

Can the Cure Time of Endodontic Sealers Affect Bond Strength to Root Dentin?

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The cure time of endodontic sealers may influence the bond strength of fiber posts to root dentin. Forty teeth were selected and endodontically filled using calcium hydroxide cement and then divided into 2 groups according to the time elapsed between endodontic filling and post luting (n = 20): Immediately - glass fiber post luting immediately after endodontic filling; and Delayed - post luting performed 7 days after endodontic filling. The roots were also subdivided according to resin cement used for post luting (RelyX ARC and RelyX Unicem). The specimens were stored at 37°C for 24 h and sectioned in six 1-mm-thick slices from cervical, middle and apical thirds. The slice specimens were submitted to a push-out test at a crosshead speed of 0.5 mm/min, and the bond strength values obtained (MPa) were submitted to two-way ANOVA in a split-plot arrangement and Tukey's test ($\alpha=0.05$). For both RelyX ARC and Unicem, the bond strength was significantly higher when the posts were cemented 7 days after the endodontic treatment. RelyX Unicem showed significantly higher bond strength values than RelyX ARC for both cementation periods. It was concluded that post luting should be made after the complete setting of the root canal sealer. Self-adhesive resin cement should be preferred for fiber post luting.

Introduction

The use of fiber posts luted with resin cements has been reported in several studies (1-3). Glass fiber posts have been widely used in restorative dentistry because of their elastic modulus similar to dentin and their capability to distribute stress more effectively than cast post-and-cores (4). However, fiber post luting is a very critical procedure, which may be affected by several issues, such as dentin contamination, post surface treatment, shrinkage stress and polymerization limitation (5,6).

The post luting procedure can be performed in the same session of the endodontic therapy (7). However, it is supposed that the unset endodontic sealer can contaminate dentin, interfering on bonding to the root canal walls (8, 9), therefore contraindicating post luting immediately after endodontic filling (10). Phenolic eugenol-based compounds and residues of calcium hydroxide sealers can negatively influence the bond strength between fiber posts and root dentin when adhesive luting is performed immediately after endodontic treatment (7,9). This supposedly occurs due to the incomplete cure reaction of these sealers, which affects the adhesion of resin cements, reducing their bond strength to tooth tissues (7).

Conventional dual-cure resin cements are claimed to produce higher bond strength values when associated to fiber posts (11). On the other hand, self-adhesive resin cements produce similar or even higher bond strength values than conventional resin cements when used for

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fiber post luting (12,13). Amongst the available methods to evaluate the bond strength of fiber posts to root canal dentin, the push-out test seems the most suitable option (14). The stress distribution in the push-out specimens has shown to be more homogeneous than in microtensile specimens (15). Additionally, data variability is more acceptable and the bond strength of different root depths can be adequately accessed by this method (15-17).

This way, the hypothesis tested in this study was that the push-out bond strength of fiber posts to the root dentin would not be influenced either by the period elapsed between root canal filling and post luting or by the type of the resin cement.

Material and Methods

Forty bovine incisors were selected and stored in 0.1% buffered thymol solution (Biopharma, Uberlândia, MG, Brazil). The selection criterion considered the similarity between the external and internal morphology of the teeth and a canal diameter smaller than 1 mm at the cervical limit. Roots 15 mm long, were produced after removing the coronal portion of the teeth. The canals were instrumented 1 mm from the apex using the stepback technique, with #25 and #30 K-Files and number 2, 3 and 4 Gates-Glidden burs (Dentsply Maillefer, Ballaigues, Switzerland), with 0.7, 0.9 and 1.1 mm in diameter, respectively. The prepared canals had an approximate diameter of 1.5 mm in the cervical third and 0.9 mm in the middle and apical thirds. Root canals were irrigated with 1% sodium hypochlorite

(Biodinâmica, Londrina, PR, Brazil). After final irrigation with distilled water, canals were dried with absorbent papers, filled with gutta-percha (Dentsply-Maillefer) and calcium-hydroxide based endodontic sealer (Sealer 26; Dentsply, Petrópolis, RJ, Brazil).

Roots were divided into 2 groups according to the time elapsed between endodontic filling and post luting (n=20): Immediately - glass fiber post luting immediately after endodontic filling; and Delayed - post luting performed 7 days after endodontic filling. The roots were also subdivided according to the resin cement used for post luting: RXARC (RelyX ARC, A3 shade, 3M ESPE, St. Paul, MN, USA) and RXUNC (RelyX Unicem, A3 shade, 3M ESPE). Cylindrical-tapered glass fiber posts were used, with 1.25 and 2.0 mm apical and cervical diameters, respectively (Whitepost DC n°.3; FGM, Joinville, SC, Brazil). Posts were cleaned with 70% alcohol solution and a silane coupling agent was applied and left to react for 1 min (Prosil, FGM). For RXARC specimens, the canal was etched with 37% phosphoric acid for 15 s, rinsed with water and dried with absorbent papers. A 2-step etch-and-rinse adhesive system (Single Bond Plus, 3M ESPE) was applied to the root canal walls and polymerized for 20 s with a LED-curing unit (RadiumCal; SDI, Victoria, Australia). The resin cement was manipulated according to the manufacturer's instructions and applied to the post and to the root canals with a #35 K file. All posts were gently inserted and held in position with pressure for 3 min. Excess cement was removed after the first minute and light-curing was performed for 40 s on incisal, buccal and lingual surfaces, totaling 120 s. For the RXUNC specimens, the root canal walls were only cleaned with 0.9% saline solution and dried with absorbent papers. The resin cement was manipulated according to

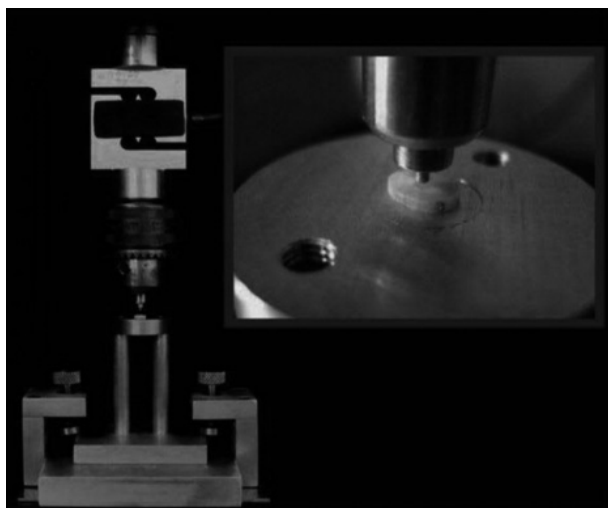


Figure 1. Root/post slice in the mechanical testing machine for the push-out test.

the manufacturer's instructions and post insertion was carried-out as described previously.

Roots were sectioned perpendicular to their long axis with a slow-speed diamond saw (Isomet 1000; Buehler, Lake Bluff, IL, USA) resulting in two slices 1.0 mm thick for each root depth (cervical, middle and apical). The slices were analyzed using optical microscopy at 40x magnification (Mitutoyo, Kanagawa, Japan) to measure both major and minor post diameters in millimeters and to identify any cracks or failures. Then, the slices were positioned allowing the 1.0 mm diameter load applicator tip to coincide with the center of the post and with the 3.0 mm diameter orifice of the metal base (Fig. 1) (7).

Specimens were loaded in a mechanical testing machine (DL 2000; EMIC, São José dos Pinhais, PR, Brazil) at a crosshead speed of 0.5 mm/min. Bond strength was calculated (MPa) dividing the load at failure (N) by the area of the bonded interface (mm²). The area of the bonded interface was calculated as follows:

$$A = \pi * h * (D + d) / 2$$

where A is the area of the bonded interface, π is 3.14, h is the thickness of the post segment (mm), D is the major diameter, and d is the minor diameter of the post segment (mm).

Data were statistically analyzed using two-way ANOVA and Tukey's test ($\alpha=0.05$) in a split plot arrangement, with plots represented by the moment of post luting, luting resin cement and root depths.

Results

Mean bond strength values and standard deviations for the experimental groups according to the moment of post luting and root depths are presented in Table 1 and illustrated in Figure 2.

Two-way ANOVA indicated significant differences for the bond strength values among the groups ($p < 0.05$). The isolated factors, moment of post luting, luting resin cement, root depths and also the interaction among factors were significant ($p < 0.01$). In general, it was shown that both luting resin cements presented increased bond strengths when post cementation was performed 7 days after the endodontic filling. Different bond strengths were verified at the three root depths for the conventional resin cement when posts were luted after 7 days. However, this behavior was not verified for the self-adhesive resin cement at the same period. In general, bond strength values were higher for the posts luted with the self-adhesive resin cement compared with those luted with the conventional resin cement.

Discussion

The hypothesis of this study was rejected since the

bond strength between the root dentin and fiber posts was influenced by the time elapsed between the endodontic filling and the post luting. The results showed that bond strength values for both luting resin cements tested were higher when the fiber posts were luted 7 days after the endodontic treatment. These results agree with those of previous studies, which indicated that contamination of the post space is minimized when the endodontic sealer is allowed to set completely before post luting (7,9). Additionally, it is postulated that the adhesive procedures are favored when the dentin is free of previous contamination from eugenol-based endodontic sealers (7,9). This behavior is observed not only for eugenol-based sealers, but also to epoxy-resin and calcium hydroxide-based sealers, as used in this study (8,10,18). Moreover, the preparation of the post space after the setting period of the sealer reduces the possibility of apical infiltration due to improved apical sealing (19).

The unset endodontic sealer had an influence on the adhesion of the luting resin cements to root canal dentin since the bond strength values were lower when the post space preparation and luting procedure were performed immediately after endodontic filling (Fig. 2). This fact may be due to the contamination of the root canal dentin by the unset sealer, which is transported from the apical region to the whole canal length by the paper points used to dry the canals or by the disposable applicators used to apply the adhesive system to the root walls (9).

As regards the resin cements used in this study, the bond strength values of RelyX Unicem were higher than those obtained by RelyX ARC after 7 days of endodontic treatment. Compared with conventional resin cements, self-adhesive cements, such as RelyX Unicem, have presented higher bond strength to root dentin (20,21). Furthermore, these cements allow a less sensitive application technique, are easier to handle and produce reliable bond strength (11).

The self-adhesive resin cement evaluated was not influenced by the different root depths as the conventional resin cement when delayed (22). This may be due to the fact that in the apical portion the number and configuration of dentin tubules are less dense (23) and dentin is more sclerotic (24). Thus, the formation of resin tags is reduced. On the other hand, this apical calcification increases the availability of apatite crystals, which is the ideal substrate for self-adhesive resin cements. Additionally, the polymerization initiator of the self-adhesive resin cement is not an alkaline amine, which can be deactivated by the acidic environment, as may occur for the conventional resin cements (25).

Based on the results of this study, clinicians should be careful in performing immediate cementation of fiber posts after endodontic filling when calcium-hydroxide based endodontic sealer is used, as post luting after 7 days of root filling resulted in higher bond strength values for both resin cements. Moreover, the self-adhesive resin cement showed higher bond strength values compared with the conventional resin cement, being less affected by the different root dentin depths. Then, this material should be preferred for luting procedures involving fiber posts.

Resumo

O tempo de presa de cimentos endodônticos pode afetar a resistência de união de pinos de fibra de vidro à dentina radicular. Quarenta dentes foram selecionados e tratados endodônticamente com cimento à base de hidróxido de cálcio. Em seguida, os mesmos foram divididos em dois grupos de acordo com o tempo decorrido entre o tratamento

Table 1. Mean bond strength values (MPa) and standard deviation (\pm SD) for the experimental groups

Root depth	RelyX ARC		RelyX Unicem	
	Immediate	Delayed	Immediate	Delayed
Cervical	7.6 \pm 4.7 Ba β	16.7 \pm 3.6Aa β	8.6 \pm 3.5Ba β	17.0 \pm 6.5Aa β
Middle	7.6 \pm 3.8 Ba β	13.0 \pm 3.3Aa δ	9.4 \pm 4.1Ba β	17.1 \pm 7.0Aa β
Apical	6.8 \pm 4.2 Ba β	9.0 \pm 2.9Ab δ	9.5 \pm 4.2Ba β	13.9 \pm 4.9Aa β

*Different capital letters represent significant differences between the luting periods for each resin cement tested (comparison in lines). Different small letters represent significant differences between root depths for each group (comparison in columns). Different symbols represent significant differences between resin cements for each resin cement and luting period tested (comparison in lines) ($p < 0.05$).

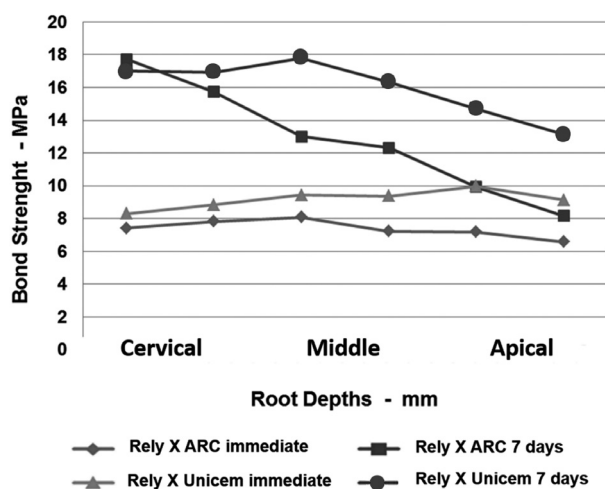


Figure 2. Bond strength of resin cements according to the moment of post luting and root depths.

endodôntico e a cimentação definitiva (n=20): Imediato - pinos de fibra de vidro cimentados após o tratamento endodôntico; e Mediato - cimentação do pino realizada 7 dias após o tratamento endodôntico. As raízes foram subdivididas de acordo com o cimento resinoso (RelyX ARC e RelyX Unicem). As amostras foram armazenadas a 37 °C durante 24 h e seccionadas em seis fatias de 1 mm de espessura relacionadas com terços cervical, médio e apical. Os espécimes foram submetidos a teste de *push-out* a uma velocidade de 0,5 mm/min e os valores de resistência de união obtidos (MPa) foram submetidos à análise de variância em esquema de parcelas subdivididas e teste de Tukey ($\alpha=0,05$). Para os cimentos RelyX ARC e Unicem, a resistência de união foi maior quando os pinos foram cimentados 7 dias após o tratamento endodôntico. RelyX Unicem apresentou valores de resistência de união superiores ao RelyX ARC para os períodos de cimentação. Concluiu-se que a cimentação do pino de fibra de vidro deve ser feita após o completo tempo de presa do cimento endodôntico. Cimentos resinosos auto-adesivos devem ser preferidos para cimentação de pinos de fibra.

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