crown, but cast metal post and core systems induced a higher rate of non-restorable fractures. On the other hand, SuaIn and co-workers [11] declared that teeth restored by cast gold posts significantly provided a higher resistance to fracture in

comparison with those restored by carbon fiber posts. Sirimai et al evaluated fracture resistance of teeth restored by cast metal, prefabricated and fiber posts. They concluded that teeth restored by cast metal posts had a higher resistance to fracture but showed more non-restorable patterns of root fracture, but in teeth restored with fiber posts only one case of root fracture was considered non-restorable. Four-year clinical success of cast metal and fiber-reinforced posts were compared in a study by Ferrari et al [12] It was concluded that the success rate of fiber-reinforced posts (90%) was more than that of cast metal posts (84%). In a study by Raygot et al [13] no significant difference was observed in fracture resistance of anterior teeth restored by cast, prefabricated or fiber-reinforced posts. Fractures occurred in 70-80% of cases in supra-crestal areas. Rosentrit [14] restored and compared anterior teeth with ceramic, fiber-reinforced and prefabricated posts and found that teeth restored with tooth-colored posts had a higher resistance to fracture in comparison with prefabricated metal posts. Salameh and colleagues [15] stated that use of fiber post in composite restoration of maxillary anterior teeth enhances their fracture resistance and improves their prognosis.

Although studies concerning fracture resistance and fracture mode of endodontically treated with different post and core systems are numerous, prefabricated posts accompanied by amalgam cores have not been investigated and use of composite cores that have bonding ability to the tooth structure is common in all investigations. On the other hand, in the majority of studies crowns are not placed upon post-retained foundations. This can minimize similarity of in vitro conditions with the real time situation. The aim of this study was to evaluate fracture resistance and fracture mode of endodontically treated teeth restored by cast metal post and core systems using two types of nationally available prefabricated posts.

Materials and Methods

This in vitro study consisted of a total of 36 sound human freshly extracted (i.e., less than 3 months) premolar teeth without any coronal carious lesions. Teeth were stored in 5% chloramine T solution for 1 week. Samples were randomly divided into three groups of 12. Using One-way ANOVA no significant difference was statistically observed in occluso-gingival and bucco-lingual dimensions of the crowns and roots among samples. (p>0.05) Samples were stored in isotonic saline solution during the experiment. The samples were decoronated 2mm above the CEJ. A one-millimeter deep chamfer finishing line with a two-millimeter ferrule was prepared. Root canals were manually prepared using step-back technique and stainless steel K-type files (Dentsply-Maillefer, Baillaigues, Switzerland). A no. 30 K-file was used as the master apical file and Gates Glidden drills no. 2 through 4 (Dentsply-Maillefer, Baillaigues, Switzerland) were used for coronal flaring. Root canals were obturated using lateral compaction of gutta percha (Dentsply-Maillefer, Baillaigues, Switzerland) and AH-26 resin sealer (Dentsply De Trey, Konstanz, Germany). Experimental groups were as follows:

Group 1: teeth restored with base metal post and core system (C&M Co, Switzerland)

Group 2: teeth restored with brass type gold plated crosshead screw posts (Nordin Dental Co., Switzerland) and a high copper non-gamma 2 spherical amalgam core (Cinalux, Faghihi Co., Iran)

Group 3: teeth restored with prefabricated glass fiber posts (Angelus dental reforpost; Angelus, londrina, PR, Brazil) and composite (Z250; 3M/ESPE, St. Paul, MN, USA) cores.

At least a four-millimeter apical plug of gutta percha remained to provide apical seal after post space preparation.

In group 1 acrylic template of the cast post and core system was prepared by Duralay (Iran ARIA DENT, Asia Chemi Teb Co., Iran) and the 5.5 millimeter core was cast using a nickel-

chromium base metal alloy. Posts were cemented using a zinc phosphate cement. (Adhesor, Spofa-Dental, Kerr Co, Germany)

Samples in group 2 were restored using proper-sized funnel-shaped gold plated crosshead screw posts (Nordin Dental Co., Switzerland) cemented by a zinc phosphate cement (Adhesor, Spofa-Dental, Kerr Co, Germany). Foundation restoration was performed using a high copper non-gamma 2 spherical amalgam core (Cinalux, Faghihi Co., Iran) after placement of a tofflemeier matrix to the height of 5.5 millimeters. Impression was made following coronal preparation.

In group 3 glass fiber posts (Angelus Dental Inc., Brazil) were cemented using a dual cure cement (Panavia F2 Kuraray, Tokyo, Japan) and cured for 20 seconds (Optilux 501, Kerr, Germany) using a power of 450 mW/cm^2. The intensity of the light source was frequently monitored. The dentinal surface of the crown was etched with a 37% phosphoric acid for 15 seconds and bonded (SingleBond, 3M/ESPE, St. Paul, MN, USA). The core restoration was placed to the height of 5.5mm and the tooth was prepared for impression following finish line refining. All preparations were performed by an experienced clinician. Impressions were made using a heavy and light body condensational polyvinyl siloxane (Speedex, Coltene) using plastic molds. Full metal crowns were prepared for all samples using a base metal nickel-chromium alloy. Restorations were cemented by the mentioned zinc phosphate cement following a fitness control for 4 minutes under pressure. Afterwards, teeth were mounted in a self-curing acrylic resin (Rapid Repair, Dentsply, USA) so that the crown margin was located 2 millimeters coronal to the acrylic edge. Subsequently, the samples were placed in distilled water for 24 hours in 37 degrees centigrade and subjected to thermal cycling with a frequency of 1000 cycles including 30 seconds of cold water with a temperature of 5 degrees centigrade, 30 seconds of warm water with a temperature of 55 degrees centi-

grade and 10 seconds of rest time. Following completion of thermal cycling, samples were placed in a universal loading machine (Zwick/Roel Z050) under static forced and a crosshead speed of 1mm/min. Samples were placed in their occlusal to middle one-thirds at a 45-degree angle with respect to their long axes. The initial drop in the recorded force-time curve of the samples was considered as resistance to fracture. (See table 1) Force application continued to clarify modes of failure. The samples were photographed to visualize fracture modes. Fractures superior to the acrylic margin were considered restorable and those extending beneath the acrylic margin was deemed non-restorable and unfavorable. Statistical measurements including mean, standard deviation and standard error was performed upon the obtained figures.

Table 1: The amount of applied forces on the samples at the time of failure

group / number	Group 1	Group 2	Group 3
1	627/59	813/85	188/79
2	534/62	404/64	507/89
3	1201/88	836/67	445/97
4	668/26	291/94	882/19
5	950	474/5	769/45
6	689/24	477/93	513/84
7	1003/06	504/66	1458/61
8	1007/21	1014/55	441/88
9	627/33	952/5	528/09
10	668/18	388/6	298/14
11	758/45	817/3	1915/14
12	746/69	788/81	188/79

Statistical analysis of the fracture modes was performed using one way analysis of variance (ANOVA). Fracture modes were also tested for their reliability using fisher exact test.

Results

The mean fracture resistance for the experimental groups were 793.96±57.46 N, 647. 16±71.33

N, and 724.66±144.07 N for the groups 1, 2, and 3, respectively. One way analysis of variance showed no significant difference among the experimental groups. (p=0.0579 > 0.05)

In group 1, 10 fractures occurred obliquely from the crown margin to a point beneath acrylic resin. One fracture occurred vertically, and another horizontally beneath the acrylic margin. All fracture types were considered non-restorable. In group 2, seven fractures happened obliquely to a point below the acrylic margin, and three horizontal fractures above the acrylic margin. One core fracture and one horizontal root fracture below the acrylic margin was also seen. Among all, eight fractures were non-restorable and eight restorable. In group 3, five post or core separation, four fractures above the acrylic margin, two fractures beneath the acrylic margin and one vertical root fracture was observed. In all cases, posts were removed from the canals in attempts to remove the fragments.

Fisher exact test sowed no significant difference between groups 2 and 3 (p>0.05), but significantly more restorable fractures were encountered in group 3 in comparison with the other two groups. (p<0.05)

Discussion

Controversial issues have been stated about the effect of post in fracture resistance of endodontically treated teeth. It appears that factors such as crowning the samples, remaining dental tissue, the amount of ferrule, speeds and angulations at which forces are applied, type of restorative material and cement, type, and length of the post are influential in fracture resistance in different studies [16-24]. In this study, the samples were equally crowned and a two-millimeter ferrule was used to simulate clinical conditions. Also, the length, diameter and design of the posts were selected according to the previous studies. The forces were applied at a 45-degree angle which is more destructive than vertical forces.

According to the conditions of the present study, fracture forces were 794, 647 and 724 N. The maximal and minimal resistance to fracture was related to the cast metal post/core and prefabricated post/amalgam core systems, respectively. There was no statistically significant difference in resistance to fracture among three different post systems. This can be attributed to the effect of the two-millimeter ferrule in experimental groups. It is corroborated by other studies that use of crown with adequate ferrule can minimize the effect of post [16-19,25,26] In other words, remaining dental tissue plays an integral part in fracture resistance of root canal treated teeth. [22,27] Silva and co-workers evaluated the effect of post, core, crown type, and presence of ferrule on biomechanical behavior of root canal treated teeth and concluded that presence of a two-millimeter ferrule from an intact dental tissue can improve stress distribution within the root structure regardless of the post or crown type [22]. Studies have shown that when the remaining dental tissue is inadequate following root canal treatment, the role of post in stress distribution will become more pronounced. [23,28,29] It was shown that unfavorable types of fracture was less frequently observed in teeth restored by fiber post and composite core. This can be due to closeness of modulus of elasticity of dentin and fiber post that causes a more even stress distribution within the root, thereby reducing the possibility of unfavorable fracture. It has been observed by other authors that metal post cause root fractures more frequently than do FRC posts, therefore repairing their restoration following fracture is more probable [2,5,9,20,27]. It has to be noted that attempts to remove the fragment in FRC group caused complete removal of the post from within the canal. This can show weakness in bonded area. When stress reaches a critical level, some cracks are propagated within the weakest point of the complex i.e. the bonded area causing separation of the post from the root canal wall. Then, transferring the forces to the post-root interface can cause root fracture [23].

Conclusion

1.There was no difference in resistance to fracture between teeth restored by cast metal posts, prefabricated posts/amalgam core, and FRC posts/composite cores when crowns with two-millimeter ferrules were placed. It might be concluded that a 2-millimeter ferrule could neutralize the effect of post/core in fracture resistance of endodontically treated teeth.

2.Use of FRC posts are suggested to effectively reduce non-restorable root fractures when a 2-millimeter ferrule can be provided due to the closeness of modulus of elasticity of FRC posts with that of dentin.

References

1-Cheung W. A review of the management of endodontically treated teeth post, core and the finalrestoration. J Am Dent Ass. 2005May; 136 (5):611-619.

2-Sirimai S, Riis DN, Morgano SM. 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 Mar;81(3):262-9.

3-Insua A, Da Silva L, Rilo B, Santana U. Comparison of the fracture resistances of pulpless teeth restored with a cast post and core or carbon-fiber post with a composite core. J Prosthet Dent. 1998 Nov;80(5):527-32.

4-Soernsen JA, Martinoff JT. Endodontically treated teeth as aboutments. J of prosthet Dent. 2003 May;53(5):631-6.

5-Vire DE .Failure of endodontically treated teeth: classification and evaluation.J Endodont. 1991Jul; 17(7):338-42.

6-Fuss Z, Lusting J, Tames A. Prevalance of vertical root fracture in extracted endodontically treated teeth. Int Endod J. 1999Aug; 32(4):283-6.

7-Salehrabi R, Rostein I. Endodontic treatment outcomes in a large patient population in the USA: An epidemiological study. J Prosthet Dent. 2003 Dec; 30(12):846-850.

8-Aquilino SA, Caplan DJ. Relationship between crown placement and the survival of endodontically treated teeth. J Prosthet Dent. 2002 Mar; 87(3):256-263.

9-Zadic Y, Sandler V, Bechor R. Analysis of factors related to extraction of endodontically treated teeth. Oral Surgery Oral Med Oral Pathol Oral Radiol Endod. 2008Nov; 106(5):e31-e35.

10-Sidoli G, King E, Setchell P, Derrick J. An in vitro evaluation of a carbon fiber-based post and core system. J Prosthet Dent. 1997Jul; 78(1):5-9.

11-Insua A, Da Silva L, Rilo B, Santana U. Comparison of the fracture resistances of pulpless teeth restored with a cast postsand core or fiber carbon post with a composite core. J Prosthet Dent. 1998 Nov; 80(5):527-32.

12-Ferrari M, Vichi A, Garcia-Godoy F.Clinical evaluation of fiber-reinforced epoxy resin posts and cast post and cores. Am J Dent. 2000 May; 13 (spec No):15B-18B.

13-Raygot C G, Chai J, Jameson D L.Fracture resistance and primary failure mode of endodontically treated teeth restored with a carbon fiber-reinforced resin post system in vitro. Int J Prosthet. 2001 Mar-Apr;14(2):141-5.

14-Rosentritt M, Sikora M, Behr M, Handel G. Invitro fracture resistance and marginal adaptation of metallic and tooth-coloured post systems. J Oral Rehabil. 2004 Jul;31(7):675-81.

15-Salameh Z, Sorrentino R, Ounsi HF, Sadig W, Atiyeh F, Ferrari M. The effect of different full-coverage crown system on fracture resistance and failure pattern of endodontically treated maxillary incisors restored with or without glass fiber posts. J Endod. 2008 Jul;34(7): 842-846.

16-Pereira JR, De Ornelas F, Conti PC, do Valle AL. Effect of a crown ferrule on the fracture resistance of endodontically treated teeth restored with prefabricated posts.2006;32:567-71.

17-Akkayan B, DMD. An invitro study evaluating the effect of ferrule length on fracture resistance of endodontically treated teeth restored with Fiber reinforeced and zirconia dowel systems. J Prosthet Dent. 2004 Jan; 92(1):155-60.

18-McDonald A V, King P A, Setchell D. In vitro study to compare impact fracture resistance of in-

tact root-treated teeth. Int Endod J. 1990 Nov; 23 (6):304-12.

19-Dean J P, Jeansonne BG, Sarker N. In vitro evaluation of carbon fiber posts. J Endod. 1998 Dec; 24 (12):807-10.

20-Goto Y, Nicholls JI, Philips KM, Junge T. Fatigue resistance of endodontically treated teeth restored with three dowel and core systems. J Prosthet Dent. 2005 Jan; 93(1):45-50.

21-Teixeira CS, Silva-Sousa YT, Sousa-Neto MD. Bond strength of fiber posts to weakened roots after resin restoration with different light-curing times. J Endod. 2009 Jul; 35(7):1034-1039.

22- Da Silva NR, Raposo LH, Versluis A, Fernandes-Neto AJ, SoaresCJ. The effect of post, core, crown type, and ferrule presence on the biomechanical behavior of endodontically treated bovine anterior teeth. J Prosthet Dent. 2010 Nov; 104 (5):306-317.

23-Da Silva GR, de Santios-filho PC, Simamoto-junior PC, et al. 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.

24-Buttel L, Krastl G, Lorch H, Naumann M, Zitzmann NU, Weiger R. Influence of post fit and post length on fracture resistance. Int Endod J. 2009 Jan;42(1):47-53.

25-Fokkinga WA, Kreulen CM, Le Bell-Rnnlf A-M, Lassila LVJ, Vallittu PK, Creugers NHJ. In vitro fracture behaviour of maxillary premolars with metal crowns and several post-and-core systems. Eur J Oral Sci. 2006 Jun; 114(3):250-6.

26-Hu Y-H, Hsu C-C, Lau Y-H. Fracture resistance of endodontically treated anterior teeth restored with four post-and-core systems. Quintessence Int. 2003 May;34(5):349-53.

27-Le Bell-Rönnlöf AM, Lassila LV, Kangasniemi I, Vallittu PK. Load-bearing capacity of human incisor restored with various fiber-reinforced composite posts. Dent Mater. 2011 Jun; 27(6):107-115.

28-Bitter K, Noetzel J, Stamm O, Vaudt J, Meyer-Lueckel H, Neumann K, et al. Randomized clinical trial comparing the effects of post placement on failure rate of postendodontic restorations: preliminary results of a mean period of 32 months. J Endod. 2009 Nov; 35(11):1477-1482.

29-Mangold JT, Kern M. Influence of glass-fiber posts on the fracture resistance and failure pattern of endodontically treated premolars with varying substance loss: an in vitro study. J Prosthet Dent. 2011 Jun;105(6):387-93.