

Effect of time interval between core preparation and post cementation on pushout bond strength of glass fiber-reinforced posts

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Abstract

Introduction: The aim of this study was to investigate the effect of timing of coronal preparation on the pushout bond strength of fiber postluted with resin cement in the root canal.

Materials and Methods: In this experimental study, 48 mandibular human premolars were selected in a 3-week range. After root canal treatment and postspace preparation, a post #2(Angelus, Brazil) was cemented into the canal by a resin-based cement (Bifix SE, VOCO, Germany). Cylindrical resin composite cores were built on the posts. Then, the specimens were divided into 4 groups of 12 specimens each: one control group without core preparation and 3 experimental groups with core preparation that was done 15 min, 1 h, and 24 h after postcementation. One day after postcementation, each root was sectioned into 3 segments. Each slice was connected to universal testing machine. The load was applied at the speed of 0.5 mm/min till failure happened. The collected data were analyzed (SPSS/PC 20.0; SPSS Inc., Chicago, IL, USA) using two-way ANOVA and *post hoc* Tukey test at $P < 0.05$ level of significance.

Results: Mean shear bond strength differences among interventional groups were not statistically significant ($P > 0.05$). Nevertheless, there were significant differences among root regions ($P < 0.001$).

Conclusion: It was concluded that core preparation and its timing does not affect adversely retention of fiber post and bond strength is higher in the cervical segment.

Keywords: Dental bonding, postcore technic, resin cements

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Clinical implications: Timing of coronal preparation does not have any adverse effect on the pushout bond strength of fiber postluted with resin cement in the root canal.

INTRODUCTION

In endodontically treated teeth with extremely destroyed crowns, using postplay an important role in retaining core material.^[1] More recently, glass fiber-reinforced posts are more popular because of their desirable physical

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properties.^[2] Their modulus of elasticity is similar to that of dentin that results in decrease of probability of root fracture.^[3,4] The chemical composition of glass fiber-reinforced posts is compatible with bis-GMA that is a basic resin material that is used for cementing post and reconstructing core.^[5] Therefore, they can create an integrated structure between dentin, resin-based cements, and restorative materials.^[3] In addition, there are many other advantages associated with glass fiber-reinforced posts compared to custom cast dowels and cores such as improvement of esthetic and reduction in cost and time.^[4,6]

Retention of post in the root canal is a necessary issue for durability and success of the restoration.^[7] To have an integrated structure with dentin, high-bond strength between resin-based cement and dentin is required. Since fiber posts were clinically used, many studies have been conducted on enhancing intra-radicular bond strength; however, bond strength to radicular dentin is much less than to coronal dentin.^[8] Long narrow root canal shape results in high polymerization shrinkage stress and C-factor; these all disturb bonding to radicular dentin.^[9]

Clinical and laboratory studies showed that most of failures in teeth restored with glass fiber-reinforced post were occurred because of debonding and low-bond strength at postresin and/or resin-dentin interface.^[10,11] The failure rate of fiber posts was about 7%–11% in a retrospective 7–11 years study; about a quarter of these failures were because of debonding.^[12]

In general, retention of post is affected by many factors such as posttype, surface configuration and geometric design, cement types and properties, endodontic procedures, irrigation materials, and C-factor.^[9,13-19] In addition to the above-mentioned factors, previous *in vitro* studies demonstrated that bond strength of fiber post has been increased by time; this is because of high frictional resistance produced by delayed hygroscopic expansion that can significantly raise the retention.^[5,9] Since ultrasonic scalers and rotary instruments used during crown preparation may influence the postretention,^[20] so the time interval waiting for coronal preparation is one of the factors that affect both microleakage and retention of fiber posts.^[1,21,22]

By performing coronal preparation 5-min after fiber postcementation, leakage had considerably increased. Thus, it is recommended to postpone coronal preparation at least 15 min after cementation.^[21] In an investigation on cast post and cores, which were cemented with zinc-phosphate cement, starting the coronal preparation 15 min and 1 h

after the cementation had reduced postbond strength. However, coronal preparation 24 h after cementation had no significant effect on retention.^[1] It will be explained by greater maturation strength of zinc-phosphate cement after 24 h.^[23] However, retention of posts cemented with dual-cure resin and glass-ionomer cement had been reduced due to coronal preparation after both 15 min and 24 h.^[22] Here, it should be mentioned that many researchers oppose this claim that there is not any proven relationship between the effects of time interval waiting for coronal preparation after postcementation and the bond strength of posts cemented with zinc phosphate or resin cements.^[7,24] As mentioned before, previous similar studies used casting posts^[1] or evaluated microleakage of fiber posts.^[21,22]

The purpose of this study is to investigate the effect of timing of coronal preparation on the bond strength of fiber postcemented with resin cement in the root canal.

The null hypotheses were 1-there is not any relationship between the timing of coronal preparation and the fiber postbond strength, and 2-The bonds strength of glass fiber-reinforced post in different root segments are similar.

MATERIALS AND METHODS

In this *in vitro* study, 48 extracted caries and fracture free, single-rooted mandibular human premolars with straight root canal were selected. They have also no previous root canal treatments or posts. The selected teeth that were extracted due to orthodontic reasons have been collected in a 3-week range. They had fully developed apices and anatomically similar size and length. For this purpose, a digital calliper was used for measuring the roots dimensions. The sample size (12 teeth/group) was selected according to a previous study that stated at least 10 teeth were needed to detect the differences depending on calculation with 5% alpha errors and 80% power of test.^[18] One researcher did all the experimental processes.

The teeth were cleaned of calculus and residual soft tissues with an ultrasonic scaler and were disinfected by immersing them into 2.5% NaOCl (Golrang, Golrang Co. Tehran, Iran) for 2 h and then stored in 0.1% NaN₃ solution until using.^[14]

To have approximately 15 mm long roots with a flat coronal surface, the crown of each tooth was sectioned at the cemento-enamel junction perpendicular to the coronal-apical axis of tooth by a low-speed diamond-coated disk (Ref. 070, D and Z, Berlin, Germany) under copious cooling water. Roots with oval canal were excluded.

The pulpal tissues were removed with a barbed broach (Dentsply/Maillefer, Ballaigues, Switzerland) and root canal debridement was performed with K-files (Dentsply/Maillefer, Switzerland) up to #35 to the working length of 14 mm. For shaping and coronal enlargement, Gates Glidden (Dentsply/Maillefer, Switzerland) sizes 2–4 were used, and the procedure was completed using K-files up to 60 with step back technique. During cleaning and shaping, apical patency was checked by passing a file #10 through the apex. By each change in the file size, irrigation was done with sodium hypochlorite solution 5%. Canals were dried using paper cones (Ariadent, Asia Chemi Teb Co, Tehran, Iran) and obturated with Gutta Percha (Ariadent, Iran) and resin-based sealer AH26 (Dentsply Caulk, Milford, German) using lateral condensation technique. Then, a cotton pellet was placed in the canal orifice, and coronal seal was created using temporary restorative material (GC Caviton; GC Dental Products Corp., Tokyo, Japan). The roots were stored for 7 days in 100% humidity at 37°C in an incubator.

After 1 week, Gutta Precha was removed from the canal with Gates Glidden drill #1–4 (Dentsply/Maillefer, Switzerland) to a depth of 10 mm. After preparation of each five canal, the instruments were replaced by new ones. After postspace preparation, canals were rinsed with distilled water and dried with paper cones.

Posts #2 (Angelus Co., Londrina, Brazil) were cut 13 mm above the apical part; therefore, 10 mm of post would enter into the canal and 3 mm was out of orifice. Dowels were cleaned by alcohol and were cemented into the canals using self-etch self-adhesive resin-based cement (Bifix SE, VOCO GmbH, Cuxhaven, Germany). To do that, equal amounts of base and catalyst of the cement was auto-mixed, and the mixture was introduced into the postspace. Dowels were coated with cement and slowly inserted into the canal with finger pressure; excess cement was removed with a brush. The resin cement was light-polymerized for 40s according to manufacturer's instruction by a halogen light unit (Coltolux50, Coltene, Altstätten, Switzerland). Before each exposure, output of the curing unit was measured by a Coltolux light meter (Coltene, Switzerland) to ensure that the intensity was sufficient for polymerization.

A cylindrical transparent mold, with a height of 5 mm and diameter of 6 mm, was used for core construction; as a result, each core covered 3 mm of the post outside the canal and was 2 mm above the post [Figure 1]. After applying a bonding agent (Clearfil SE Bond, Kuraray, Japan) on the dentin surface, a little amount of composite resin (Filtek Z250 shade A3, 3M ESPE, St. Paul, USA)



Figure 1: The core was made over the post

was incrementally adapted around the post, and then, the mold was filled with composite resin and placed on the post. Each sides of the core were polymerized for 40s by a light cure unit (Coltolux50, Switzerland). The specimens were mounted along their long axes in acrylic resin molds so that the coronal surfaces of roots were placed at the same level with the superior surface of the molds and the cores were stayed out of the acrylic molds. Then, the specimens were divided into 4 groups of 12 specimens each: 3 experimental groups and one control group without core preparation. In experimental groups, core preparation was performed 15 min, 1 h, and 24 h after postcementation. In this period, the specimens were stored in 100% humidity at 37°C in an incubator. Each core was prepared for 4 min: 1 min of incisal preparation and 3 min of axial preparation in the direction of the long axis of root, by a chamfer diamond instrument No. 879, ISO: 1/10 mm (Tizkavan, Tehran, Iran) simulating preparation for a metal-ceramic crown. After core preparation, specimens were stored in the incubator again so that total storage time for each group was 24 h.

The molds were placed in the cutting machine TL-3000 (Vafaei Industrial, Tehran, Iran). The first section in thickness of 1 mm was performed to disport cores and ensure that remaining surfaces of roots and molds would be flat. Further sections were done to obtain three 2 mm thick root slices (coronal, middle, and apical slice) with a diamond saw under copious cooling water [Figure 2].

Each slice was taken out from the inside of acrylic resin and connected to an universal testing machine so that the load was applied on the apical aspect of root slice in an apical-coronal direction. To have space for excluding post from root segment, postcenter was placed on center of a cylindrical hole with 2.5 mm diameter, which was in the center of a table in the universal testing machine [Figures 3 and 4]. Diameter of the head of loading bar was 0.7, 0.9, and 1.1 mm for apical, middle, and coronal thirds

of root, respectively. The load was applied at the speed of 0.5 mm/min till failure happened and the postsegment displaced in the root slice. To calculate bond strength in MPa, the load at the time of failure represented in (N) was divided by the interfacial area of the postfragment that refers to the lateral surface of the truncated cone

frustum slice and was calculated using following formula:
 $A = \pi(r_1 + r_2)\sqrt{(r_1 - r_2)^2 + b^2}$ Here, r_1 and r_2 are the coronal and apical root segment radius, respectively. b is the slice thickness in mm and π is equal to 3.14.

The collected data were analyzed with statistical software (SPSS/PC 20.0; SPSS Inc., Chicago, IL, USA) using two-way ANOVA and *post hoc* Tukey test at $P < 0.05$ level of significance.

RESULTS

Table 1 presents the mean pushout bond strength values (in MPa) and standard deviation in different groups and root regions. The two-way ANOVA [Table 2] demonstrated that core preparation and time interval between it and postcementation had no significant effect on fiber postpushout shear bond strength ($P = 0.394$), and there was no interaction between timing of core preparation and root regions ($P = 0.603$). Nevertheless, there were significant differences between bond strength among different root regions ($P < 0.001$). In all groups, mean bond strength was significantly higher in coronal segment than in middle and apical segments ($P < 0.001$). The mean bond strength

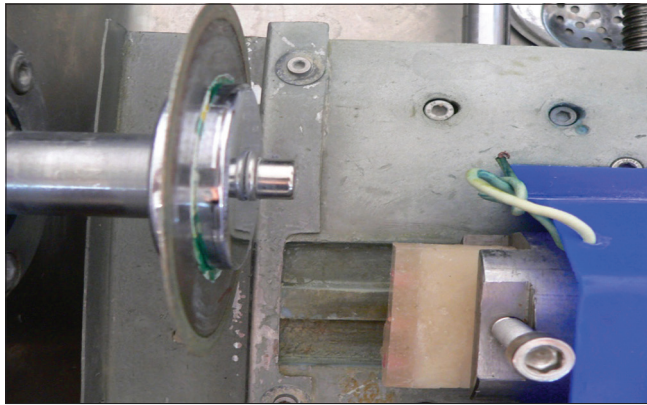


Figure 2: Machine with a diamond saw for sectioning the roots

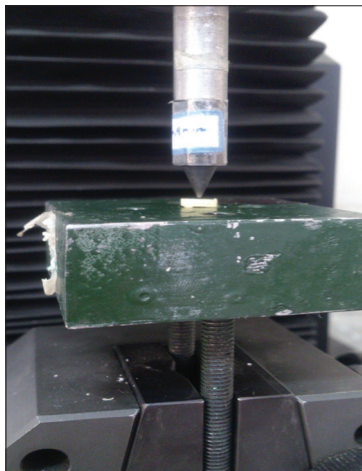


Figure 3: One of the test samples in the Universal testing machine

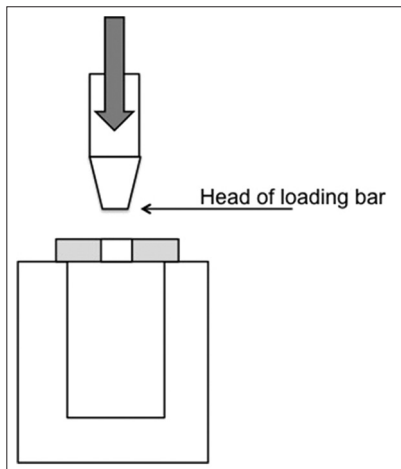


Figure 4: Schematic view of inserting force on the postspecimens

Table 1: Mean shear bond strength of fiber post

| Group | Root region | Mean pushout bond strength (MPa) | SD |
|--------------------------|-------------|----------------------------------|------|
| No preparation | Coronal | 18.21 | 7.52 |
| | Middle | 11.21 | 4.77 |
| | Apical | 6.92 | 3.91 |
| | Total | 12.11 | 7.21 |
| Preparation after 15 min | Coronal | 16.81 | 6.04 |
| | Middle | 10.43 | 6.29 |
| | Apical | 6.02 | 3.83 |
| | Total | 11.09 | 6.97 |
| Preparation after 1 h | Coronal | 13.83 | 7.95 |
| | Middle | 8.89 | 4.05 |
| | Apical | 8.34 | 4.90 |
| | Total | 10.36 | 6.23 |
| Preparation after 24 h | Coronal | 17.32 | 2.88 |
| | Middle | 10.79 | 4.71 |
| | Apical | 8.78 | 6.04 |
| | Total | 12.30 | 5.89 |

SD: Standard deviation

Table 2: Results of two-way analysis of variance for timing of preparation and root segments

| Source | Type III sum of squares | df | Mean square | F | Significant |
|------------------|-------------------------|-----|-------------|---------|-------------|
| Corrected model | 2271.543 ^a | 11 | 206.504 | 6.949 | 0.000 |
| Intercept | 18,934.907 | 1 | 18,934.907 | 637.195 | 0.000 |
| Time | 89.283 | 3 | 29.761 | 1.002 | 0.394 |
| Root region | 2046.821 | 2 | 1023.410 | 34.440 | 0.000 |
| Time×root region | 135.439 | 6 | 22.573 | 0.760 | 0.603 |
| Error | 3922.514 | 132 | 29.716 | | |
| Total | 25,128.964 | 144 | | | |
| Corrected total | 6194.057 | 143 | | | |

^a $R^2=0.367$ (adjusted $R^2=0.314$)

was higher in middle segments in comparison to apical segments, but there were not any significant differences between these two sections. Although bond strength of control group was higher than prepared groups, Tukey HSD test revealed that core preparation carried out at time intervals of the study did not significantly decrease fiber postbond strength [Table 3]. In Table 4, the results of Tukey HSD test for different root sections are shown.

DISCUSSION

According to the obtained results of this study, one can concluded that the first hypothesis is acceptable; therefore, bond strength of post is not significantly affected by preparation and timing.

The previous studies showed that in an investigation of cast posts cemented with a resin cement (Panavia), the postbond strength does not decrease by performing core preparation even 15 min after postcementation.^[7]

Since ultrasonic vibration is the most favorite method of removing intraradicular cemented posts, majority of the previous experimental studies have focused on the effect of the ultrasonic vibration on the postretention. As the effect of ultrasound vibration on bond strength may be similar to the effect of high-speed rotary instrument, the results of such experimental studies can somewhat be comparable to the findings of the current study. Gomes

et al.^[20] indicated that 10 min application of ultrasound did not affect the retention of cast posts cemented with resin cement; however, it decreased retention of those cemented with zinc phosphate and glass ionomer cements.

The viscoelastic nature of resin cement and composite core can absorb induced vibration at the time of preparation and consequently will reduce inserted forces to the bond.^[25,26] In addition, resin cement is really resistant to the vibration.^[27] Furthermore, in this study, based on the manufacturer's instruction, the assumed setting time of the cement (Bifix SE) was 4 min while minimum time interval between postcementation and core preparation of the current study was 15 min. Bond strength rises by time,^[5,9,22] which may compensate the stresses during preparation. Based on the above-mentioned reasons, it can be concluded that core preparation does not considerably deteriorate bond strength of resin cement; it can also be concluded that fiber postcementation with resin cement and preparation of core constructed on it can be done in one visit. Hence, the chair time will decrease and the patient will be more comfortable.

On the contrary, many researchers have demonstrated that use of high-speed rotary instruments 15 min, even 24 h, after cementation of metal posts with dual-cured resin cements had caused lower bond strength.^[22]

The second hypothesis, which is about the bond strength in different root regions, is rejected based on the findings of

Table 3: Post hoc Tukey test results for timing of preparation

| Time (I) | Time (J) | Mean difference (I-J) | SE | Significant | 95% CI | |
|----------------|----------------|-----------------------|---------|-------------|-------------|-------------|
| | | | | | Lower bound | Upper bound |
| No preparation | 15 min | 1.0231 | 1.28487 | 0.856 | -2.3203 | 4.3664 |
| | 1 h | 1.7536 | 1.28487 | 0.524 | -1.5897 | 5.0969 |
| | 1 day | -0.1869 | 1.28487 | 0.999 | -3.5303 | 3.1564 |
| 15 min | No preparation | -1.0231 | 1.28487 | 0.856 | -4.3664 | 2.3203 |
| | 1 h | 0.7306 | 1.28487 | 0.941 | -2.6128 | 4.0739 |
| | 1 day | -1.2100 | 1.28487 | 0.782 | -4.5533 | 2.1333 |
| 1 h | No preparation | -1.7536 | 1.28487 | 0.524 | -5.0969 | 1.5897 |
| | 15 min | -0.7306 | 1.28487 | 0.941 | -4.0739 | 2.6128 |
| | 1 day | -1.9406 | 1.28487 | 0.434 | -5.2839 | 1.4028 |
| 1 day | No preparation | 0.1869 | 1.28487 | 0.999 | -3.1564 | 3.5303 |
| | 15 min | 1.2100 | 1.28487 | 0.782 | -2.1333 | 4.5533 |
| | 1 h | 1.9406 | 1.28487 | 0.434 | -1.4028 | 5.2839 |

SE: Standard error, CI: Confidence interval

Table 4: Post hoc Tukey test results for root section

| Root region (I) | Root region (J) | Mean difference (I-J) | SE | Significant | 95% CI | |
|-----------------|-----------------|-----------------------|---------|-------------|-------------|-------------|
| | | | | | Lower bound | Upper bound |
| Coronal | Middle | 6.2110 | 1.11273 | 0.000 | 3.5734 | 8.8487 |
| | Apical | 9.0242 | 1.11273 | 0.000 | 6.3865 | 11.6618 |
| Middle | Coronal | -6.2110 | 1.11273 | 0.000 | -8.8487 | -3.5734 |
| | Apical | 2.8131 | 1.11273 | 0.034 | 0.1755 | 5.4508 |
| Apical | Coronal | -9.0242 | 1.11273 | 0.000 | -11.6618 | -6.3865 |
| | Middle | -2.8131 | 1.11273 | 0.034 | -5.4508 | -0.1755 |

SE: Standard error, CI: Confidence interval

the current study. It means that bond strength in coronal segment is significantly higher than that in the middle and apical thirds and middle bond strength is significantly higher than apical bond strength.

Many of the previous experimental results are consistent with the findings of the current study; they believe that bond strength in the cervical portion of root is noticeably higher than middle and apical thirds.^[28-31] However, some others have claimed that postbond strength is not affected by root region.^[32,33] In many other investigations, it has been proven that bond strength is higher in apical third than middle and cervical.^[34,35]

In a finite element study, it was observed that in root canal treated incisors; the induced stress in the cervical dentin and the maximum displacement values is more for fiber post compared to dentin post.^[36] Fortunately, the bonding strength of fiber posts to root canal dentine is higher in the cervical area,^[28-31] and the higher stress in this area can tolerated better.

Light-curing increases polymerization reaction of the dual-cured cements,^[36-38] thus, reduction of light transmission yields lower polymerization in middle and apical thirds. Many other reasons, such as impaired etching and disturbance in applying bonding agent to and reduction of tubules number and diameter in deeper areas that decrease number of resin tags and their uniformity^[31,39] can also decrease bond strength in middle and apical thirds.

These contradictions can be explained by considering the different experimental approach of each study. As an example, Gaston *et al.*^[34] did not perform root canal therapy before postspace preparation; so, there were no Gutta Percha and sealer residue, which are difficult to remove from postspace and prohibits favorable bond to dentin structures.^[40] They also longitudinally sectioned the specimens before postcementation that causes better access to the apical segments. Furthermore, more adaptation of post with root canal walls in apical portions, and less cement volume that reduces polymerization shrinkage leads to reduction in creating the stress in the bond area and make higher bond strength in the apical third.^[35]

In Aksornmuang *et al.*^[32] study, posts were coated with mixture of two bonding agents before cementation. Their results showed insignificant bond strength in different root regions. In addition, cement polymerization along the canal depends on its type.^[41] In a comparison among three cements, only Relyx U100 cement showed similar values of bond strength along the root canal.^[42] This can be

explained by considering interaction with hydroxyapatite, which makes a homogenous bond to tooth structure.^[43]

In the future studies, it is suggested to investigate mode of failure and effect of thermocycling on bond strength. In addition, this study can be repeated using other materials, for example, glass ionomer core and participating teeth with some remained crown structure.

CONCLUSION

Within the limitations of this study, it was concluded that core preparation and its timing does not have any effect on the retention of fiber posts, and the bond strength is higher in the cervical segment than in the middle and is higher in the middle third than in the apical third of root.

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Conflicts of interest

There are no conflicts of interest.

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