

Comparison of bond strength in different levels of post space of fiber-reinforced post luted with different resin cements

Ahmed F. Al-Jaff B. D. S M.Sc. ⁽¹⁾

Haitham J. Al-Azzawi B. D. S M.Sc. ⁽²⁾

ABSTRACT

Background: with the advent of new adhesive materials in dentistry, it has become important to measure regional bond strength along the length of the canal of human teeth to assess the bond strength of resin cements to endodontically treated teeth. This study aimed to investigate the effect of post space region (coronal, middle and apical) and the mode of polymerization of the resin cement on the retention of the translucent fiber post to root canal dentin, by using pull-out and push-out test methods.

Material and methods: extracted single rooted mandibular first premolars (n=32) were instrumented with ProTaper universal system files (for hand use) and obturated with gutta-percha and AH26® root canal sealer. After 24hrs in the incubator, post space was prepared to a depth of 8mm using FRCPostec drills no.3. . The prepared samples were randomly divided into two main groups (16 samples each) according to the resin cement mode of polymerization (Group A Dual-cure, RelyxU100), (Group B Self-cure, SpeedCem). Then each group was subdivided into two groups (each with 8 samples) according to the test performed (A1: RelyxU100 and Push-out test, A2: RelyxU100 and pull-out test, B1: SpeedCem and push-out test, B2: SpeedCem and pull-out test). Pull-out and push-out bond strength test were measured using a universal testing machine to measure the bond strength.

Results: regarding the root region, the bond strength values decreased significantly from the coronal to the apical region in both cements tested. For the mode of polymerization, no statistical significant difference was detected between the dual- and self- polymerized resin cements.

Conclusions: the retention of fiber post was affected by the root region while the mode of polymerization didn't affect the bond strength. When measuring the bond strength of luted fiber post, the push-out test appears to be more dependable than the conventional pull-out

Keywords: Fiber post, self-adhesive resin cement, push-out test, root region. (J Bagh Coll Dentistry 2011;23(3):1-5).

INTRODUCTION

Fiber posts have been introduced in the early 1990s to restore endodontically treated teeth with an excessive loss of dentinal structure as an alternative to cast post-and-core and metal dowels. Because their elastic modulus is claimed to be similar to that of the dentin, the risk of vertical root fracture is expected to be reduced ⁽¹⁾. Furthermore, quartz or glass fiber posts (white or translucent) can be used in situations of higher elastic demands ⁽²⁾.

The adhesion of cements can be influenced by the anatomical and histological characteristics of the root canal, including the orientation of the dentin tubules. Moreover, since the number of tubules decreases from the crown to the apical root ⁽³⁾, the response to acid etching and, consequently, the dentin bonding can vary among different areas of the same root canal ⁽⁴⁾.

An adequate polymerization of luting agent is necessary to provide its mechanical properties that clinically ensure post retention. Many current resin luting agents polymerized through a dual-curing process that requires light exposure to initiate the reaction. It has been reported that the mechanical properties of dual-cure type resin agents improved after photo-activation compared with chemical-activation alone ⁽⁵⁾. Dual-cure resin cements are different in their handling characteristics, compositions and properties (such as polymerization ability, flexural strength and hardness). These differences may have an effect on the adhesion to root dentine substrate ⁽⁶⁾.

Bond strength can be determined by several techniques, but the push-out bond strength test is believed to provide a better estimation of the actual bonding effectiveness than a conventional shear bond strength test. Using a push-out protocol, failure occurs parallel to the post-cement-dentin interface, which is similar to the clinical condition. Although the microtensile method has also been applied to root dentin, the push-out test seems to be more reliable because of the absence of premature failures and the variability of data distribution ⁽⁷⁾

(1) M.Sc student, Department of conservative dentistry, college of dentistry, university of Baghdad.

(2) Professor, Department of conservative dentistry, college of dentistry, university of Baghdad.

MATERIALS AND METHODS

Sample preparation. Thirty-two recently extracted human mandibular first premolars, predominantly extracted for orthodontic reason, were selected, with patient's age ranged from (18-25) years old. The selection criteria for teeth including the followings⁽⁸⁾: Single straight root, no visible root caries, no fractures, cracks or external resorption on examination with 10X magnifying eye lens and light cure device, and diagnostic X-ray was taken to confirm the existence of a single straight canal, fully formed apex and no signs of internal resorption, calcification or previous endodontic therapy. The teeth were stored in 1% Thymol solution prior to the study. The crown of each tooth was sectioned perpendicularly to the long axis of the tooth at the cementum-enamel junction, using diamond disc under water coolant to obtain 14 mm length root. Plastic test tube was used as a mold to hold the specimens during root canal instrumentation, obturation and post space preparation. The roots were placed with the aid of dental surveyor (Dentaurum, Germany) to position the long axis of the roots parallel to that of plastic tubes.

Endodontic treatment. Root canal instrumentation was performed using ProTaper universal hand files (Dentsply, Maillefer) in balanced force technique following manufacturer's instructions. Irrigation was performed using 1ml of 2.25% NaOCl solution after every change of file size throughout the cleaning and shaping of the root canals. The canals were then rinsed with 5ml of distilled water as a final irrigation, dried with paper points, canals were then filled with single cone technique by gutta-percha for ProTaper F4 (Dentsply, Maillefer) and AH26® root canal sealer. After filling, the coronal surplus of the root filling was removed with a heated excavator and the access opening were sealed with temporary filling material, and stored for 24hrs 37°C in 100% humidity.

Post space preparation. Filling material from the cervical and middle thirds was removed with pesos drills (Largo, Maillefer, Switzerland) and the canal walls of each space was enlarged with low speed FRC Postec® Plus drills No.3 (Ivoclar, Schaan, Liechtenstein) under copious water cooling, following the manufacturer's instructions, creating (8mm) deep post space measured from the coronal end of the, keeping at least 5mm of gutta-percha apically⁽⁹⁾.

Post cementation. At this point, the samples were randomly divided into two groups of 16 samples each, depending on the resin cement's mode of polymerization (self-, dual-cured), then each

group are further sub-divided into two groups (8 samples each), according to the test performed.

Group A1: RelyxU100 tested with Push-out test.

Group A2: RelyxU100 tested with pull-out test.

Group B1: SpeedCem tested with push-out test.

Group B2: SpeedCem tested with pull-out test.

Group A1, A2:

Prior to cementation, the post space was irrigated with 2ml of 2.5% NaOCl and then finally irrigated with 2ml of distilled water and then dried with paperpoint (F4). Before cementation procedure, each post was marked at distance of 8mm from the apical end corresponding to the post space preparation, in this way; the complete seating of the post was verified⁽¹⁰⁾. Equal parts of base and catalyst were dispensed and mixed into a homogenous paste with 20 sec., in accordance with manufacturer's instructions. After this, the cement were placed inside the post space with the aid of #40 lentulo spiral, and the post was inserted and held, under a constant load of 4.5 Kg for 60 sec.⁽¹¹⁾, the excess cement was removed and further polymerization of the resin cement was performed for 20 sec. from occlusal direction according to manufacturer's instructions.

Group B1, B2

The procedure was the same as that of (A1, A2), except that the SpeedCem resin cement was allowed to auto-cured for 4 minutes according to the manufacturer's instructions.

Push-out bond strength test. The specimens were embedded in a clear acrylic resin, maintaining the post axis parallel to the wall of diamond disc mounted on straight handpiece, the cutting was made under heavy water flow.

From each specimen, 3 post/dentin sections (cervical, middle, and apical) were obtained, each 2 in mm thick. The exact length of fiber post segments in each section was measured using a vernier⁽¹²⁾. Then each slice was marked on its apical side with indelible marker, to make sure that the load will be applied in apico-coronal direction due to the conical shape of the FRC Post used in the study⁽¹¹⁾.

Push-out tests were performed by applying a compressive load to the apical aspect of each section via a cylindrical plunger mounted on Universal Testing Machine (Tinius-Olsen, Philadelphi) managed by computer software. The load was performed at a cross head speed of 0.5 min/min until the post segment was dislodged from the root slice⁽¹³⁾. The maximum force required to dislodge each post was recorded in N and converted into Mpa. considering the bonding surface area (mm²) of the post segment, post diameters were measured on each segment of the post/dentin section using Nikon metallurgical

microscope, and the total bonding area for each post segment was calculated using the formula of a conical frustrum⁽¹⁴⁾:

$$\pi (R1+R2)\sqrt{(R1 - R2)^2 + h^2}$$

Where *R1* represent the coronal post radius, *R2* represent the apical post radius and *h* is the thickness of the slice.

Pull-out bond strength test. Custom-made plastic mold with internal dimensions of 2cm X 2cm and depth of 3cm was used. Parallelism between post, canal and resin block was obtained using a dental surveyor (CO). The acrylic resin was extending to a level extending 1mm below the coronal end of the root⁽¹⁰⁾.

The pull-out test was performed by Universal Testing Machine (Tinius-Olsen, Philadelphia) managed by computer software at a crosshead speed of 0.5 mm/ min and the load cell was set at 50 KG. The maximum force required to dislodge each post was recorded in N and converted into Mpa. The bonding surface area was calculated by the same formula used for the push-out test specimens⁽¹⁴⁾.

RESULTS

All statistical analysis was performed using commercially available software (SPSS for Windows) version 15. The level of significance was 0.05

1. Push-out test.

The mean push-out bond strength of resin cements in different root regions are shown in (Figure 1). The mean push-out bond strength values for RelyxU100 were higher than that of SpeedCem in the all three regions. The coronal region in both resin cements had higher mean push-out bond strength values, followed by the middle and the apical regions.

In the first analysis, one-way ANOVA test revealed that the bond strength was significantly affected by the different regions of the post space, with reduction from cervical to apical region. With RelyxU100, a statistically significant difference ($P < 0.05$) were found among all three thirds. With SpeedCem resin cement, highly significant difference ($P < 0.01$) were found among all regions. It was determined by the LSD multiple comparison test that (TAB), in RelyxU100 there is a significant difference ($P < 0.05$) in mean push-out bond strength between the coronal and the apical regions. A significant difference ($P < 0.05$) exist between the coronal and apical regions of the SpeedCem. A non significant difference in mean push-out bond strength ($P > 0.05$) between the coronal and middle regions in both types of resin

cements. A non significant difference is also found between the middle and the apical regions in both types of resin cements.

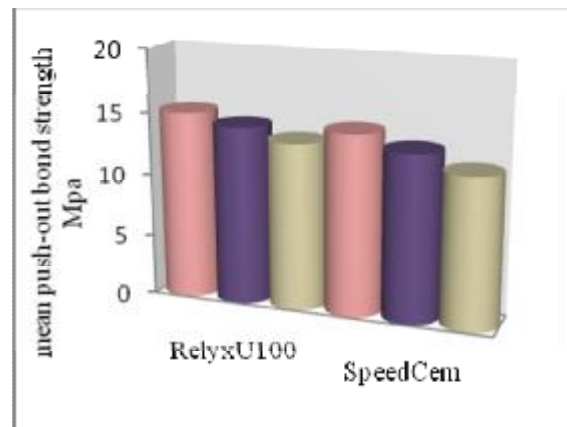


Figure 1: Bar chart showing the mean push-out bond strength of the resin cements.

2. Pull-out test.

Figure 2 shows that the mean pull-out bond strength for RelyxU100 was higher than for SpeedCem resin cement.

In the second analysis, the mode of polymerization showed a non significant influenced on the bond strength, in both push-out and pull-out tests ($P = 0.067$).

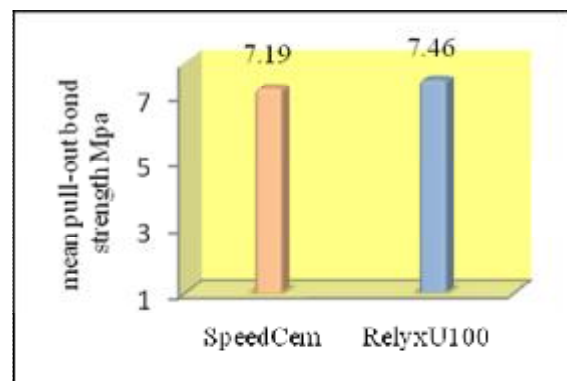


Figure 2: Bar chart represents the mean pull-out bond strength values.

DISCUSSION

The success of fiber post-and-core restorative procedures depends, in part, on the cementation technique used to create a link between the post and root canal dentin⁽¹⁵⁾. The objective of developing this kind of resin cement was to reduce technique sensitivity and make handling simpler without scarifying good adhesion to tooth surface, compared to two or three steps. The present study investigates the bond strengths of various resin cements to root canal dentine using a push-out model. Push-out tests result in a shear stress at the interface between dentine and cement

as well as between post and cement; this is comparable with the stresses under clinical conditions. The push-out design is characterized by polymerization stresses that would happen in the clinical situation⁽¹⁴⁾.

Several factors may contribute to the reduction in the bond strength from coronal to apical direction. Some of these factors are inherited to the root dentin composition, and others are related to the restoration techniques used⁽¹⁶⁾. The structure of dentin is an important factor that should be taken into account in term of bonding⁽¹⁷⁾. The bond strength in different post space levels seems to be influenced by tubule density and area of a tubular dentin. According to previous study⁽¹⁸⁾, as the number of dentinal tubules decreases, mainly from coronal to the apical thirds of the post space dentin, the difference in the tubule density may explain why the strongest adhesion occurred in the most coronal sections.

Also, lower bond strength values in the apical region may be related to factors associated with accessibility and direct viewing to the operative site. Because the apical part of the canal is the least accessible part of the root canal; certain factors such as discontinuous area covered by remnants of gutta-percha and endodontic sealer may hamper the penetration of the resin cement into the dentinal tubule. This agrees with⁽¹⁾ who stated that it's crucial to obtain a "clean" surface, simply because small residue can reduce the area of surface available for post bonding.

Additionally, for the dual cure resin cement, another possible explanation is that the decreasing effect of light curing at greater distance from the light source might be responsible for the lower bond strength apically⁽¹¹⁾. Since the higher bond strength value of resin cement is related to higher degree of monomer conversion and the degree of conversion decrease when the distance from the light source increased⁽¹⁹⁾. And because of that in the deep part of the post space, the light penetration is limited which may result in lower degree of conversion of polymerized dimethacrylate resin monomer, consequently, lower bond strength values recorded in the apical region of the root canal.

An adequate polymerization of the luting agent is necessary to provide its mechanical properties, which clinically ensure post retention. The polymerization contraction may affect the dentin-adhesion interface at different levels, depended on the Configuration factor (C-factor). In intra-coronal restorations, the C-factor is very high, this is because there is a large area of resin cement bonded to dental substrate and endodontic

post, and there is little free area to allow for polymerization contraction⁽²⁰⁾. It has been reported that the light exposure demanded to start the polymerization reaction on the dual-cured cements increases the velocity of the polymerization, leading to higher stress along the cavity, because the material could not flow to relief the polymerization stress. On the other hand, slower setting materials may reduce stresses at the bonding interface because the slow setting allows flow of the material to relive polymerization stress⁽²¹⁾.

Direct comparison between pull-out and push-out test for the adhesive cements tested showed that push-out bond values were higher than those of pull-out. This is probably due to that larger specimens seem to contain more defects or stress raisers such as air bubbles, phase separation, and surface roughness than smaller specimens at the bonded interface or within the substrate. If the bonding interface is not uniform, this will lead to non-uniform stress distribution, consequently, a crack line may develop which creates a stress concentration that will be dissipated by rapid crack propagation causing failure within the substrate. This may initiate fracture at the defect, resulting in lower tensile bond strength that might be measured in smaller samples this is agreed with⁽²²⁾. On the other hand, high bond strength value for push-out test may be attributed to that the smaller specimens contains a lower number of internal defects, this is reported to produce a more homogenous stress distribution and less cohesive type of failure⁽²³⁾. Also, root slicing, which is employed in the methodology of the test, was justified by the intention to favor stress uniformity by loading smaller-sized specimens. In addition, sectioning allowed the differentiation of the bonding conditions existing at different root levels and providing useful measurements with limited variability⁽²⁴⁾.

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