

COMPARING THE STABILITY OF CAST METAL POST AND CORE WITH GLASS FIBER POST MANUFACTURED BY CAD/CAM (IN VITRO STUDY)

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ABSTRACT

The dentist often resorts to post and cores for restoration of damaged teeth due to endodontic treatments and previous restorations in order to prepare them to receive the final restoration. A large number of different systems have appeared for this purpose including cast metal post, cores, and glass fiber post; however, the stability of post and cores is one of the problems that faces the dentist when use them.

This controlled in vitro experimental study aimed to compare the stability of conventional cast metal post and cores with glass fiber post and cores manufactured using TRI-LOR fiber discs milled by CAD/CAM.

Thirty extracted single-rooted lower first premolars, endodontically treated and prepared to receive the posts, were randomly divided into two groups. Each group included 15 premolars, the post and cores of both groups were waxed, the samples of first group were scanned (CAD star scanner, Austria) and milled by CAD/CAM (ROLAND/DWX-52, Japan) using glass fiber discs (TRI-LOR, BIOLOREN, Italy) samples of second group were manufactured by lost wax technique using NiCr alloy (4all, ivoclar vivadent). All the posts were cemented using self-adhesive resin cement. Removal strength tests were carried out using the general mechanical tests device (testometric) which located in the Research and Industrial Testing Center in Damascus.

After conducting the statistical test (T Student), we found that the mean of milled fiber glass posts group was (132.13N) while the mean of cast metal posts was (70.60N), so removal strength was significantly higher ($p < 0.05$) in the CAD/CAM post groups than in the groups with cast metal posts.

The fiber glass post and cores made using CAD/CAM was more resistant and therefore more stable "than the cast metal post and cores.

KEYWORDS: cast metal post and cores, trilor fiber disc, CAD/CAM, glass fiber posts

INTRODUCTION

When teeth have been endodontically treated they have often lost dental structure and require the use of an intraradicular post and a filling core to retain the definitive restoration [Zicari F et al, 2008]. For many years, metal posts were used as intraradicular retention for endodontically treated teeth [Sorrentino R et al., 2016]. They have shown high survival rates after 10 years [Gomez P, 2010] as metal posts have been hypothesized to have

high elastic moduli in comparison with that of dentine, which could increase the risks of root fracture and catastrophic failure [Zarone F, 2006]. Recently, fiber-reinforced composite was introduced as part of computer-aided design/computer-assisted manufacturing (CAD/CAM) dental materials. These combine of high mechanical properties and color stability of ceramic with the low elastic modulus closer to that of dentin (18 GPa) and high resilience of composite resin, which is considered a favorable property from a biomechanical standpoint. [Goracci C, 2011; Figueiredo F et al., 2015]. They can be bonded to dentin with resin cements [Lamichhane A et al., 2014], making them theoretically ideal materials for manu-

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facturing a custom post and core that can achieve a perfect fit [Falco S, 2017].

Digital Dentistry and advances in CAD-CAM milling technique have resulted in high precision, efficient, and accurate systems that have reduced the processing time and decreased the error rate of manufacturing dental appliances [Miyazaki T et al., 2009]. Therefore, using CAD-CAM technology to produce anatomic prefabricated custom intraradicular retainers seems a viable option, especially considering the possibility of milling both the post and core [Liu P et al., 2010]. Manufacturing custom glass fiber posts with a CAD-CAM milling technique has advantages. This process allows for a cement layer of minimum thickness, simplifies the technique by reducing clinical steps, and eliminates the necessity to adhesively bond a composite resin to build-up an adequate core for assisting restoration retaining, creating a monolayer intraradicular retainer system [Liu P et al., 2010]. Therefore, the purpose of this study was to investigate the stability of milling custom fit anatomical post and cores from fiber reinforced composite disks using CAD/CAM technology on the bond strength to root canal dentin compared with metal post and core.

MATERIALS AND METHODS

This study was conducted at Damascus University Faculty of Dentistry, Department of fixed Prosthodontics. Thirty single-rooted lower first premolars free of cracks and caries were extracted for orthodontic or gingival reasons used in this study with approximately one size and length, where the average length of the roots was approximately 15 mm so the idea was to make the length of the post within the root canal is equal to two-thirds of the root length [Stockton L, 1999], and to eliminate the effect of premolars volumes on the results, dimension of the teeth were measured buccolingually and mesiodistally. Then stored in 0.5% solution of chlora-

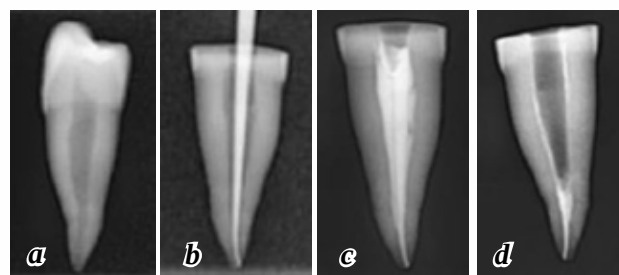


FIGURE 1 Radiographic appearance of endodontic treatment and post space preparation.

mine T for a week, crowns were cut vertically perpendicular to the longitudinal axis of the tooth above the cemento-enamel junction

Cement-enamel junction (CEJ) of 2 mm by diamond disk attached to its stand on a low-speed micro motor grip with continuous cooling with water. After that, the cutting surface was adjusted using a wide cylindrical diamond bur, root canal treatments were performed using nickel-titanium rotary instruments (VDW, RECIPROC BLUE, GERMANY) to an apical size of 30 and a 0.06 taper at a working length of 0.5 mm from the apex with 5.25% sodium hypochlorite irrigation. Canals were then obturated with gutta percha and root canal sealer (ADSEL, META BIOMED, USA) using warm vertical compaction. Then, the post space preparation was performed at a depth of 10 mm from the sectioned surface with Peeso reamers (Dentsply Sirona, Ballaigues, Switzerland) were used gradually (size 1 to 3) to homogenize the shape and remove residual gutta percha (Fig. 1). The details of the investigated materials are listed in table 1.

In figure 1 there are different periods of the tooth, where (a) is the tooth before the root canal treatment, (b) is the cone feet after canal preparation, (c) is the tooth after canal obturation, (d) is the post space preparation with remain of 4 mm of filling from apex.

The samples were divided into two groups; each of them included 15 premolars. After that, we placed the sample teeth in one package, then the teeth were

TABLE 1

Composition of the investigated material

Description	Material	Composition	Manufacturer
Milled post and core	Trilor Blanks Disk	Epoxy resin matrix [25% vol], multi directional glass fiber reinforcement [75% vol]	Bioloren, Saronno, Italy
Cast metal post and core	4all	Ni 61.4 Cr 25.7 Mo 11.0 Si 1.5 Mn <1.0, Al <1.0, C <1.0	Ivoclar Vivadent, Liechtenstein

randomly drawn for the first and second group as follows: first group restore with cast metal post and core, second group restore with fiber glass post and core made of TRILOR by CAD/CAM.

First and second groups post and cores were waxed in a direct manner using casting wax. A waxy mass was added to the coronal end of the core, taking the shape of a rectangular with dimensions (8, 8, 2 mm) (Fig. 2).

Then they were coated with investment powder of phosphorous and casting in the style of a lost wax in a nickel-chrome alloy. After that, we sand blasting the post with aluminum oxide granules (50 microns) with pressing of 2 bar by placing the head of the sand blasting device at 1 cm from the

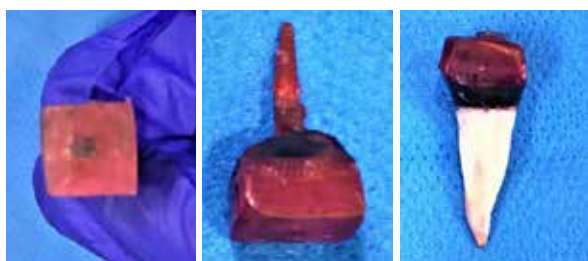


FIGURE 2 Waxing post and core.

post for 30 seconds, then all the post and cores were washed with water to remove the traces of aluminum oxide atoms and then dried followed by the application of metal zirconia primer for a period of 180 seconds. Then the casted metal post and cores were thoroughly examined to ensure their internal adaptation and absence of any obstruction to their entry and exit within the canal, and they were free of casting defects then we cemented the post and core using self-adhesive resin cement (breeze Kerr, USA) according to the manufacturer's instructions (Fig 3 a,b). Then a temporary compensation was made over the post and cores and the samples were kept in a chloramine T solution at room temperature for 24 hours.

Waxing Post and cores in a direct manner using casting wax, a waxy mass was added to the coronal end of the core, taking the shape of a rectangular with dimensions (8, 8, 2) mm.

Second group post and cores after waxing were sent to the technician's laboratory to make the post and cores by CAD/CAM system. The wax shapes were placed on special bases; they were photographed by 3D scanner, after that a special program was used for design on the computer (EXO-

CAD), to draw the edges of the post and cores then stabilize the depicted shape as the final one. Then the shapes were paved within the TRILOR discs with a thickness of (20 mm) to fit the lengths of the post and cores, then a CNC (Computer numerical control) file was implemented and sent to the milled machine (CAM), which in turn will drill the post and cores using a 2 mm drill to give the initial shape. A drill measuring 1 mm was used to give the post and core its final shape knowing that the limit of standard error within the movement of that machine is 0.010 mm.

After the milling process was completed, the post and cores were removed from the TRILOR discs, to be trimmed. Then the post were prepared for luting according to the manufacturer's instructions, by etching it.

With 9% fluoric acid that was applied to the root section of the post up to 10 mm for 60 seconds. Then the post was washed with water for 15 seconds, dried with air then treated with the silane agent (silane, monobond-n, Liechtenstein) that was brushed on the surface of the post by special brushes, and then left for a minute until it dries. Then bonding material was applied on the post without light curing. After this stage, self-adhesive cement (breeze Kerr, USA) was mixed and injected into the entrance of the root canal and pushed inward by the burbs measuring 30, also cement was placed on the post [Fokkinga W et al, 2005] then post was intertied into canal until it settles inside its sheath by finger pressure for 10 seconds to en-

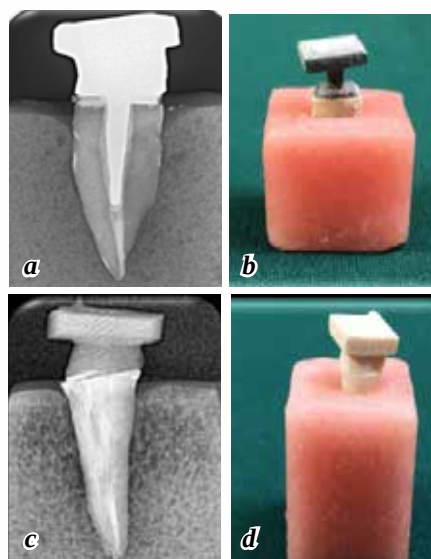


FIGURE 3 Cast metal post and core (a,b), Glass fiber post and core (c, d) after cementation.

TABLE 2

Descriptive Statistics of Removal Force [in newtons] values according to Studied Group.

Studied Variable = Removal Force [in newtons]						
Studied Group	N	Mean	SD	SE	Min	Max
TRILOR Fiber Discs Group	15	132.13	24.88	6.42	100	181
Cast Metal Post and Core Group	15	70.60	10.14	2.62	55	89

sure that bubbles do not form within the root canal (Fig 3 c,d) [Salameh Z *et al*, 2008]. Then, a temporary compensation was made over the post and cores, the samples were stored in a chloramine T solution at room temperature for 24 hours.

Post and cores were numbered with numbers similar to the corresponding roots. All samples were subjected to pull out test by general mechanical tests device at the Research and Industrial Testing Center in Damascus. Each sample was installed on the device so that the removal strength was parallel to the long axis of post and cores, the test was conducted so that the heads of the device moved away at a speed of 0.5 mm/minute until the moment of failure. The highest value of failure was recorded in the Newton, which represents the post resistance to its exit from its sheath. The failure of adhesion between the posts and dentin root canal was confirmed by pulling the post out to make sure his release from his sheath.

RESULTS

I – Sample Description

The sample consisted of 30 extracted single-rooted lower first premolars which were divided into two equal distinct groups according to studied Post and Core Types (TRILOR Fiber Discs Group and Cast Metal Post and Core Group).

II – Statistical Analysis Results

Removal Force [in newtons] values were measured for each studied premolar in the sample. Then, the Effects of Studied Group on Removal Force [in newtons] values was studied and the analysis results were like it is shown below.

Average of Removal Force values according to Studied Group.

Effect of Studied Group on Removal Force [in newtons] values:

A T- test was applied to know if there were significant differences in Removal Force [in newtons] values between TRILOR Fiber Discs Group and

Cast Metal Post and Core Group groups like it is shown below (Table 3).

Confidence level of 95%, there were significant differences in Removal Force [in newtons] values between TRILOR Fiber Discs Group and Cast Metal Post and Core Group in the studied sample. Referring to the POSITIVE algebraic sign of Mean Difference indicates that Removal Force [in newtons] values in TRILOR Fiber Discs Group were greater than those of Cast Metal Post and Core Group in the sample.

DISCUSSION

After applying mechanical tests on the samples and conducting the statistical study, we found significant differences between the groups where mean of resistance to removal strength of glass fiber post and core made from TRILOR was [132.13N], while mean of cast metal post and core was [70.60N] and this can be attributed to:

Change in dimensions and errors that occur during the waxing, cladding, casting and trimming stages in lost wax manufacturing technique and thus affect the final dimensions of the metal post, shrinkage in the size of the cast post can occur which cause an increase in film thickness of the cement around the post and voids within cement [Halle E, 1984]. Therefore, they are less stable than glass fiber post which adapt better into the canal and therefore reducing in the cement thickness around the post (Fig 4 a,b). These results were in agreement with a study conducted

TABLE 3

T-test results in Removal Force values between Cast Metal Post and Core groups.

Studied Variable = Removal Force [in newtons]			
Mean Difference	t Value	P-Value	Significant Diff.?
61.53	8.87	0.000	YES

NOTE: P-Value was much lower than 0.05

by Geramipanh F, who found that weakly adapted posts within root canal lead to the occurrence of a diaphragm gap and if there is no adequate amount of cement, it may lead to a leakage and thus the entry of germs and oral fluid into the canal [Geramipanh F, 2013]. That leads to failure of the post and core system. Also found that the increase in cement film thickness leads to an increase in sclerotic shrinkage and thus a reduction in the bonding forces caused by the occurrence of pores and bubbles during the occurrence of cement hardening [Kremeier K et al., 2008]. While differed with our result because he found that the thickness of cement around the cast metal post and core was lower than the thickness of the cement around fiber glass post and cores made from TRI-LOR and thus higher stability [Vichi A et al., 2017]. Also found that manufacturing of metal post in traditional way achieved better adaptation than milling technique in the coronal section of the pos [Jafarian Z et al., 2020].

There is an increase in the size of the post and consequently the need to prune it or the need to increase the preparation within the root canal, this increases the width of the preparation and the possibility of exposing the root to fracture [Musikant B et al., 1985]. These results were in agreement with a study conducted by [Dietschi D, 2008], who found that the excess preparation of the dental root canal to receive the post leads to a weak fit between the post and its canal and thus an increased risk of failure.

Glass fiber posts manufactured using TRI-LOR also have a modulus of elasticity close to the elastic modulus of dentine 18 MPa allowing a uniform

and homogeneous distribution of stresses applied to the restored tooth and a uniform transmission to the support dentin in contrast to the metal having a high elastic modulus [D'Arcangelo C et al, 2007]. This leads to concentrated forces in a specific area and thus an increased risk of fracture [Martinez-Insua A et al, 1998]. Similarly, found that the posts must have a good internal adaptation in order to improve the stability of the post in addition to a vital compatibility and elastic modulus close to that in dentin for the homogeneous distribution of forces on long axis of tooth [Pereira J, 2013].

These results were consistent with a study conducted by Salameh Z, who found that the use of CAD/CAM technology in manufacturing had a positive effect in increasing the stability of post and cores within the dental canal [Salameh Z, 2019]. While differed with our result, he did not find any difference in the stability between the fiber glass post and cores manufactured using TRI-LOR and the cast metal post and cores [Goracci C, 2017]. Also found that the internal adaptation of the post within the root canal does not affect stability [Sorensen J, 1990].

The type of adhesive cement affects the resistance of the removal strength as the cement interacts with both, post material and walls of the root canal. This is what happened when using the resin cement to cementing glass fiber post because the stability that is achieved with the glass fiber post is a real adhesion stability as the chemical nature of these posts corresponds to the BIS-GMA resin commonly used in adhesion, [Malferrari S et al, 2003]. Also, the fibers that contained in TRI-LOR discs have been silanated [exposed to silane] before

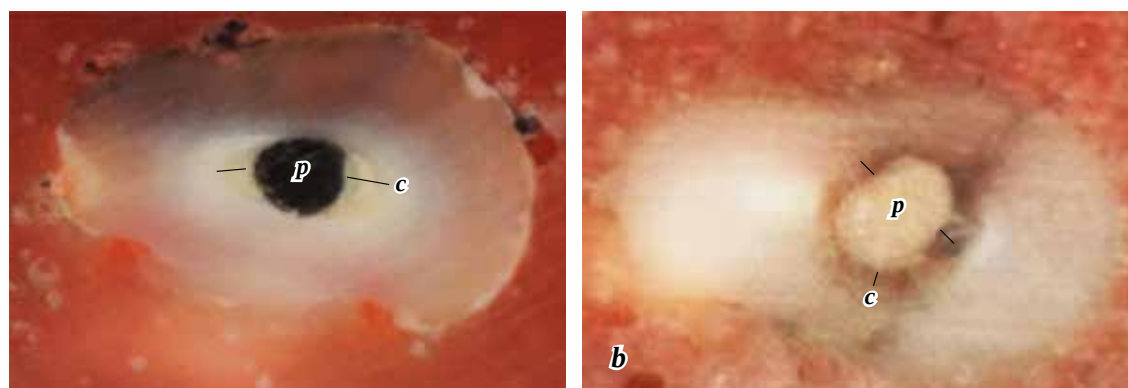


FIGURE 4. Representative cross sectional stereomicroscope photograph [x20 magnification] of a cast metal and glass fiber post in the middle of tooth [p] and the presence of a thick cement layer around it[c]. It should be emphasized that root canals in premolars are rarely round.

being immersed within the resin matrix which would help to improve the bonding process [Goracci C *et al.*, 2005b]. These results were in agreement with a study conducted by Park S, where it was found that the use of silane bonding agent contributes to increasing the surface wettability and contributes to forming a chemical bond between glass fibers and resin cement and thus better bonding and stability than metal [Park S, 2001].

The scanning electronic microscope has explained the mechanism of bonding between the posts bonding systems and the root dentin walls as being mainly mechanical microscopic in nature dependent on the hybridization of the dentine surface with a diminished mineral salts to form what is called the dentin resin interferon region: the layer that contains the elongations of the bonding material within the dentin tubules. And on the formation of the resin elongations, as mentioned by the chemical bond as one of the mechanisms affecting that bond [Ohlmann B *et al.*, 2008]. While found that the mechanical adhesion of resin cement with glass posts is similar to adhesion with the metal posts [Fonseca R *et al.*, 2004].

For the cast metal post and core the resin cement will interact with the metal by inserting into

the blanks caused by the sand blasting process and consequently a mechanical reaction, and by the correlation that occurs between the resin cement and the metal zirconia primer, but the change in dimensions that occurs to the metal caused by the manufacturing process affects the adhesion due to the symmetric contraction caused by the hardening of the resin cement which is stronger than bonding with the metal and consequently a vacuum around the posts occur which in turn leads to weak adhesion [Feilzer A, 1990; Sayes Siham, Al-Bunni Sufouh, 2012]. Similarly found that the resin cement shrinks when it is polymerized by a rate of 1.2 to 6%, which would aggravate the concentration of stresses and thus a failure of adhesion occurs because the absence of good internal adaptation of the posts within the canal [Soares C, 2017].

CONCLUSION

The stability of the glass fiber post and core made using TRILOR was better than the stability of cast metal post and core cemented with self-adhesive resin cement therefore Using CAD/CAM technology to make post and core is better than using the traditional method [lost wax technique] to made them.

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