

ORIGINAL ARTICLE

Effect of root-canal sealer on the bond strength of fiberglass post to root dentin

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Abstract

Objective. To evaluate the effects of different root-canal sealers on the bond strength of a fiberglass post cemented with self-adhesive resin cements. **Material and methods.** Forty extracted maxillary single-rooted canines were prepared with the crown-down technique and randomly divided into four groups according to the tested sealer: Group 1: control group, gutta-percha cone only (no sealer); Group 2: EndoREZ; Group 3: Sealapex; Group 4: Endofill. The roots were obturated with the gutta-percha cone using the cold lateral compaction technique. Fiberglass posts were cemented into the prepared post spaces with the self-adhesive cement RelyX Unicem. Bonded specimens were sectioned into 1-mm thick slabs and a push-out test was performed in a universal machine. **Results.** Data were subjected to ANOVA and Tukey tests ($\alpha = 0.05$). No significant difference was detected between Groups 1–3 ($P > 0.05$). Group 4 showed a lower bond strength than the other sealers ($P < 0.05$). **Conclusions.** Endofill negatively interfered with the bond to root dentine; however, EndoRez and Sealapex did not affect the bond strength of the fiberglass post cemented with self-adhesive resin cements.

Key Words: Bond strength, fiberglass post, push-out, root-canal sealers, self-adhesive

Introduction

Endodontically treated teeth frequently require indirect restorations because of extensive loss of the healthy tooth structure as a result of carious lesions, previous restorations and/or fractures. In such cases, the use of intraradicular posts is recommended to promote retention of the final restoration [1–3]. Cast metal posts and core systems have traditionally been used for intraradicular retention. However, these materials have a high elastic modulus and, therefore, are more likely to cause fracture of the remaining dental structure [4]. Fiberglass posts have led to great advances, especially as a result of their mechanical properties, such as a high flexural strength and an elasticity modulus similar to that of dentine, which minimize the transmission of stresses on the root walls and decrease the possibility of fractures [5,6]. Furthermore, another important advantage of fiberglass

posts is their good esthetic appearance, with no risk of gingival discoloration or alteration of the root surface by corrosive products, especially in the anterior region [7], and they can also be adhesively cemented in the root canal [8,9].

For the adhesion cementation of fiberglass posts, either ‘conventional’ composite or self-adhesive resin cements are available. The self-adhesive resin cements were introduced onto the dental market in 2002 with the advantage that no pretreatment of the tooth surface is required [10,11]. This leads to a simplified and time-saving cementation procedure [11,12] with a bonding mechanism based on micro-mechanical retention and chemical adhesion [13,14]. The self-adhesive resin cements contain multifunctional hydrophilic monomers with phosphoric acid groups, which can react with the hydroxyapatite (HAp) and also penetrate and modify the smear layer [15,16]. The chemical interaction between the acidic

monomers and HAP ensures adhesion of the self-adhesive cements onto dentin [17]. However, depending on its composition, the root-canal sealer might interfere with the durability and adhesion of a post retainer to root dentin. Studies have evaluated the effect of root-canal sealers and their compounds on the retention of intraradicular posts and the results have shown a decrease in bond strength of posts fixed with resin cements in canals obturated with a root-canal sealer containing eugenol [18–22]. Ngoh et al. [18] and Hagge et al. [19] observed that eugenol reduced the bond strength of resin cement to the dentin of the root canal. Demiryurek et al. [20] observed that the highest bond strength of fiber posts was found in a group obturated with a calcium hydroxide-based sealer and that resin- and eugenol-based sealers showed lower bond strengths. Other studies verified that no significant differences were found between the retention of posts in eugenol and non-eugenol-containing root-canal sealers [23,24].

Therefore, based on the literature it is unclear whether the presence of eugenol and other components of root-canal sealers affects the retention of posts. The purpose of this study was to evaluate the effects of different root-canal sealers on the bond strength between a fiberglass post and root dentin fixed with self-adhesive cement. The null hypothesis was that the resin- and calcium hydroxide-based sealers do not negatively interfere with bond strength and that the zinc oxide/eugenol-based sealers have a negative influence on the bond strength between a fiberglass post and root dentin.

Material and methods

Forty caries-free, recently extracted single-rooted human teeth with straight root canals were used. The inclusion criteria were: absence of caries or root cracks; absence of previous endodontic treatments; and root length ≥ 13 mm. Teeth were stored in 0.02% thymol solution [25] and prepared within 1 month of extraction. Each tooth was decoronated below the cemento-enamel junction perpendicularly to the longitudinal axis using a slow-speed, water-cooled diamond disc (Isomet 2000; Buehler Ltd, Lake Bluff, IL).

All root canals were prepared by the same trained operator. The working length was determined as 1 mm above the root length. The endodontic preparation was carried out using the crown-down technique with size 2–4 Gates Glidden drills (Dentsply-Maillefer, Konstanz, Switzerland) and rotary Ni–Ti instruments of the K3 System (SybronEndo, Glendora, CA). The apical preparation was extended until it was a size 35/0.04. The root canal was irrigated between instrumentations with 2 ml of 2.5% sodium hypochlorite using a long 27-gauge needle. The final irrigation was done with 2 ml of

17% EDTA solution for 5 min followed by 5 ml of distilled water. The patency of the canals was maintained with a size 10 K-file (Dentsply-Maillefer).

The root specimens were dried with paper points (Dentsply-Maillefer), randomly divided into four groups of 10 teeth by means of Minitab Statistical Software (Minitab Corporation, Chicago, IL) and filled as follows: Group 1: control group, gutta-percha points only (no sealer); Group 2: EndoREZ (resin-based sealer; Ultradent, South Jordan, UT); Group 3: Sealapex (calcium hydroxide-based sealer; SybronEndo); Group 4: Endofill (Dentsply-Maillefer, Petrópolis, RJ, Brazil). The roots were obturated with gutta-percha (Dentsply-Maillefer) using the cold lateral compaction technique. The root-canal sealers were prepared and used according to the manufacturers' instructions. After vertical condensation, a temporary filling material (Cavit W; Premier Dental Produtos, Rio de Janeiro, RJ, Brazil) was used to seal the coronal orifice.

After storage at 100% humidity for 1 week at 37°C, the temporary filling material was removed with a size 2 Peeso reamer (Dentsply-Maillefer). The root-canal sealer was removed from the root canals (11 mm depth) with heated instruments (SSWhite, Rio de Janeiro, RJ, Brazil). Post-fixation spaces were prepared using size 3 Largo burs (Dentsply-Maillefer) with a low-speed handpiece (Kavo, Joinville, SC, Brazil). The effectiveness of removal of the root-canal filling material was assessed using magnification loops (Carl Zeiss, Jena, Germany). After preparation, the root canals were cleaned with a 0.2% chlorhexidine digluconate solution and dried with absorbent paper points.

The self-adhesive resin cement (RelyX Unicem; 3M ESPE, Seefeld, Germany) was manipulated and placed onto the posts by hand and into the canal spaces using 20-gauge Accudose Needle Tubes (Centrix; DFL, Rio de Janeiro, RJ, Brazil). Because this cement sets extremely rapidly when deprived of oxygen, the posts were placed in position immediately after application of the cement. The posts (fiberglass post; Ângelus, Londrina, PR, Brazil) were seated to full depth using finger pressure and light polymerization was carried out for 40 s using a quartz–tungsten–halogen light (Optilux 501; Kerr, Orange, CA) with an irradiance of 500 mW/cm². The specimens were kept humid for 24 h at 37°C.

After storage, each root was cut horizontally with a slow-speed, water-cooled diamond saw (Isomet 2000) to produce one slice ≈ 1 -mm thick for each root region (apical, middle and cervical). The first slice was not included, in order to avoid the influence of excess coronal material. The push-out test was performed by applying a load at a rate of 0.5 mm/min in the crown in the direction of the apex until the post segment was dislodged from the root slide. The push-out bond strength was measured with a

universal testing machine (DL 2000; EMIC, São José dos Pinhais, PR, Brazil). The maximum failure load values were recorded (N) and converted into megapascals, considering the bonding area (mm^2) of the post segments. The post diameters were measured on each surface of the post/dentin sections using a digital caliper (Vonder, Curitiba, PR, Brazil), and the total bonding area for each post segment was calculated using the formula $\pi(R+r)[h^2+(R-r)^2]^{0.5}$, where R represents the coronal post radius, r the apical post radius and h the thickness of the slice.

For the fracture analysis, the specimens were submitted to a careful visual examination at a magnification of $\times 20$ (Carl Zeiss). The failure mode was classified into five types according to [26,27]: (1) adhesive between the post and resin cement (no cement visible around the post); (2) mixed, with resin cement covering 0–50% of the post diameter; (3) mixed, with resin cement covering 50–100% of the post surface; (4) adhesive between resin cement and root canal (post enveloped by resin cement); and (5) cohesive in dentin.

Means and standard deviations (SDs) of bond strengths were calculated and the data were subjected to ANOVA tests using a factorial design with root-canal sealer (EndoREZ, Sealapex and Endofill) and radicular region (coronal, middle and apical) as variables. Multiple comparisons were done using the Tukey test at a significance level of 0.05.

Results

The mean push-out bond strengths and SDs are presented in Table I. The results of ANOVA revealed significant differences between the groups ($P < 0.0001$). No significant difference was detected between Groups 1–3 ($P > 0.05$). Group 4 showed lowest bond strength ($P < 0.05$). No significant differences were found among the root regions (coronal, middle and apical).

Table II presents the results of the predominating types of failure in each group. The prevalence of mixed fractures and adhesive cement–dentin was verified in all of the analyzed groups.

Discussion

To develop this research, the roots of human maxillary canine teeth were selected. The use of only the tip of the root allowed the samples to be standardized, and thus enabled more reliable results to be obtained. However, the results of this study may be transferred to other groups of teeth. Various methods are available to analyze the adhesive bond of composite cements and the bond strength of fiber posts. The two most commonly used techniques are the microtensile bond strength and push-out tests. Most scientists prefer the push-out test for analysis of the bond strength of fiber posts to root dentin because it has been documented that the results of this test are more reliable for fiber posts compared to the microtensile test. By using the push-out test, the premature loss of samples during the manufacturing of the specimens is reduced. Furthermore, the push-out test enables the measurement of bond strength to very small areas such as the interior of a root canal [28].

In this experiment, a significant reduction in the bond strength of a fiberglass post to root dentin cemented with self-adhesive cement was observed when the eugenol-based sealer was used. However, no significant differences were detected between the control group and the resin- and calcium hydroxide-based sealer groups. Regarding these results, the null hypothesis was confirmed.

Some studies have determined that eugenol-based sealers decrease the bond strength of resinous cement [18–22]. Eugenol residues remaining on the dentin may interfere with the polymerization of adhesive resin and, because of their interdiffusion through dentin, they can cause a significant reduction in adhesive effectiveness or even modify the polymerized resin surface [23], thus decreasing the bond strength of the resinous cement. Markowitz et al. [29] reported that a chelating reaction occurs when zinc oxide is mixed with eugenol, resulting in grains of zinc oxide being absorbed in a zinc eugenolate matrix, which makes it impossible for the eugenol to be released. However, due to the presence of fluids inside dentinal tubules, this reaction becomes reversible: the eugenol released then penetrates the dentin and tends to

Table I. Mean \pm SD* push-out bond strength values (MPa) according to the root-canal sealer.

Group	Root region		
	Coronal	Middle	Apical
No sealer (control)	5.49 \pm 0.53 ^a	5.24 \pm 0.62 ^a	5.22 \pm 1.12 ^a
Resin-based sealer (EndoREZ)	5.45 \pm 1.37 ^a	5.41 \pm 1.39 ^a	5.35 \pm 1.49 ^a
Calcium hydroxide-based sealer (Sealapex)	5.34 \pm 0.74 ^a	5.41 \pm 1.26 ^a	5.34 \pm 1.32 ^a
Eugenol-based sealer (Endofill)	3.46 \pm 0.87 ^b	3.14 \pm 0.95 ^b	3.17 \pm 0.90 ^b

*The same superscripted letters indicate no significant differences ($P > 0.05$) [27].

Table II. Failure mode in each group. The values shown represent the number of failures.

Group	Adhesive: post-cement	Mixed 0–50%	Mixed 50–100%	Adhesive: cement–dentin	Cohesive	Total
No sealer (control)	3	12	8	4	3	30
Resin-based sealer (EndoREZ)	3	9	12	5	1	30
Calcium hydroxide-based sealer (Sealapex)	2	10	10	6	2	30
Eugenol-based sealer (Endofill)	–	5	10	15	–	30

become concentrated at the tooth–adhesive interface [30].

The EndoREZ and Sealapex sealers showed higher bond strength values than the Endofill canal sealer. EndoREZ is a urethane methacrylate resin-based sealer [31] and its monomeric composition might be responsible for its higher adhesion to the Rely X Unicem luting material. The groups filled with the calcium hydroxide-based sealer showed no significant difference in bond strength in comparison with the control group. These findings are in agreement with those of previous studies [22,32,33]. The EndoREZ and Sealapex sealers have resin components in their composition, this may have affinity for components and Rely X Unicem lead to a better interaction than Eugenol. Another probable reason for the higher bond strength found when using EndoREZ and Sealapex is that these root-canal sealers were more completely removed from the root-canal walls during preparation for post-fixation performed using the wide Largo burs, whereas eugenol was not properly removed due to interdiffusion through the dentin.

Regarding the fracture analysis, it should be emphasized that predominant types of failure in the eugenol-containing sealer group were adhesion between the resin cement and root canal and the mixed type (with resin cement covering 50–100% of the post surface), implying that the weak link was the bond between the resin cement and the root-canal dentin. Therefore, some sealer components may have remained behind and interfered with effective dentin bonding. The quality of the bond in the control group and in the resin- and calcium hydroxide-based sealer groups appeared to be superior because the predominant type of failure was the mixed type. This suggests that the bond between the resin cement and the root-canal dentin was less affected than that in the eugenol-containing group (Table II).

Dual-resin cements have been recommended for luting fiberglass posts to compensate for the reduction of light and to allow greater polymerization of the cement in the thirds deeper root canal [34]. The dual curing resin RelyX Unicem consists of special methacrylate monomers with bonded phosphoric acid groups and at least two unsaturated C=C double

bonds. These methacrylated phosphoric esters are found in the liquid phase of the product in combination with dimethacrylates, acetate, stabilizers and initiators. The phosphoric acid methacrylate contributes a total phosphorus content of $\approx 3\%$ and is supposed to react with the basic fillers and HAP [13]. In analyzing the bond with HAP, Gerth et al. [13] showed that the calcium in the HAP reacts with the cements. The oxidation state of these calcium atoms is lowered by a charge-transfer process with calcium, which acts as an electron acceptor. This calcium component could be attributed to atoms at the surface of the HAP interacting with the composites. The HAP calcium atoms are cross-linked by organic functional groups which change their electronic structure. This interaction is most probably based on chelation of the calcium ions by acid groups and produces chemical adhesion to HAP in the tooth structure. Therefore, the bond to the tooth structure is based on the principle that monomers react with basic salts and hapatita in tooth structure [35]. In addition, for the RelyX Unicem cement used in this study, bonding released free radicals, which can be initiated by exposure to light or by using mechanisms of oxidation-reduction, which characterize the three aspects of cement polymerization: acid/base reaction, curing and polymerization in the absence of light [13]. These characteristics explain the similar bond strength values that were found in the coronal, middle and apical regions.

Although it was performed *in vitro*, this study provides information that is important to clinical practice because the luting procedure represents an important step in the clinical use of fiber posts. Most clinical failures involving endodontically treated teeth restored with fiber posts occur as a result of debonding [36,37]. Therefore, it seems important to investigate the bond strength between a fiberglass post and root dentin, as was done in this study conducted in endodontically treated teeth, in which intra-radicular posts are not only necessary but recommended to promote retention of the final restoration. Thus, when analyzing the results obtained in this study, it will be observed that there is good reason for suggesting the use of a resin- or calcium hydroxide-based sealer to fill the root canal, and to avoid using the eugenol-based sealer when a fiber post is necessary.

Within the limitations of the present study, it was determined that the eugenol-based sealer negatively interfered with the bond to root dentin; however, the resin- and calcium hydroxide-based sealers did not interfere with the bond strength of the fiberglass post cemented with self-adhesive resin cements. Several aspects, however, need further research, including the fact that a smear layer is present after preparation of the root-canal dentin, which can be removed effectively with different auxiliary chemical substances in combination with EDTA. Furthermore, different protocols of hybridization of root dentin must be evaluated in order to increase the bond strength and long-term adhesion of the fiber posts.

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