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Effect of root canal sealers on bond strength of fibreglass posts cemented with self-adhesive resin cements

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Abstract

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Aim This study evaluated the effects of different root canal sealers on the bond strength of a fibreglass post cemented with self-adhesive resin cements.

Methodology The root canals of 50 extracted maxillary single-rooted canine teeth were prepared with the crown-down technique and randomly divided into five groups according to the sealer used: group 1: control group, gutta-percha points only (no sealer); group 2: AH Plus (resin-based sealer); group 3: self-etch Epiphany (resin-based sealer); group 4: Sealer 26 (calcium hydroxide-based sealer); and group 5: Endomethasone (zinc oxide eugenol-based sealer). The root canals were filled with gutta-percha, the cold lateral compaction technique, except for group 3 where Resilon was used. Post spaces were prepared, and fibreglass posts were cemented 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. Failure modes were observed and classified into five types: (i) adhesive between the post and resin cement; (ii) mixed, with resin cement covering 0–50% of the post diameter; (iii) mixed, with resin cement covering 50–100% of the post surface; (iv) adhesive between resin cement and root canal; and (v) cohesive in dentine. Data of bond strength were submitted to ANOVA and Tukey test ($\alpha = 0.05$).

Results No significant difference was detected between control group, AH Plus, Epiphany and Sealer 26 ($P > 0.05$). The Endomethasone group had significantly lower bond strength values than the other sealers ($P < 0.05$). The prevalence of mixed fractures and adhesive cement-dentine failure was verified in the eugenol-containing sealer group; in the control group, the resin-based and calcium hydroxide-based sealer groups, the predominant mode of failure was the mixed type.

Conclusion Endomethasone interfered negatively with the bond to root dentine; however, AH Plus, Epiphany and Sealer 26 did not interfere in the bond strength of a fibreglass post cemented with self-adhesive resin cements.

Keywords: bond strength, fibreglass post, push-out, root canal sealers, self-adhesive.

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Introduction

Root filled teeth frequently require indirect restorations because of extensive loss of tooth structure as a result of carious lesions, previous restorations and/or fractures. In such cases, the use of intraradicular posts is recommended to provide retention of the final

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restoration (Boone *et al.* 2001, Cagidiaco *et al.* 2008, Cecchin *et al.* 2010). 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 tooth (Asmussen *et al.* 1999). Fibreglass posts have a high flexural strength and elasticity modulus similar to that of dentine, minimizing the transmission of stresses to the root walls and decreasing the possibility of fractures (Lassila *et al.* 2004, Schwartz & Robbins 2004). Furthermore, fibreglass posts have good aesthetic appearance, with no risk of gingival discoloration or alteration of the root surface by corrosive products, especially in the anterior region (Solomon & Osman 2003); they can also be cemented in the root canal using adhesive techniques (Mayhew *et al.* 2000, Kececi *et al.* 2008).

For the cementation of fibreglass posts, either 'conventional' composite or self-adhesive resin cements are available. The self-adhesive resin cements were introduced into the dental market in 2002 with the advantage that no pre-treatment of the tooth surface is required (Monticelli *et al.* 2008, Toman *et al.* 2009). This leads to a simplified and time-saving cementation procedure (Ibarra *et al.* 2007, Toman *et al.* 2009) with a bonding mechanism based on micromechanical retention and chemical adhesion (Gerth *et al.* 2006, Zicari *et al.* 2008). 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 (Fu *et al.* 2005, Hikita *et al.* 2007). The chemical interaction between the acidic monomers and HAp ensures adhesion of the self-adhesive cements onto dentin (Radovic *et al.* 2008).

Bitter *et al.* (2009) reported that the self-adhesive resin cement (Rely X Unicem, 3M ESPE Seefeld, Germany) had only a sporadic hybrid layer and resin tags but high bond strengths. These results indicate that chemical interactions between the adhesive cement and hydroxyapatite might be more crucial for root dentine bonding than the ability of the same material to hybridize dentine. Macedo *et al.* (2010) evaluated the effect of the cement type on fibre posts retention and reported that the Rely X Unicem had similar values of retention with conventional resin cements. Zicari *et al.* (2008) revealed that the bond strength obtained for RelyX Unicem was in the same range as Variolink II (Ivoclar Vivadent, Schaan, Liechtenstein) and Panavia F (Kuraray Co Ltd, Osaka, Japan). Bitter *et al.* (2006) reported the highest bond strength for RelyX Unicem, compared to Varioink II (Ivoclar-Vivadent), Multilink (Ivoclar-Vivadent), Panavia F (Kuraray), PermaFlo (Ultradent) and Clearfil Core (Kuraray).

However, depending on its composition, the root canal sealer might interfere with the durability and adhesion of a post to root dentine. 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 the retention of posts fixed by resin cements in canals filled with a root canal sealer containing eugenol (Ngoh *et al.* 2001, Cohen *et al.* 2002, Hagge *et al.* 2002a, Menezes *et al.* 2008, Demiryurek *et al.* 2010). Ngoh *et al.* (18) and Hagge *et al.* (2002a,b) observed that eugenol reduced the bond strength of resin cement to the dentine of the root canal. Demiryurek *et al.* (2010) observed that the highest bond strength of fibre posts was found in the group root filled with a calcium hydroxide-based sealer and that the resin-based and eugenol-based sealers had lower bond strengths. Other studies concluded that no significant differences were found between the retention of posts when eugenol and non-eugenol-containing root canal sealers were used (Schwartz *et al.* 1998, Baldissara *et al.* 2006).

The purpose of this study was to evaluate the effects of different root canal sealers on the bond strength between a fibreglass post and root dentin cemented with self-adhesive cement. The null hypothesis was that the resin-based and calcium hydroxide-based sealers do not negatively interfere, whereas the zinc oxide eugenol-based sealers have a negative influence on the bond strength between a fibreglass post and root dentine.

Materials and methods

Fifty extracted maxillary single-rooted canine teeth with straight root canals were selected. The inclusion criteria were absence of caries or root cracks, absence of previous endodontic treatment, and root length of at least 13 mm. Teeth were stored in 0.02% thymol solution (DeWald 1997) and prepared within 1 month of extraction. Each tooth was decoronated below the cementoenamel junction perpendicularly to the longitudinal axis using a slow-speed, water-cooled diamond disc (Isomet 2000; Buehler Ltd, Lake Bluff, IL, USA).

All root canals were prepared by one trained operator. The root canal of each tooth was explored using a size 06 K-file (Dentsply Maillefer, Ballaigues, Switzerland) until the apical foramen was reached and the tip of the file was visible. The actual canal length was determined, and working length was established by deducting 1 mm. The root canal preparation was carried out using the crown-down technique with sizes 2–4 Gates Glidden drills (Dentsply Maillefer) and rotary Ni-Ti instruments of the K3 System (SybronEndo, Glendora, CA, USA). Apical preparation was extended to size 35, 0.04 taper. The root canal was irrigated between instruments with 2 mL of 2.5% sodium hypochlorite (Natufarma pharmacy, Passo Fundo, RS, Brazil). Final irrigation was carried out with 2 mL of 17% EDTA solution (Natufarma pharmacy) for 3 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 canals were dried with paper points (Dentsply Maillefer) and divided randomly into five groups of 10 teeth (n = 10) and filled as follows: group 1: control group, gutta-percha points only (no sealer); group 2: AH Plus (resin-based sealer; Dentsply DeTrey GmbH, Konstanz, Germany); group 3: self-etch Epiphany (resin-based sealer; Pentron Clinical Technologies, Wallingford, CT, USA); group 4: Sealer 26 (calcium hydroxide–based sealer; Dentsply Maillefer, Petrópolis, RJ, Brasil); and group 5: Endomethasone (zinc oxide eugenol-based sealer; Septodont, Saint-Maur-Dês-Fossés, France). All the canals were filled using a cold lateral compaction technique. However, in groups 1, 2 and 4, gutta-percha points (Dentsply Maillefer) were used, and in group 3, Resilon points were used. The root canal sealers were prepared and used according to the manufacturers' instructions. After root filling, a temporary filling material (Cavit W; Premier Dental Produtos, Rio de Janeiro, RJ, Brazil) was used to seal the coronal access cavity.

After storage at 100% humidity for 1 week at 37 °C, the temporary filling material was removed with a 1014 drill (KG Sorensen, Barueri, SP, Brazil). The root canal sealer and core materials were 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, Joinvile, SC, Brazil). The effectiveness of the removal of the root filling material was assessed using magnification loops (Carl Zeiss, Jena, Germany). After preparation, the post space was cleaned with a 0.2% chlorhexidine digluconate solution and dried with absorbent paper points.

The self-adhesive resin cement (RelyX Unicem) was manipulated and placed onto the fibreglass posts (Angelus, Londrina, PR, Brazil) by hand and into the canal 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 (fibreglass post; Ângelus, Londrina PR, Brazil) were seated to full depth using finger pressure, and a light polymerization was carried out for 40 s using the quartz–tungsten–halogen light (Ultraled; Dabi Atlante, Ribeirao Preto, SP, Brazil) with an irradiance of 500 mW cm^{-2}. 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 approximately 1 mm thick from the coronal, middle and apical regions of the post space. The first slice was not included to avoid the influence of excess coronal material. The push-out test was performed by applying a load at 0.5 mm min^{-1} from the apical to coronal direction until the post segment was dislodged from the root section. The push-out bond strength was measured with a universal testing machine (EMIC DL 2000; São José dos Pinhais, PR, Brazil). The maximum failure load values were recorded (N) and converted into MPa, considering the bonding area (mm^2) of the post segments. The post diameters were measured on each surface of the post/dentine sections using the digital calliper (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.

All fractured specimens were observed under 20× magnification with a stereoscope (Carl Zeiss) from the cervical direction and the apical direction to determine the mode of failure. The mode of failure was classified into five types (Perdigao *et al.* 2006, D'Arcangelo *et al.* 2007): (i) adhesive between the post and resin cement (no cement visible around the post); (ii) mixed, with resin cement covering 0–50% of the post diameter; (iii) mixed, with resin cement covering 50–100% of the post surface; (iv) adhesive between resin cement and root canal (post enveloped by resin cement); and (v) cohesive in dentin.

Averages and standard deviations of bond strength were calculated, and data were subjected to ANOVA test using a factorial design with root canal sealer (AH Plus, Epiphany, Sealer 26 and Endomethasone) and root region (coronal, middle and apical). Multiple comparisons were achieved using the Tukey test at a 0.05 significance level.

Results

The mean push-out bond strengths and standard deviations are in Table 1. There were significant differences between the groups ($P < 0.01$). No significant difference was detected between the control group and the resin-based and calcium hydroxide-based sealer groups ($P > 0.05$). The eugenol-based sealer group had the lowest bond strength ($P < 0.05$). No significant differences were found amongst the root regions (coronal, middle and apical).

Table 2 presents the results of the predominating types of failures in each group. The prevalence of mixed fractures and adhesive cement-dentine failure was verified in all of the groups.

Discussion

In this experiment, a significant reduction in the bond strength of a fibreglass post to root dentine 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-based and calcium hydroxide-based sealer groups. Thus, the null hypothesis of the present study was confirmed.

In this study, fibreglass posts were cemented 1 week after root canal filling because Vano *et al.* (2006, 2008) concluded that clinicians should be cautious about performing post space preparation and cementation of fibre posts immediately after filling of the root canals with zinc oxide eugenol or epoxy resin sealers, respectively. These authors observed that delayed cementation resulted in higher post–dentine interfacial strengths.

Several studies have determined that eugenol-based sealers decrease the bond strength of resinous cements (Ngoh *et al.* 2001, Cohen *et al.* 2002, Hagge *et al.* 2002b, Menezes *et al.* 2008, Demiryurek *et al.* 2010). Eugenol residues remaining on the dentine might interfere with the polymerization of adhesive resins and, because of their interdiffusion through dentine, they can cause a significant reduction in the adhesive effectiveness or even modify the polymerized resin surface (Baldissara *et al.* 2006) and decrease the bond strength of the resinous cement. Markowitz *et al.* (1992) reported that a chelating reaction occurs when zinc oxide is mixed with eugenol, resulting in grains of zinc oxide absorbed in a zinc eugenolate matrix, which makes it impossible for the eugenol to be released. However, because of the presence of fluids inside dentinal tubules, this reaction becomes reversible; the eugenol released then penetrates the dentine and tends to become concentrated at the tooth–adhesive interface (Ganss & Jung 1998).

The AH Plus, Epiphany and Sealer 26 sealers had higher bond strength values than Endomethasone. Epiphany is a urethane methacrylate resin-based sealer

Table 1 Mean push-out bond strength values and standard deviations in MPa of various sealers at coronal, middle and apical thirds of root canal

	Root regions		
Groups	Coronal	Middle	Apical
No sealer (control)	5.51 ± 0.51[a]	5.22 ± 0.42[a]	5.44 ± 0.93[a]
Resin-based sealer (AH Plus)	5.39 ± 0.84[a]	5.16 ± 0.86[a]	5.24 ± 0.94[a]
Resin-based sealer (Epiphany)	5.28 ± 0.93[a]	5.34 ± 1.19[a]	5.20 ± 1.53[a]
Calcium hydroxide-based sealer (Sealer 26)	5.34 ± 0.78[a]	5.29 ± 1.04[a]	5.34 ± 1.32[a]
Eugenol-based sealer (Endomethasone)	3.37 ± 0.64[b]	3.71 ± 0.78[b]	3.35 ± 0.65[b]

The same superscript letter indicates no statistically significant difference ($P > 0.05$).

Table 2 Types of failures present in each root canal sealer group

Groups	1 Adhesive: Post-cement	2 Mixed 0–50%	3 Mixed 50–100%	4 Adhesive: Cement-Dentin	5 Cohesive	Total
No sealer (control)	2	13	9	5	1	30
Resin-based sealer (AH Plus)	2	8	14	5	1	30
Resin-based sealer (Epiphany)	1	8	13	9	–	30
Calcium hydroxide-based sealer (Sealer 26)	2	8	12	7	1	30
Eugenol-based sealer (Endomethasone)	1	6	10	13	–	30

(Shipper & Trope 2004) used with a self-etching primer that has been reported to demonstrate improvements in the apical seal (Shipper & Trope 2004) and adhesion to root dentine (Gogos *et al.* 2004). Its monomeric composition might be responsible for the higher adhesion to the Rely X Unicem luting material. In the present study, the groups filled with the calcium hydroxide-based sealer were no significantly different in comparison with the control group. This is in agreement with the results of other studies (Hagge *et al.* 2002b, Kurtz *et al.* 2003, Menezes *et al.* 2008). AH Plus and Sealer 26 has in its composition the epoxy resin bisphenol, which might have affinity for components of Rely X Unicem that might 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 removed completely from the root canal walls during canal preparation using the wide Largo burs, whereas eugenol was not properly removed owing to interdiffusion through the dentine.

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 dentine. Therefore, some sealer components might have remained and interfered with effective dentine bonding. The quality of the bond in the control group and the resin-based 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 dentine was less affected than in the eugenol-containing group (Table 2).

Dual resin cements have been recommended for luting fibreglass posts to compensate for the reduction in light and to allow greater polymerization of the cement within the root canal (Kurtz *et al.* 2003, Akgungor & Akkayan 2006). The dual-curing resin RelyX Unicem consists of methacrylate monomers with bonded phosphoric acid groups and at least two unsaturated C = C double bonds. Therefore, the bond to the tooth structure is based on the principle that monomers react with basic salts and hydroxyapatite in tooth structure (Bitter *et al.* 2006). 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 (Gerth *et al.* 2006). These characteristics explain the similar values of bond strength that were found in the coronal, middle and apical regions.

However, several aspects of the bond strength of a fibre post in root dentine need further research, including the effect of various chemicals used during root canal treatment on canal walls. For example, Moreira *et al.* (2009) observed that NaOCl, whether or not in association with 17% EDTA, caused alterations to the dentine collagen, whereas chlorhexidine did not. Furthermore, different protocols of hybridization of root dentine must be evaluated to increase the bond strength and long-term adhesion of the fibreglass posts.

Conclusion

A eugenol-based sealer negatively interfered with the bond to root dentine; however, the resin-based and calcium hydroxide-based sealer groups did not interfere with the bond strength of fibreglass posts cemented with self-adhesive resin cement.

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