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

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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

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 endodontically 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, Sualn 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 consi-
dered 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 com-
pared 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 col-
leagues [15] stated that use of fiber post in com-
posite restoration of maxillary anterior teeth en-
hances 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 foun-
dations. 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 us-
ing two types of nationally available prefabric-
cated 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 ca-
rious lesions. Teeth were stored in 5% chloro-
mine T solution for 1 week. Samples were ran-
domly 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 ex-
periment. 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, Baillauges, Swit-
zerland). A no. 30 K-file was used as the master 
apical file and Gates Glidden drills no. 2 through 
4 (Dentsply-Maillefer, Baillauges, Switzerland) 
were used for coronal flaring. Root canals were 
 obturated using lateral compaction of gutta per-
cha (Dentsply-Maillefer, Baillauges, 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, 
lonrina, 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. (Adhe- 
sor, 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 toffle-
meier matrix to the height of 5.5 millimeters. 
Impression was made following coronal prepara-

tion.
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, Ger-
many) using a power of 450 mW/cm². The in-
tensity of the light source was frequently moni-
tored. 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 po-
lyvinyl 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 men-
tonced zinc phosphate cement following a fitness 
control for 4 minutes under pressure. After-
wards, teeth were mounted in a self-curing acryl-
ic resin (Rapid Repair, Dentsply, USA) so that 
the crown margin was located 2 millimeters co-
ronal to the acrylic edge. Subsequently, the 
samples were placed in distilled water for 24 hours 
in 37 degrees centigrade and subjected to ther-
mal cycling with a frequency of 1000 cycles in-
cluding 30 seconds of cold water with a tempera-
ture 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 contin-
ued 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 be-
neath the acrylic margin was deemed non-
restorable and unfavorable. Statistical measure-
ments including mean, standard deviation and 
standard error was performed upon the obtained 
figures.

<table>
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<th>Group 3</th>
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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 experi-
mental 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 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
18-McDonald A V, King P A, Setchell D. In vitro study to compare impact fracture resistance of in-