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ORIGINAL RESEARCH

Influence of Relining Post on the Bond Strength of Resin Cements

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ABSTRACT

This study evaluated the influence of relining fiber posts on the bond strength (BS) of resin cements in the root canal. Forty bovine teeth were divided in four groups (n = 10): G1 (ARC)—fiber post cemented with resin cement RelyX ARC; G2 (ARC+Z350)—relined fiber post cemented with RelyX ARC; G3 (U200)—fiber post cemented with self-adhesive cement RelyX U200; G4 (U200+Z350)—relined fiber post cemented with RelyX U200. The roots were sectioned in six 1.2-mm slices and the push-out test was performed. Data were analyzed by three-way analysis of variance (ANOVA), and Tukey's test (α = 0.05). For the conventional resin cement, there was no significant difference between groups G1-ARC (15.5 ± 3.8) and G2-ARC+Z350 (16.1 ± 4.5). For the self-adhesive cement, the results revealed higher BS values for relined posts G4-U200 + Z350 (19.9 ± 7.9) as compared to non-relined posts G3-U200 (14.4 ± 4.5). For both cements, in groups of relined posts, the apical and the cervical thirds presented similar BS. Relining enhances the performance of the self-adhesive resin cement, and the interaction between relining and root third influences the BS to the conventional resin cement.

Keywords: Dental posts, Root canal, Shear strength.

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INTRODUCTION

Endodontically treated teeth presenting loss of tooth structure due to caries, fractures or excessive wear by successive replacements of restorations present significant reduction in fracture resistance.[1] The loss of tooth structure also impairs the retention of restorative materials. Dental posts enhance this retention and allow maintenance of the definitive restoration in the long-term, increasing the tooth surviva[1,2]

For many years, cast posts and cores have been the main options for restoration of endodontically treated teeth. However, some disadvantages associated with this system led to the use of glass fiber posts (GFP) as an alternative to metallic posts and cores. The GFP have excellent esthetics, good adhesion to polymers used for cementation (resin cements) and good biomechanical performance; because post, cement and dentin constitute a homogeneous ensemble.[3] They distribute the occlusal stress more uniformly along the root, leading to lower occurrence of root fractures.[4]

However, the cementation of GFP is a sensitive technique and some variables may impair the bond between cement and dentin, such as the several materials used for endodontic treatment,[5-7] root canal morphological variations,[8,9] control of dentin moisture, formation of bubbles in the resin cement and difficult curing of the resin cement at the middle and apical root thirds.[5-12] Therefore, a successful treatment requires good bonding between cement and post, as well as between cement and dentin, since the poor bonding between these interfaces may lead to debonding and/or fracture of the post and core.[13]

Several cementation agents and corresponding adhesive systems have been proposed for bonding GFP to the root dentin. *In vitro* studies on the bond strength of different cements to fiber posts and root dentin have been conducted, yet controversial outcomes have been reported.[14-17]

Moreover, the thickness of cement has been scarcely investigated. Since they are prefabricated systems, the GFP do not adapt perfectly to the internal shape and diameter of all root canals.[18] The lack of adaptation leads to formation of a thick cement layer, which generates high polymerization shrinkage stress on the root canal walls and greater quantity of bubbles, which predispose to adhesive failures.[19] Some authors have suggested relining these posts with composite resin to reduce the difference between diameters of the root canal and post, which reduces the thickness of the cement layer.[18,19]

Due to the wide variety of available products and difficult bonding inside the root canal space, it is difficult to select a cementation strategy that may provide reliable and long-lasting bonding to the root dentin. Therefore, it is necessary to investigate the adhesion of fiber posts inside the root canal to assure satisfactory performance of these systems. This study evaluated the influence of a relining post on the bond strength of two dual-cured resin cements to the different root thirds. Fiber posts were relined with composite resin and cemented with a conventional and a self-adhesive cement. The roots were prepared and the shear bond strength was performed. The reline technique can influence the bond strength of resin cements on root canal, interfering on the performance of these materials.

MATERIALS AND METHODS

Materials

Resin cement Rely X ARC, Resin cement Rely X U200, glass fiber post, phosphoric acid, silane, Activator Adper Scotchbond multi-purpose plus, Catalyst Adper Scotchbond multi-purpose plus, Primer Adper Scotchbond multi-purpose, Adhesive Adper Scotchbond Multi-Purpose and Resin Filtek Z350 XT. The materials composition and their manufacturer are presented in Table 1.

Roots Preparation

Forty bovine incisors with completely formed straight roots with similar shape and size were selected for this study. Periapical radiographs (Kodak insight dental film; Eastman Kodak Company) were obtained from all teeth to check the root canal anatomy. The crown of each tooth was sectioned below the cementoenamel junction using a double-sided diamond disk (Flexible diamond disc; KG Sorensen, Brazil at low speed under cooling, achieving a uniform root length of 18 mm.

The root canals were instrumented with files (K-Flex; Dentsply maillefer USA) and irrigated with distilled water. Root canal preparation for cementation of GFP was performed at a length of 13 mm, using the specific bur supplied with the post system (Whitepost DC; FGM), one size greater than the posts to widen the root canals. After intracanal preparation, debris was removed from the root canal by irrigation with distilled water and drying with paper points (Absorbent paper points; Dentsply maillefer). The roots were randomly divided in four study groups, according to the type of cement and post employed (Table 2).

Posts Preparation

The surfaces of GFP of all groups were cleaned with 70% alcohol for 1 minute and air dried, followed by silanization (Silane coupling agent; Dentsply).

The posts in group G1 (ARC) received one coat of catalyst (Adper Scotchbond multi-purpose plus; 3M ESPE), which was gently air dried 10 seconds after application.

The posts of relined groups G2 (ARC+Z350) and G4 (U200 + Z350) received one coat of adhesive (Adper Scotchbond Multi-Purpose; 3M ESPE) light-activated with a 800 mW/cm^2 power light-polymerizing unit for 40 seconds (DEMI LED Curing Light; Kerr California). Following, their surface was covered with composite resin (Filtek Z350 XT; 3M ESPE). The post/resin assembly was introduced in the root canal previously isolated with bidistilled glycerin (KY; Johnson & Johnson) to acquire the root canal shape. The resin was light-polymerized for 5 seconds. Following, light-polymerizing for further 60 seconds was performed on the post outside the root canal to assure the complete resin polymerization. The root canals were thoroughly rinsed with distilled water and dried with absorbent paper points. The GFP were again cleaned with 70% alcohol for 1 minute and covered with one coat of silane. At 1 minute after silane application, the GFP in group G2 (ARC + Z350) received one coat of catalyst. Table 2 summarizes the sequence of post preparation in the different groups.

Cementation Procedure

The GFP were cemented strictly following the manufacturers' instructions (Table 2). After cementation, the

Table 1: Materials employed, composition and manufacturer

Materials	*Composition*	*Manufacturer*
RelyX ARC	Silicon-treated silica, 2,2 ethylenedioxy diethyl dimethacrylate, diglycidyl ether bisphenol methacrylate, functionalized dimethacrylate polymer	3M ESPE, St Paul, MN, USA
RelyX U200	Base paste: silane-treated glass powder, 2-propenoic acid, 2-methyl, 1,1-[1-(hydroxymethyl)-1,2-ethanodiyl] ester, triethylene glycol dimethacrylate (TEG-DMA), silica with silane, glass fiber, sodium persulfate and t-butyl per-3,5,5-trimethyl-hexanoate. Catalyst paste: silane-treated glass powder, substitute dimethacrylate, silica with silane, sodium p-toluenesulfonate, 1-benzyl-5-phenyl-baric acid, calcium salts, 1,2-dodecane dimethacrylate, calcium hydroxide and titanium dioxide	3M ESPE/AG, Seefeld, Germany
Glass fiber post	Epoxy resin, epoxy hardener and glass fibers	FGM, Joinvile, SC, Brazil
Phosphoric acid 37%	Phosphoric acid 37%, thickener, dye and deionized water	FGM, Joinvile, SC, Brazil
Silane	Silane, ethanol and acetic acid	Dentsply, Petrópolis, RJ, Brazil
Activator Adper Scotchbond Multi-Purpose Plus	Ethyl solution of sulphinic acid and photoinitiator	3M/ESPE, St Paul, MN, USA
Catalyst Adper Scotchbond Multi-Purpose Plus	Bis-GMA, HEMA, benzoyl peroxide	3M/ESPE, St Paul, MN, USA
Primer Adper Scotchbond Multi-Purpose	HEMA and polyalkenoic acid copolymer	3M/ESPE, St Paul, MN, USA
Adhesive Adper Scotchbond Multi-Purpose	Bis-GMA, HEMA, amine polymerization initiators	3M/ESPE, St Paul, MN, USA
Resin Filtek Z350 XT	Bis-GMA, UDMA, TEGDMA, bis-EMA, silica, zirconia	3M/ESPE, St Paul, MN, USA

Table 2: Experimental groups, posts preparation and cementation sequence

Groups	*Post-treatment*	*Root canal preparation + cementation*
G1 (ARC): Glass fiber post + resin cement RelyX ARC	Alcohol 70% (1 minute) + silane (1 minute) + catalyst	Etching with phosphoric acid 37% (15 seconds) + rinsing (15 seconds) + drying with absorbent paper points + activator + primer + catalyst + insertion of cement RelyX ARC in the root canal + insertion of post in the root canal + light-polymerizing for 40 seconds
G2 (ARC + Z350): Relined glass fiber post + resin cement RelyX ARC	Alcohol 70% (1 minute) + silane (1 minute) + adhesive + light-polymerizing for 40 seconds + composite resin + insertion of post/resin assembly in the isolated root canal + light-polymerizing for 5 second in the root canal + light-polymerizing for 60 second outside the root canal Alcohol 70% (1 minute) + silane (1 minute) + catalyst	
G3 (U200): Glass fiber post + resin cement RelyX U200	Alcohol 70% (1 minute) + silane (1 minute)	Irrigation with distilled water + drying with absorbent paper points + insertion of cement RelyX U200 in the root canal + insertion of the post in the root canal + light-polymerizing for 40 seconds
G4 (U200 + Z350): Relined glass fiber post + resin cement RelyX U200	Alcohol 70% (1 minute) + silane (1 minute) + adhesive + light-polymerizing for 40 seconds + composite resin + insertion of post/resin assembly in the isolated root canal + light- polymerizing for 5 seconds in the root canal + light-polymerizing for 60 seconds outside the root canal Alcohol 70% (1 minute) + silane (1 minute)	

apices of all groups were sealed with utility wax and the roots were stored in a humid environment at 37°C for one week.

Push-out Test

After the storage period, the roots were transversely sectioned using a diamond disk in a cutting machine (IsoMet; Buehler), at low speed and constant cooling. The first section was obtained at 1 mm from the cemento-enamel junction and discarded. Six slices with 1.2 mm thickness were obtained, two for each root third.

Color photographs of the cervical and apical surfaces of each slice were obtained using a stereomicroscope (SZ61; Olympus Latina America Inc.) at 30× magnification. The photographs were captured as JPEG images. For each section, both cervical and apical diameters of the post were measured in pixels using the digital software Image (National Institute of Health, Maryland, USA, http:/rsb.info.nih.gov/ij/).

The push-out test was performed at a speed of 0.5 mm/min in a universal testing machine with load capacity of 500 N (3342; Instron Corp). The load was applied on the apical aspect of specimens in apical-cervical direction, to push the post to the widest part of the sectioned root. The bond strength value (BS), expressed in MPa, was calculated by the formula F/A, in which 'F' is the maximum force before rupture of the interface recorded by the universal testing machine in Newtons (N) and 'A' is the bonded interface area in millimeters.

The dentin/post interface area was calculated using the truncated cone area formula: $\pi(R + r)[h^2 + (R - r)^2]^{0.5}$, in which π is a constant equal to 3.14; h is the slice height; R is the greatest and r is the smallest post radius, obtained on the cervical and apical diameters of each slice, respectively.

Fracture Pattern Analysis

The specimens were analyzed on a stereomicroscope at 40x magnification to analyze the fracture pattern. The failure mode was classified as: (1) adhesive failure at the dentin/cement interface, (2) adhesive failure at the cement/post interface, (3) cohesive failure of the post, and (4) mixed failure (with different combinations between the types of failures). Cohesive fractures in dentin and in cement were not observed and thus were not included in the classification.

STATISTICAL ANALYSIS

Data were tabulated in an MS Excel worksheet and analyzed on the software SPSS (version 17.0). The Kolmogorov-Smirnov test was used to verify if data presented normal distribution ($p < 0.05$). Significant differences in the variable bond strength of posts between groups and root thirds were evaluated by three-way analysis of variance (ANOVA) (cement, treatments and thirds), followed by the Tukey test. The fracture pattern was analyzed by the Chi-square test. All tests were conducted at a significance level of 5%.

RESULTS AND DISCUSSION

Table 3 presents the mean bond strength values (BS) for the different study groups.

Studies demonstrated that relining promotes better adaptation to the root canal walls, promoting better contact between the post/cement/dentin assembly and consequently greater bond strength.[18-20] The close contact with the root canal walls reduces the thickness of the resin cement layer, with less formation of bubbles and reducing the stresses at the adhesive interface during polymerization shrinkage.[19]

Additionally, the retention of relined posts to the root canal may depend on the friction resistance to displacement, more than on the adhesion by micromechanical and chemical retention promoted by the resin adhesive agents.[12,18]

In this study, for the self-adhesive cement, the group of relined posts G4 (U200 + Z350) presented higher BS than the non-relined group G3 (U200). Conversely, contrary to that reported in the literature, the group G1 (ARC) presented similar mean BS as group G2 (ARC + Z350). Materials used during endodontic treatment, such as sodium hypochlorite and EDTA5 may interfere with the bond strength.[5] Studies also revealed that the bond strength of resin cement is influenced by the type of endodontic cement and root canal obturation.[6,7,21] Also, higher BS values were obtained in the cementation of fiber posts with self-adhesive[21] and conventional resin cement[7] in root canals without previous utilization of obturation material.[7,21] In this study, the root canals were irrigated only with distilled water and were not obturated. The non-accomplishment of endodontic treatment allowed avoiding any interference on adhesion of the post/cement/dentin assembly, either due to irrigants or remnants of obturation material, enhancing analysis of the performance of each cement in the root canal. This may have improved the standard of etching and increased the performance of the conventional resin cement, leading to similar BS values for conventional (G1 ARC) and relined posts (G2 ARC + Z350).

The quality of adhesion may also be influenced by the composition of dentin, since the tubular density and diameter of tubuli are reduced in apical direction, which may influence the mechanism of micromechanical bond.[8] In group G1 (ARC), the BS at the adhesive interface was significantly affected by the root region. The cervical and middle thirds presented similar mean BS and higher than

Table 3: Mean and standard deviation of bond strength according to the type of resin cement and type of post

	ARC			*U200*		
	Conventional post (G1)	*Relined post (G2)*		*Conventional post (G3)*	*Relined post (G4)*	
Root region	*Mean (± SD)*	*Mean (± SD)*	p^1	*Mean (± sd)*	*Mean (± SD)*	p^1
Cervical	18.6 (3.4)^{Aa}	16.4 (4.6)^{Aab}	0.23	15.7 (3.8)^{Aa}	22.3 (8.1)^{Ba}	0.04*
Middle	15.9 (2.5)^{Aa}	18.9 (2.9)^{Aa}	0.01*	14.3 (5.2)^{Aa}	22.7 (8.7)^{Aa}	0.02*
Apical	12.2 (2.5)^{Ab}	12.7 (3.6)^{Ab}	0.73	13.2 (4.5)^{Aa}	15.2 (4.8)^{Aa}	0.36
Total	15.5 (3.8)^{A}	16.1 (4.5)^{A}	0.67	14.4 (4.5)^{A}	19.9 (7.9)^{B}	< 0.01*

Different upper case letters indicate statistical differences in the rows (same treatment and different cements). Different lower case letters indicate statistical differences in the columns (same cement and treatment and different root regions).[1]Comparision between different treatments for the same cement the apical third. Previous studies also showed highest bond strength to cervical third.[9,22] Other factors, such as difficult access to the apical region and possible limitations of cement flow may be assigned for this result,[12,22] as well as the decreasing effectiveness of light curing at regions farther from the light source, since that the performance of the dual-cured resin cements improve after setting by light and chemical activation; demonstrating the importance of light curing.[12,22,23]

No significant difference was found between the root thirds of fiber posts cemented with self-adhesive cements. The lowest sensitivity of the technique may have favored the performance of this cement at the three root thirds, since the procedures of etching, rinsing, drying and application of adhesive system, considered critical steps, are eliminated. Conversely, previous studies[9,22] observed regional differences between the three thirds for posts cemented with self-adhesive cement, with higher BS values for the coronal region and lower for the apical region.[9,22] The self-adhesive cements contain acid phosphoric esters responsible for substrate etching, yet they are not as effective as phosphoric acid.[15] The absence of endodontic treatment, in this studies, may have favored the chemical interaction with calcium of hydroxyapatite, enhancing their mechanical properties.

Regardless of the cement used, no significant difference was found between the cervical and apical thirds for the groups of relined posts. The retention found at the apical region, similar to the BS of the cervical region for groups G2 (ARC + Z350) and G4 (U200 + Z350), may have been caused by relining.[18]

It was observed that the type of fracture was dependent on the type of treatment ($p < 0.0001$) (Table 4). Analysis of the fracture patterns revealed good adhesion between dentin and resin cement in groups G1 (ARC) and G3 (U200), in which there was predominance of adhesive failures at the post/cement interface. Adhesive failures at the cement/dentin interface was more frequently observed in groups G2 (ARC + Z350) and G4 (U200 + Z350), reinforcing the idea that the bond strength in these groups may also have been influenced by the greater contact of the post with the root canal wall. Another hypothesis for these findings would be the composition of the materials used. As they have similar composition, resin cement and composite resin used to reline may have greater interaction than resin cement with the post surface.

Table 4: Analysis of the fracture pattern for the different groups

Type of failure	*G1 ARC*	*G2 ARC + Z350*	*G3 U200*	*G4 U200 + Z350*	
	N (%)	*N (%)*	*N (%)*	*N (%)*	*p*
Adhesive dentin/cement	01 (1.7)	28 (46.6)	07 (11.7)	24 (40.0)	< 0.0001
Adhesive cement/post	28 (46.7)	04 (6.7)	24 (40.0)	01 (1.7)	
Cohesive of the post	02 (3.3)	04 (6.7)	10 (16.7)	11 (18.3)	
Mixed	19 (31.6)	21 (35.0)	16 (26.6)	22 (36.7)	
Loss	10 (16.7)	03 (5.0)	03 (5.0)	02 (3.3)	

Although this study has been conducted in a careful way, this is a *in vitro* experiment, so the real oral conditions are not fully replicate. Additionally, endodontic treatment was not done. Thus, clinical and laboratory studies are suggested to simulate clinical conditions and evaluate the performance of relined posts and the different resin cements in long-term

CONCLUSION

Within the limitations of this study, it was concluded that relining enhances the performance of self-adhesive resin cement and the interaction between root third and relining influences the bond strength to the conventional resin cement.

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