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Original Article

Studying Fracture Strength of Root-treated and Reconstructed Teeth with Two Types of Post and Core

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ABSTRACT

In modern dentistry, the optimal treatment of the crowns of root-treated teeth whose crown structure has suffered severe destruction has always been a challenge. The use of Post and Core casting is a way to reconstruct teeth after root canal treatment, whose long-term success has been proven in studies, and it is the treatment of choice for reconstructing teeth with high decay. Therefore, this study was conducted to investigate the fracture strength of root-treated teeth that have been restored with nickel-chromium posts and non-precious gold alloys (NPG). In this study, 20 maxillary central teeth were collected and root canal treatment was performed with the same conditions and equipment for each tooth. Then each tooth was mounted in clear acrylic blocks. Posts and Cores were made by direct method. Then the samples were randomly divided into two groups of 10 each. The posts were cemented and the samples were placed in simulated conditions in the oral environment, and then the Universal Testing Machine recorded the fracture strength of the samples. The t-test was used to compare the average fracture strength. Based on the results, the fracture strength of nickel-chromium post was higher than the fracture resistance of NPG, but there was no significant difference between the two groups ($p > 0.05$). In both groups, most types of failure were irreversible, and there was no difference in the type of failure between the two groups ($p > 0.05$). Based on the results of this study, the fracture strength of teeth restored with two types of post and Core casting, NPG and nickel chrome, is not different from each other.

Keywords: Teeth, Fracture strength, Root, Post and core casting

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Introduction

Restoring root-treated teeth is difficult for various reasons, including maintaining the remaining dental structure, and preventing microleakage, function, and aesthetics. Due to the loss of large amounts of dental tissues in such cases, restoration is faced with problems, and the remaining tissues, especially in the crown part, are not able to maintain the restorative material and bear chewing pressure. Most of the root-treated teeth need crown reconstruction with posts, cores, and veneers to have an acceptable function [1-3]. Rooted teeth and living teeth have similar biomechanical properties and factors increase their susceptibility to failure. Therefore, the lifespan of teeth depends on the amount of dental tissue loss and the ability of restorative materials to replace it [4, 5].

The prognosis of root-treated teeth is affected by the amount of tissue lost in the root, the amount of tooth crown tissue loss, post material type, post design, post length, post diameter, core material type, luting cement and adhesive system, and the height of the ferrule is [5,

6]. Extensive loss of crown structure requires a Post and Core system and complete crown restoration. Post and Core are used to restore materials lost due to caries, trauma, or root canal preparation to provide grip and stability for veneers. The type of material and the construction technique of the Post and Core correspond to the amount of lost minerals [4, 7].

Currently, the material of choice for the Post and Core system of metal casting is Nickel-Chromium (Ni-Cr) alloy. Ni-Cr alloys create a layer of chromium oxide that prevents tarnishing and staining of teeth. These alloys also have disadvantages, for example, most of them have a breaking point of more than half of the root length due to the high hardness of the post. Their advantages include an appearance similar to gold alloys, ease of use and easy casting in the laboratory, proper accuracy, easy polishing, and high quality [8-10]. High biocompatibility, good contrast, and favorable color are the positive features of this type of ceramic. One of the main weaknesses of these types of posts is that the elasticity coefficient is higher than the tooth tissue, which causes concern about stress concentration in the tooth tissue [11-13].

FRC posts (Fiber-reinforced composite) are another type of post used. The main advantages of these posts are good strength, elasticity coefficient close to dentine, and compatibility with bonding techniques. The main disadvantage of these posts is the dark color and ugly appearance [14-16]. The main purpose of glass and quartz FRC posts is to enhance the beauty and eliminate the dark color of carbon FRC posts [17, 18].

This study was conducted to investigate the fracture strength of root-treated teeth that were restored with Post and Core nickel-chromium and NPG.

Materials and Methods

In this in vitro study, teeth with similar lengths and root canal anatomy were selected. A parallel radiographic image was used to examine the anatomy of the root canal **(Figure 1)**.

Figure 1. Examining the root canal anatomy of teeth with parallel periapical radiography.

To homogenize the samples, first, the diameter and length of the teeth were measured and recorded with a digital measuring gauge from the mesiodistal, and buccolingual, encisoapical parts. Samples that had more than three mm of standard deviation were excluded from the study. 20 maxillary central teeth were extracted in 0.9% isotonic solution and kept, and root treatment was performed with the step-back lateral Obturation method. The teeth were cut with a diamond fissure bur with water cooling up to 2 mm above the CEJ (to create a 2 mm ferrule) according to the shape and form of the CEJ, and the teeth that had an encioapical length of less than 15 mm after cutting were were excluded from the study and replaced with another tooth. All specimens were immersed in water for two days at 37°C while the upper 3 mm of the canal was filled with Cavisol dressing. In the next step, the canal of the teeth was emptied from the post seat with a high-speed angle (low-speed device) with piezo one and two, respectively, and the space was prepared for making the post. The channel was washed with water and dried with Powar and using absorbent paper points. At this stage, the teeth were randomly divided into two groups of 10. The first group: post group and blind cast Ni-Cr Wirobond Ni-Cr Alloy (BEGO Ltd., Germany), after canal preparation in this group, molding by pin jet and Duralay acrylic (Reliance Dental Manufacturing, Worth, IL) was done and sent to the laboratory to make Post and Core. The second group was the NPG group (WiroBond NPG Alloy, Aalbadent, USA), all the steps were the same as the first group, and the only difference was the type of alloy that was used in this group. For all the posts, a flat position was installed to apply the force of the device. Finally, after the construction, all the posts were cleaned with 22% ethanol, and the canal was thoroughly washed with water, it was dried and prepared for attaching the post by using an air blower and paper towels so that the dentin was somewhat moist. All posts were cemented and glued with glass ionomer Luting & Lining cement (GC Co; Tokyo, Japan) according to the manufacturer's instructions, and finally all teeth were placed in clear acrylics (Ivoclar Vivadent Co, Zurich, Germany) in such a way that they were mounted according to the clamp of the Universal testing machine (at the same time, the minimum thickness of the acrylic mount was considered to be 2 mm in all areas around the teeth). Then they were subjected to angular pressure at an angle of 45 degrees to the longitudinal axis, two millimeters below (500 N Cell with a crosshead speed of one mm/min of the incisal edge) **(Figure 2)**.

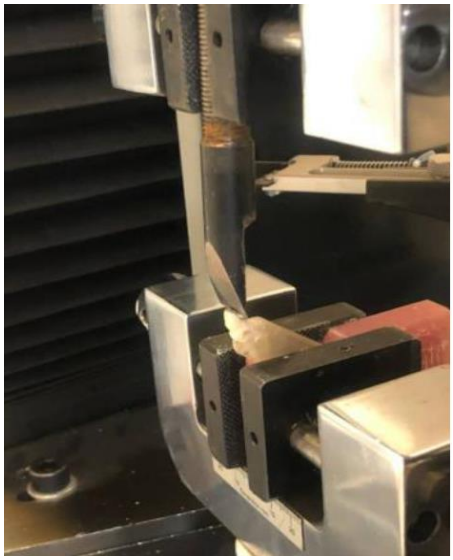

Figure 2. Measurement of fracture resistance by Universal testing device.

Finally, the amount of force applied to break each post and core was recorded. In addition, the type of fracture (because transparent acrylic was used for mounting) was also investigated and classified into the following three groups: 1- Vertical fracture, 2- Irreversible horizontal fracture (horizontal fractures lower than 1 mm) From CEJ, which is a root fracture, and in most cases, tooth reconstruction is not possible after this type of fracture), 3- Reversible horizontal fracture (horizontal fractures above CEJ or crown area fractures).

In the data analysis, the Shapiro-Wilk test was used for the normality of the distribution of the fracture resistance data, and the normality of the distribution was confirmed. Independent t-test was used to compare fracture resistance between groups, and Fisher's exact test was used to compare fracture type. The level of significance in statistical tests was considered equal to 5%. SPSS version 26 software was used in data analysis.

Results and Discussion

The normality of data distribution was confirmed using the Shapiro-Wilk test. The range of changes (difference between the lowest and the highest value) was lower in the nickel-chromium post group than in the NPG post; however, the average fracture resistance between the two types of nickel-chrome post and NPG post did not have a significant difference **(Table 1)**.

Table 1. Mean and standard deviation of failure resistance of the studied groups.

Group	Number	Mean ± SD	Min.	Max.	Independent t-test
Post nickel chrome	10	233.80 ± 67.19	123.00	353.00	T = 0.314 P = 0.757
Post PNG	10	223.00 ± 85.65	110.00	383.00	

Regarding the comparison of the frequency distribution of fracture types between the groups, 20% of fractures in the Post and Core Ni-Cr group and 30% of fractures in the Post and Core NPG group are reversible, 70% of fractures in the Post and Core Ni-Cr group and 60% of fractures in the Post and Core NPG group was irreversible and 10% of fractures in each of the two groups were vertical. The groups did not differ significantly in terms of the type of resistance to failure **(Table 2)**.

Table 2. Frequency distribution of failure types among groups.

Group	Type of failure		Vertical	Total
	Reversible failure	Irreversible failure		
Post and Core nickel chrome	2 (20%)	7 (70%)	1 (10%)	10 (100%)
Post and Core NPG	3 (30%)	6 (60%)	1 (10%)	10 (100%)
Total	5 (25%)	13 (65%)	2 (10%)	20 (100%)
Fisher's exact test	P = 0.871			

One of the major and common problems of casting Post and Core is root fractures. Due to the difference in the elasticity coefficient of cast posts and dentin, the forces and stresses directly enter the dental tissue and the result is the occurrence of irreparable fractures in the tooth [19, 20]. In the study of Streedevi *et al*. it was stated that two mm ferrule and casting posts and cores have the best result in fracture resistance compared to teeth restored with prefabricated posts or casting posts and cores without ferrule [21]. Mankar *et al*. stated that ferrule is more effective than cement in fracture resistance of root-treated teeth restored with cast posts and cores [22].

In this study, according to the results of other previous studies [11, 23, 24], a two mm ferrule was used to recreate the standard clinical conditions [10, 12, 25]. In

the present study, similar to other studies, the approximate size of the average length of the crown of the central teeth (10 mm) was used for the post length (5.15). In the study of Khiavi *et al*. the length of the posts was considered to be 8 mm [12]. Although in the study of Khiavi *et al*. the post length was considered equal to the average crown, because the examined teeth were maxillary single-rooted premolars, the total length of the post was shorter [12].

In Haghighi's study, the length of the post was considered 11 mm [13]. Zinc phosphate cement and glass ionomer are popular due to their ease of use, availability, and successful clinical history. In this study, glass ionomer was used as cement. In the study of Haghighi *et al*. and Khiavi *et al*. glass ionomer cement was used, but in the study of Gholami *et al*. zinc phosphate cement was used and in the study of Habibzadeh *et al*. resin cement was used [11-13, 25]. Torabi *et al*. also stated that cast posts and cores have a higher threshold for failure, but in case of failure, most of the fractures are irreparable [20]. In contrast, FRC posts have lower fracture resistance, but the fractures that occur are repairable. Although the clinical success of FRC posts is high, due to the more difficult application, the need to leave at least 50% healthy tissue, higher cost, high technical sensitivity, and the impossibility of use in people with heavy occlusion [26], cast posts are still very popular [23]. Therefore, in this study, two types of post-casting, nickel-chromium, and NPG were investigated and compared.

In the present study, as in the study of Haghighi *et al*. veneers were not made for the teeth due to the increase in tooth fracture resistance and the Ferrol effect, which causes a false increase in fracture resistance [13]. However, in the study of Habibzadeh *et al*. and Khiavi *et al*. because the study conditions are similar to the mouth, veneers were used [12, 27]. In the study of Habibzadeh *et al*. as in the present study, no significant difference was seen in the fracture strength of treated teeth restored with post and nickel chrome and NPG blinds [25]. In Khaledi *et al*.'s study, similar to the present study, no significant difference was found between the fracture resistance of NPG and nickel-chromium posts [9]. In Haghighi's study, the fracture resistance of root-treated teeth restored with NPG posts and cores was higher than nickel chrome posts and cores [13]. The reason for the difference with the present study could be due to the use of maxillary second molar teeth in Haghighi's study. In addition, in Haghighi's study, an indirect technique was used to make cast posts and cores.

In the study of Khiavi *et al*. the fracture resistance of root-treated central teeth restored with cast NPG posts and cores was higher than nickel chrome posts and cores [12]. In the study of Khiavi *et al*., the teeth were reconstructed with all-metal veneers before examining fracture resistance. In Gholami *et al*.'s study, unlike the present study, the fracture resistance of reconstructed teeth with NPG posts was higher than that of nickel chrome posts [11]. This difference could be due to the use of premolars in Gholami's study. In addition, in Gholami's study, canal preparation was done up to Piezo No. 4, while in the present study, canal preparation was done up to Piezo No. 2.

In the present study, failure was seen in all teeth. Most of the fractures in both groups were irreversible, and the percentage of vertical fractures was similar and equal in both groups. There was no difference between the two groups in terms of the type of failure. The average force applied to anterior teeth in the jaw is reported to be 222 newtons [28]. In the NiChrome group, all but one tooth failed at a force greater than 222 N, but in the NPG group, six teeth failed at a force less than 222 N. In the study of Khiavi *et al*. the most observed types of failure were unrepairable [12]. In Haghighi's study all the fractures were in the root and were non-repairable [13]. In Habibzadeh *et al*.'s study, most of the failures in the post and core group of nickel-chromium porcelain veneers and vertical cracks occurred in the CEJ part of the root [27]. In the NPG group, most of the fractures were below the CEJ and were unrepairable. Habibzadeh *et al*. in another study stated that most of the fractures occur in posts and cores of nickel-chromium casts in porcelain crowns and the next level is fractures at the CEJ level of the root [25]. Khaledi *et al*. stated that the failure rate of NPG posts is higher than that of nickel-chromium posts [9]. The cause of this phenomenon can be due to the lower elasticity coefficient of NPG posts compared to nickel chrome. A higher elasticity coefficient means less bending in the post and more stress accumulation in the tooth structure.

Conclusion

This study was conducted to investigate the fracture strength of root-treated teeth that have been restored with nickel-chromium posts and non-precious gold alloys (NPG). Based on the results, the fracture strength of nickel-chromium post was higher than the fracture resistance of NPG, but there was no significant difference between the two groups. In both groups, the most severe type of failure was irreversible, and there was no difference in the type of failure between the two groups. Based on the results of this study, the fracture strength of teeth restored with two types of Post and Core casting, NPG and nickel chrome, is not different

from each other. In both types of Post and Core, most types of failure were non-repairable.

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