

Comparison of Fracture Strength of Endodontically Treated Teeth Restored with Two Different Cast Metallic Post Systems

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Abstract

Statement of Problem: Endodontically treated teeth are more prone to fracture. The post and core are often used to provide the necessary retention for prosthetic rehabilitation. **Objectives:** The purpose of this study was to: 1) compare the fracture strength of endodontically treated teeth restored either with Nickel-Chromium (Ni-Cr) post or Non-Precious Gold-color alloy (NPG) post compared to the control group and 2) evaluate the fracture site in each group.

Materials and Methods: In this experimental study, endodontic treatment was carried out for 45 extracted maxillary premolars. The specimens were divided into 3 groups (n=15). Group1: restored with NPG post and core, group2: restored with Ni-Cr post and core, and group 3, no post and core were used after endodontic treatment and the access cavity was filled with amalgam. Failure force was recorded in Newton when root or remaining coronal structure fracture was occurred. Data were analyzed using one-way analysis of variance (ANOVA), Student t-test and Tukey HSD test to compare the three groups.

Results: There was a statistically significant difference among all groups (P<0.05). Fracture resistance of the teeth restored by NPG posts was significantly higher than those restored by Ni-Cr (P<0.001). Results showed that the fracture mainly occurred in the root of the teeth restored with Ni-Cr and NPG post while fractures occurred in the core portion of the teeth restored with amalgam.

Conclusions: The findings of the present study indicated that the fracture strength of the teeth without using cast post and core was significantly lower than the teeth restored with cast post and core. Also the teeth restored by NPG post had a significantly higher fracture resistance than Ni-Cr posts.

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Introduction

Dental decay is a destructive chronic disease with multifactorial etiopathogenicity that determines dental hard tissue loss, and pulp injury. The decision to maintain, restore and particularly use an endodontically treated tooth as abutment, depends on the amount of tooth structure remained, radicular morphology and its periodontal health [1, 2]. Coronal destruction,

aesthetic demand and tooth integrity determine the type of restoration. Generally a pulpless tooth is weak due to decays, previous restorations, access cavity, brittleness and loss of moisture caused by the vital pulp [3-5]. Therefore, placement of the post and core is often used to provide reinforcement, replace the lost dentin, and provide crown protection and necessary retention for subsequent prosthetic rehabilitation [6-8].

The post systems could be fabricated by several

materials with different amounts of rigidity. The difference between the elastic modulus of the dentin and the post material may be a source of stress for root structures [9]. It was reported that the use of post systems with an elastic modulus similar to that of the dentin results in a mechanically homogenous unit with better biomechanical performance [10]. On the other hand, higher modulus of elasticity results in less stress and distribution of more force on the abutment teeth [11, 12]. Therefore, the post and core's material is critical in regard to stress distribution in endodontically treated teeth.

Moreover the size and shape of the post and core, preparation design of the tooth, and type of the used luting agent influence the tooth's resistance to fracture. When properly designed, the custom-made post can conform to a canal of any shape to provide maximum retention and allow more even distribution of stresses throughout the tooth structure [13].

For many years, cast posts and cores were regarded as the treatment of choice for endodontically treated teeth. Cast posts offer a good fit to the root canal, as they are a direct replica of the root canal. The amount of coronal and root structure that remains after root canal treatment and post space preparation plays an important role in the longevity of the tooth and restoration [14-17]. On the contrary, some *in vitro* and *in vivo* studies have demonstrated that a cast post not only does not reinforce endodontically treated teeth, but also causes fracture in the root [18].

The purpose of this study was to compare the fracture strength of endodontically treated teeth with conventional post (Ni- Cr), NPG post and those without post and core systems. The site of fracture in each group was also investigated.

Materials and Methods

In this experimental study, 45 extracted single-root second maxillary premolars, without caries, fracture or crack were selected from Surgical Department of Zahedan Dental School. Teeth with mesio-distal width of 5-5.5 mm and bucco-lingual width of 7-8 mm were selected for standardization purpose using vernier-caliper; root length was approximately 15 mm.

Endodontic Procedure

Access cavity was performed using high speed handpiece and long diamond fissure bur with cooled water. The canals were cleaned and shaped using step back preparation technique with Gates-Glidden

and K-files with a master apical file of No 35. All enlargement procedures were followed by irrigation with 5.25% sodium hypochlorite. AH-26 was used as a sealer and the canals were obturated by gutta-perca using lateral condensing technique. The root surfaces were dipped into a melted wax to a depth of 2 mm, below the cervical line to produce a layer of 0.2 to 0.3 mm using a carver providing this thickness to be approximately equal to the average thickness of the periodontal ligament. The teeth were then mounted in acrylic resin blocks (Pekatray, Bayer, Leverkusen, Germany) and positioned using custom-made positioner such that 2 mm of the cervical part of root was out of acrylic resin (to duplicate the biologic width). Wax spacer was removed from the root surface and from the alveolus of the acrylic resin block. Light bodies of condensate silicone impression material (Speedex, Colten, AG, Feldwiesenstrasse 20, CH-9450 Altstatta, Switzerland) were mixed and applied into the acrylic resin alveolus. The teeth were then reinserted into the test blocks with the same positioned, and the impression material was allowed to set. The thin layer of silicon material simulated the periodontal ligament. After PDL simulation, the teeth were embedded in resin base in 20*20*20 mm³ dimension above cemento-enamel junction (CEJ) with 1mm ferrule effect around the teeth.

All specimens were divided into 3 groups of 15 specimens each. Group1, restored with NPG post and core, group2 restored with Ni- Cr post and core and group 3 as control group.

Post and Core Fabrication Method

The distance from orifice to apex was measured using standardized periapical radiography. Post space was prepared leaving 4mm of Gutta-perca at the apex using peeso-reamer No 2 and 3. Radiographies were taken after preparation. Impression was taken using Duralay acryl and then they casted with NPG or Ni-Cr. The posts were cemented with glass-ionomer cement under firm finger pressure. The characteristic of the alloys is presented in Table 1.

For group 3 as control group, no post was used and only the access cavity was filled with amalgam.

Fracture Strength Testing

Compressive load was applied to the specimens using a universal testing machine (Zwick/Roll Z020; Zwick GmbH & Co, Germany) at a cross-head speed of 0.5 mm/ min, and the maximum load at the specimen failure was recorded. The specimens were fixed to

Table 1: The alloys used in this study

Alloys	Composition	Modulus of Elasticity (MPa)	Vickers Hardness HV1	Elongation Percent %	Compression/ Density g/cm ³	Manufacturer
Ni-Cr	Ni, Cr,Mo,Si,Mn,Al,Cl,	200Gpa	235HV1	12%	824gr/cm ³	Ivoclar Vivadent
NPG	Cu, Al, Fe, Zn, Mn, Ni	Not available	140HV1	15%	7.8gr/cm ³	Aalbadent

Ni-Cr=Nickel-Chromium, NPG=non precious gold alloy

a cylindrical metal base with a 45° hole in its upper part. The indented buccal cusp was placed upward to fit the metal point coupled to the upper part of the universal testing machine. Compression was applied at an angle of 45° to the cusp. All procedures were performed by the same operator. Then the fracture force was recorded in Newton. Data were analyzed by SPSS version 16. One-way analysis of variance (ANOVA), Student t-test and Tukey HSD test were used for statistical analyses at the significant level of 0.05.

Results

Fracture strength was recorded when there was fracture in the root or upon the remaining coronal structure. Table 2 summarizes the fracture strength means obtained for the three groups. Kolmogorov-Smirnov and Shapiro-Wilk tests showed data distribution normality in the three groups. There was a statistically significant difference between the three groups ($P < 0.001$). Post hoc test showed a statistically significant difference between group 1- 2, group 1-3, and group 2 -3. Fracture resistance of the teeth restored by NPG posts was significantly higher than that of those restored by Ni- Cr and that of the control group ($P < 0.001$). In addition, fracture resistance of the teeth restored by Ni- Cr was significantly higher than that of the control group ($P < 0.001$).

Fracture mainly occurred in the root of the teeth restored with posts. However, fracture site was in 12 cores and 3 roots of the control group (Table 3).

Discussion

This study investigated the fracture strength of the endodontically treated teeth restored by conventional Ni-Cr post or NPG post with those without post and core. Also, the site of fracture in each group was evaluated.

It has been shown that the maintenance of 1 mm of the coronal tooth structure was enough to act as ferrule effect [19, 20] and increase resistance [18]. Hence, in the current study, all the specimens had at least 1mm coronal structure as ferrules.

Post fabrication is recommended for the teeth with a high risk of fracture. This is especially true for the maxillary premolars. It was showed that premolars have a fairly high failure rate if restored with two or three surface amalgam restorations [21]. Nimigean *et al* [1] studied 94 digital panoramic radiographies. In their study, a significant rate of post retained restorations was observed on premolars. The lowest percentage of the post retained restoration was recorded in the anterior mandibular teeth. In our study, maxillary premolars were used because they have smaller pulp chambers and less tooth structure, and often require a post [1, 22].

According to the results of the present study, the null hypothesis was rejected means post's material does not affect the fracture resistance of the restored teeth. Bregman [2] reported 90.6% success rate after 6 years of service for custom cast post core. However, the literature reveals the controversies regarding the use of different post-core systems in the management of endodontically treated teeth. Lovdahl *et al* [3] found that endodontically unrestored teeth were twice as resistant to fracture as the post-reinforced teeth. Also Sendhilnathan *et al* [23] showed that endodontically treated teeth restored with cast-post core were as strong as the untreated group. However, Zhi-yue and Yu-Xing [4] reported that the teeth restored with custom cast post- core were more resistant to fracture than endodontically treated teeth. Aquilino *et al* [24] reported that endodontically treated teeth without post were lost six times more than the teeth with post. The findings of the present study indicated that the fracture strength of the teeth without cast post and core was significantly lower than those restored with cast post and core. The reason could be due to loss of moisture supplied by the vital pulp, extensive structural defects due to decay, trauma, and previous restorations. Heydecke *et al*, [25] found no difference in fracture resistance between prefabricated post core and custom cast post core. Sendhilnathan *et al* [23] showed the teeth restored with custom cast post -core had higher resistance to fracture than those restored with prefabricated titanium post and composite core. Hence, cast post-cores were preferred to other systems.

Table 2: Fracture force of endodontically treated teeth (Newton)

Endodontically treated Groups	Mean±SD	Minimum	Maximum	P value
The teeth restored with NPG P&C	966±97	780	1191	< 0.001
The teeth restored with Ni-Cr P&C	516±52	431	609	<0.001
The teeth restored without P&C	107±35	56	160	

NPG: Non- precious Gold-color alloy, Ni-Cr: Nickel- Chromium, P&C: Post and Core

Table 3: Failure type of endodontically treated teeth (N=45)

Failure type	NPG	Ni-Cr	Control
Root structure	11	15	3
Coronal structure	4	0	12
Total	15	15	15

NPG: Non- precious Gold-color alloy, Ni- Cr: Nickel- Chromium

Chetana [26], and Hedge [27] found that fracture resistance of the teeth restored with Ni-Cr post and core was higher than those restored with glass-fiber post. In another study, it was shown that the fracture resistance of the teeth restored by cast metallic post was more than that of the prefabricated posts which could be due to proper fit of these posts to the root canal since they are obtained from an impression taking directly from the root canal. Therefore only a very thin layer of cement fills the space between the dentin and post [18]. But if a prefabricated post is used, the excess space within the root canal would be taken up with a bulk of luting cement which results in a potentially weak area in the restoration; therefore, it may compromise the long-term prognosis of the restored teeth [23-26]. The present study showed that NPG post caused significantly higher fracture resistance of the teeth than Ni-Cr posts which could be due to the similarity of elastic modulus of NPG posts and dentin structure.

Regarding the site of fracture, most failures in the cast post and core occurred in the root. Another study reported that 100% of failures with cast metallic post-core systems occurring in the root [18] which is in agreement with our study. When stress is applied to the post system, a very rigid post (with high modulus of elasticity) will no longer follow the elastic deformation but will create localized stress peak inside the root, eventually leading to root fracture [18].

Conclusions

Within the limitation of present study, the following conclusions were drawn: 1- the fracture strength of the teeth without cast post and core was significantly lower than that in the teeth restored with cast post and core. 2- NPG post caused significantly higher fracture resistance than Ni-Cr posts. 3- The fracture mainly occurred in the root of the teeth restored with Ni-Cr and NPG post while the teeth restored with amalgam fractured in the core portion.

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