Comparison of regional bond strength of post space of fiber-reinforced post luted with two types of cements at different testing times

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ABSTRACT

Back ground: This in vitro study was carried out to investigate the effect of post space regions (coronal, middle and apical), Time and the mode of polymerization (dual, self-cured) of the cements used on the bond strength between translucent fiber post and root dentin by using push-out test.

Materials and Methods: Forty eight extracted mandibular first premolars (single root) were instrumented with ProTaper Universal system files (for hand use) and obturated with gutta percha for ProTaper and AH26® root canal sealer following the manufacturer instructions, after 24 hours post space was prepared using FRC postec® plus drills no.3 creating 8 mm depth post space. The prepared samples were randomly divided into two main groups (24 samples each) according to the used cement (Group M, self-cure, Multilink N) and (Group R, dual cure, Relyx U100). Then each group was subdivided into three groups (each group contains 8 samples) according to the testing time after cementation. (g M1: push out test after 24 hour of cementation with Multilink N), (g M2: push out test after one week of cementation with Multilink N),(g M3: push out test after two weeks of cementation with Multilink N), (g R1: push out test after 24 hours of cementation with RelyxU100), (g R2: push-out test after one week of cementation with RelyxU100), (g R3: push out test after two weeks of cementation with RelyxU100). After cementation and incubation each root was sectioned horizontally into 3 slices (2 mm in thickness) represent the coronal, middle and apical regions of the post space. Push out bond strength test was performed and measured using a universal testing machine (Tinius-Olsen) at across head speed of 0.5 mm/min.

Results: showed that regarding the root region, the bond strength values increased significantly apical to coronal region in both tested cements. For the effect of time, the bond strength values also significantly increased with time for both tested cements. For mode of polymerization, the self-cured resin cement Multilink N showed higher bond strength values.

Conclusion: the retention of fiber post was affected by root region, mode of polymerization of the cements used and time elapsed after cementation of the post.

Key words: Fiber post, Multilink resin cement, RelyxU100, Push-out test, root region. (J Bagh Coll Dentistry 2013; 25(3):19-23).

INTRODUCTION

In 1990 Duret et al [(1)] described a non-metallic material for the fabrication of posts based on the carbon-fiber reinforcement principle. Laboratory-based studies have shown that these posts have a high tensile strength and modulus of elasticity, similar to dentine. Previously, rigid metal posts resisted lateral forces without distortion and this resulted in stress transfer to the less rigid dentine causing potential root cracking and fracture.

Recently, fiber-reinforced composite (FRC) post-and core systems have come to be widely used in the restoration of endodontically treated teeth. FRC posts offer a number of advantages over metal posts due to their modulus of elasticity being closer to that of dentin and superior esthetic quality [(2)]. Adhesive composite cement, whose elastic modulus in the same range of that of both of the post and dentin, are routinely used to adhesively lute the post into the root [(3)]. Recently developed self-adhesive resin cements do not require pretreatment of the dentin.

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Because these cements do not use an adhesive system, they drastically reduce the number of application steps, shortening clinical treatment time and decreasing technique sensitivity since it minimizes procedural errors throughout the treatment phases [(4)]. 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 conventional shear bond strength test [(5)].

MATERIALS AND METHODS

Sample Selection

Forty eight extracted single rooted teeth (mandibular premolars), collected from different health centers were used in this study. The age, gender, pulpal status and reason for extraction were not considered, and the criteria for teeth selection including the followings: Single straight root, No visible root caries, No fractures, cracks or external resorption on examination with x10 magnifying eye lens and light cure device, 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, patent apical foramen.

Samples preparation

Length of the root was determined by a digital vernier and marker. The tooth hold with moist gauze to avoid dehydration and the crown of the tooth was sectioned with a diamond discs mounted on straight hand piece, under water coolant. The length of the root was adjusted to 14 mm from a flat reference point to the root apex. The mold was obtained by using a plastic test tube (2.5ml). The condensation silicon impression material base and catalyst were mixed according to manufacturer's instructions; the putty was folded and kneaded gently for about 30 sec. until the color was even, without any stripes. The putty material was placed inside the plastic tubes and the coronal end was adjusted with the coronal end of the tube. After that the teeth were placed in the center of the putty material with the aid of dental surveyor to position the long axis of the roots parallel to that of the plastic tubes [6].

Endodontic treatment

Root canal instrumentation was performed using ProTaper hand files (Dentsply, Switzerland) in crown down technique. Irrigation performed using of 2.5% NaOCl after every change of file size throughout the cleaning and shaping of the root canals, dried with paper points and filled with gutta-percha for ProTaper F4 (Dentsply, Switzerland) and AH26 root canal sealar (Dentsply, Germany). The excess gutta-percha at the canal orifice was removed. The access opening were sealed with temporary filling material, and stored at 37ºC, 100 % humidity in an incubator (Memmert, Germany) for 24h

Post space preparation

After 24 hrs, filling material of the cervical and middle thirds was removed with Pesso drills no.1, and the canal walls of each specimen were enlarged with low speed FRC Postec® Plus drills no.3 under copious water cooling, following the manufacturer's instructions, creating (8mm) deep post space measured from the coronal end of the root [6], keeping at least 5mm of Gutta- Percha apically [7]. The length of the post drill was measured by the endo- measuring block and marked with rubber stopper; post space preparation was done with a low –speed straight handpiece attached to a dental surveyor to obtain vertical preparation with standard diameter and dentinal walls parallel to the long axis of the roots.

Sample grouping

The heavy body mounted roots were randomly assigned into two groups (n=24 each), depending on the type of the resin cement used multilink (N) or RelyX™ U100 (R) and then each group is sub-divided into three groups (n=8 each)

Group R1, tested 1day after cementation.
Group R2, tested1week after cementation.
Group R3, tested 2weeks after cementation
Group M1, tested 1day after cementation.
Group M2, tested 1week after cementation.
Group M3, tested 2weeks after cementation

Post Cementation

Prior to post cementation, the post space was irrigated with 2.5% NAOCL and then final irrigation was accomplished with (5ml) of distilled water and the post space was dried with paper point. Before cementation procedures, each post was marked at a distance of (8mm) from the apical end corresponding to the post space preparation. In this way complete seating of the post could be verified [8]. The coronal part of the post (above the marked area) was attached to the dental surveyor (mandrel clamp was fitted to the upper arm to hold the prefabricated post to which the prepared specimens was then fitted) according to manufacturer's instructions.

The cement was mixed and applied on the post, after that the heavy body mounted plastic tube placed on the base of the dental surveyor and the upper arm holding the fiber post was lowered down until the post is fully seated inside the post space. Excess of luting agent was immediately removed with a small brush.

A constant load of 2.5 Kg was applied for 60 sec. using the custom-made loading apparatus to stabilize the fiber posts in position. The specimens were sealed with temporary restoration, all stored in distilled water, for groups R1, M1 the samples were stored in the incubator for 24 hours, for groups R2, M2 the samples were stored for 1 week and for groups R3,M3 the samples were stored for 2weeks, all the samples were stored at 37º C temperature and 100% humidity in the incubator

Preparation of the specimens for Push-out test

Disposable plastic syringes were used as molds into which the freshly prepared acrylic paste was loaded. Before loading the syringes with acrylic, the apical end of the roots were fixed on the face of the plastic piston of the syringes with a resin adhesive as recommended by the manufacturers, so that the roots would be almost centrally located within the acrylic blocks and to ensure that the sectioning would be almost perpendicular to the long axis of the roots. After loading the syringe with the freshly prepared workable acrylic paste the piston of the syringe with the root fixed on its apex was pushed into the acrylic paste with gentle pressure to allow the complete embedding of the root into the acrylic, and to allow the escape of the excess material through the opened syringe tip. The material was allowed to cure under cooled water, cooled water was necessary to compensate for the anticipated rise in the temperature of the samples subsequent to the exothermic curing reaction of the cold cure resin. The acrylic molds were allowed to cure completely for at least 30min as recommended by the manufacturers [9].

Root Sectioning

The sectioning of the root was made by using diamond wheel bur mounted on straight hand piece and engine with a rotation speed regulator, the hand piece was assembled in a cutting device. The cuts were made under heavy flow of cold water (19-25°C) to minimize smearing [9]. From each specimen, 3 post/dentin sections (coronal, middle, and apical) were obtained, each 2 mm thick. Thus, each study group of 8 roots provided a total of 24 test specimens, consisting of 8 specimens from each of the 3 different post space regions. The exact length of fiber post segments in each section was measured using a digital Vernier [10]. Then each slice was marked on its apical side with marker pen 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. Then the slices from each root region was stored in a plastic container and labeled

Push-out bond strength test

Push-out tests were performed by applying a compressive load to the apical aspect of each slice via a cylindrical plunger mounted on Tinius-Olsen Universal Testing Machine managed by computer software. Because of the tapered design of the post, two different sizes of punch pin: 1.0 mm diameter for the coronal, 0.6 mm for the middle and apical slices, were used for the push-out testing. The punch pin was positioned to contact only the post, without stressing the surrounding root canal walls [11]. The specimens were placed inside the mold with its apical direction upward and the coronal direction downwards because the load should be applied to the apical aspect of the root slice and in an apical–coronal direction, so as to push the post towards the larger part of the root slice, thus avoiding any limitation to the post movement. Loading was performed at a crosshead speed of 0.5 mm/ min until the post segment was dislodged from the root slice [12]**.** A maximum failure load value was recorded (N) and converted into MPa, considering the bonding area (mm^2) of the post segments. The apical and cervical diameters of the root canal post of each slice were measured using an optical microscope managed by computer software. Three slices from different levels of the same tooth were placed and examined under the optical microscope (magnification 50X) to measure the diameter of the coronal and the apical surfaces, two readings (diameter) were obtained from each surface; after that the average of the readings was used as a post surface diameter, from which the radius was calculated. The bonding surface was calculated using the formula of a conical frustum [13]**.**

$\Pi (R1+R2))(R1-R2)\pi 2 +h2$

Where R1 represents the coronal post radius, R2 represents the apical post radius and h is the thickness of the slice

RESULTS

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

Push out test

The mean push-out bond strength of resin cements in different root regions are shown in **(Figures 1, 2 and 3).** It's obvious that the mean push-out bond strength (MPBS) of the Multilink N is higher than that of Relyx U100 in all three regions at all intervals . It's also clear that the coronal region in both resin cements have higher MPBS values, followed by middle and apical regions. The highest MPBS seen at the coronal region of Multilink N after 2 weeks while the lowest value seen at the apical region of the Relyx U100 Resin cement after 24 h.

Statistical analysis of data by using the ANOVA test revealed that there was a significant difference ($P<0.05$) among different regions within each resin cement except for the coronal region of Multilink N between group 1, 2 and 3 there was no statistical difference.

DISCUSSION

The results of this in vitro study require the rejection of the null hypothesis that cement type and the testing time have no effect on the interfacial strength of the luted fiber posts.

The bond strength of fiber post in cervical, middle and apical region

Both adhesive cements tested demonstrated measurable adhesion to root dentin, with the highest values for the coronal region and lowest for the apical region the explanation for this result could be attributed to different factors such as the gradual decease in the number of the dentinal tubules from the coronal to the apical part of the root thus the reduced infiltration of the adhesive into the tubules and less formation of the resin tags in the apical parts, and because the adhesion is enhanced by penetration of the resin into the tubules, its values is low at the apical third. This coincides with Zorba et al. [7] who stated that the difference in the number of tubules may explain why the strongest adhesion occurred in the most coronal sections where there is a greater number of tubules per square mm, but the result findings conflict with Foxton et al. [14] who stated that the apical bond strength was significantly higher in the apical region because the bond strength is related more to the area of solid dentin than to the tubule density and when the post space were created, the rotary drill created a smear layer on the dentin surface, the use of a brush or irrigant to clean the debris from the post space may have removed some, but not all, of the superficial layer in the cervical and middle third, but it didn't reach the apical third and this smear layer formation during the post space preparation that could not be removed by NaOCL irrigation.

In 2005, Foxton et al. [14] prepared the post space without previous endodontic treatment; also they didn't use any irrigation solution (NaOCL).

In 2001, Morris et al. [15] reported the biomechanical behavior of root canal dentin would have been different if it had been endodontically treated or treated with NaOCL. Other factor is that the coronal portion of the canal is the most accessible part of the canal space making it easier to etch and more thoroughly apply the adhesive agent than in deeper area of the canal

The effect of time on the bond strength of fiber post

The study findings revealed a significant increase in bond strength values when the specimens are tested 1 week and 2 weeks after post space preparation and post cementation, this behavior is probably caused by the water sorption and subsequent hygroscopic expansion of the cements and/or by continuation of its setting reaction. Hygroscopic expansion occurs within water-based cements, two distinct phases of reaction occur in these water-based materials, the initial phase utilizes water that is present originally within the mixed cement. Once this water is consumed, the second phase can only occur when water is available from either the underlying dentin [16] or the external environment.

Additionally, evidence has been collected that the availability of water during the maturation phase of the cement materials leads to the formation of a distinct silica rich phase that contributes to a gradual increase in mechanical properties with time [17]. Such a phenomenon might have increased the frictional resistance of the cements against the root canal walls and, subsequently, improved fiber post retention. This is in agreement with Reis et al. [18] who stated that the effective retention mechanism for fiber posts to the root canals is largely derived from sliding friction of the cement against the internal walls of root canals instead of true adhesion to intra-radicular dentin.

Comparison of push test values between the self-cure and dual cure resin cement

This study revealed that the bonding strength values of the self-curing resin material is higher than the dual cure resin material, This might be attributed to several factors, one of them is that the type of post employed, the FRC post used in this study is produced by the same manufactures of the self-cure resin cement (Multilink N) which make it a full system pack and more compatible. And because the dual cure resin cement (Relyx U 100) is alight polymerized adhesive its bonding strength values is compromised at the apical and middle regions of the root where the curing light might not reach, while the self-cure cement (Multilink N) is a self-cure resin with a light curing option in which the main reaction is chemical and its polymerization can be further enhanced achieved by the light cure. The findings of this study coincides with study by Behr et al. [19] which revealed The self-activating system showed a more uniform resin tag and resin-dentin inter-diffusion zone formation along root canal walls than dual-curing systems, while other conflict with this study such as Da Silva et al. [4] that revealed in her study that the bonding strength values of dual cure resin is higher than of self-cure resin cement. This might be due to methodological variation.

Additionally, the Multilink N (self-cure) require salinization of the post with mono bond S which serves as a bonding agent and create a durable chemical bond between the FRC post and the resin cement, this is in agreement with Goracci et al. [11] who stated that the bond strength between the FRC post and the resin cement is significantly improved when using a silane ,while disagree with Bitter et al. [20] who stated that in push-out tests the bond strength of the resin cement to the FRC posts were not significantly affected by silanization.

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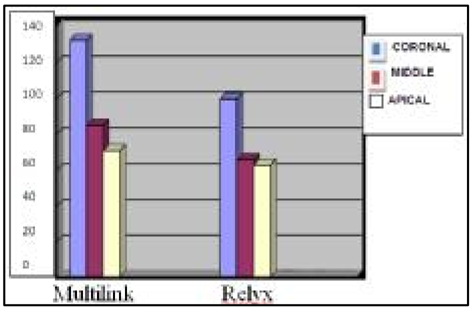

Fig. 1. Mean push-out bond strength of resin cements after 24 h.

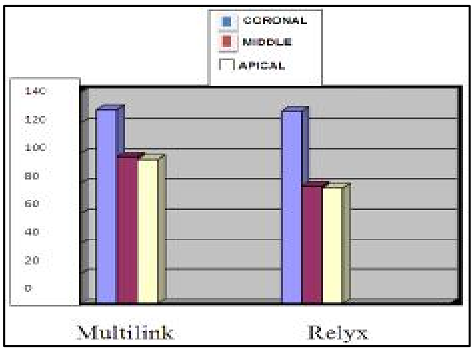

Fig. 2. Mean push-out bond strength of resin cements after a week.

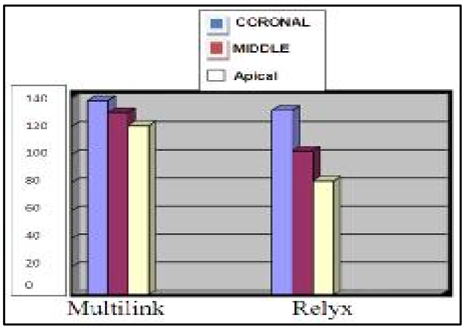

Fig. 3. Mean push-out bond strength of resin cements after two weeks