

ORIGINAL RESEARCH

The Effect of Self-adhesive and Self-etching Resin Cements on the Bond Strength of Nonmetallic Posts in Different Root Thirds

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ABSTRACT

Purpose: The purpose of this study was to evaluate the effect of self-adhesive and self-etching resin cements on the bond strength of nonmetallic posts in different root regions.

Materials and methods: Sixty single-rooted human teeth were decoronated, endodontically treated, post-space prepared, and divided into six groups. Glass-fiber (GF) posts (Exacto, Angelus) and fiber-reinforced composite (FRC) posts (EverStick, StickTeck) were cemented with self-adhesive resin cement (Breeze) (SA) (Pentral Clinical) and self-etching resin cement (Panavia-F) (SE) (Kuraray). Six 1-mm-thick rods were obtained from the cervical (C), middle (M), and apical (A) regions of the roots. The specimens were then subjected to microtensile testing in a special machine (BISCO; Schaumburg, IL, USA) at a crosshead speed of 0.5 mm/min. Microtensile bond strength data were analyzed with two-way ANOVA and Tukey's tests.

Results: Means (and SD) of the MPa were: GF/SA/C: 14.32 (2.84), GF/SA/M: 10.69 (2.72), GF/SA/A: 6.77 (2.17), GF/SE/C: 11.56 (4.13), GF/SE/M: 6.49 (2.54), GF/SE/A: 3.60 (1.29), FRC/SA/C: 16.89 (2.66), FRC/SA/M: 13.18 (2.19), FRC/SA/A: 8.45 (1.77), FRC/SE/C: 13.69 (3.26), FRC/SE/M: 9.58 (2.23), FRC/SE/A: 5.62 (2.12). The difference among the regions was statistically significant for all groups ($p < 0.05$). The self-adhesive resin cement showed better results than the self-etching resin cement when compared to each post ($p < 0.05$).

No statistically significant differences in bond strengths of the resin cements when comparable to each post ($p > 0.05$).

Conclusion: The bond strength values were significantly affected by the resin cement and the highest values were found for self-adhesive resin cement.

Keywords: Post, Resin cement, Bond strength.

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INTRODUCTION

The restoration of nonvital and severely compromised teeth is often performed by using intracanal posts.^{37,39} These prefabricated posts are commonly used to improve the retention of core foundation materials and can be cemented immediately after post space preparation.²³ Except for ceramics, the nonmetallic posts are preferred over metallic posts because they have a better stress distribution and may help prevent root fractures in the long term.^{2,4} Carbon-fiber posts were the first used for this purpose, followed by glass fiber-, quartz fiber- and fiber-reinforced composite (FRC) posts.

The resin cement used for postcementation is an important factor in the long-term success of a restoration. Adhesive luting is usually recommended for luting the post to the root canal dentine, and it has been demonstrated that different types of bonding systems can be used in combination with different resin cements. Bonding capacity between them may be influenced by contraction stresses induced by polymerization of the resin material.^{15,28} The contraction stresses may occur at the dentin-luting material interface at different regions, depending on the preparation configuration (C-factor). The C-factor is an important consideration in bonding procedures^{3,14} and can be high inside the root because there is little free area to relieve contraction polymerization.^{8,12} The type of post,⁴² the proprieties

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of the luting materials, and the characteristics of the root canal can also be affected.^{17,26,35} Additionally, some authors have demonstrated different bond strengths values in these regions,¹⁷ whereas other suggested that no differences existed between these regions.¹⁸

The recent resin cements can be found in self-adhesives or combined with self-etching adhesives. The Breeze resin cement is a self-adhesive system that does not require any pretreatment of the dentin. The application technique for these new materials is simpler than the cementation procedure and is more operator-sensitive than when using total-etching systems.^{1,11,19,22,44}

Microtensile, push-out, and pull-out tests have been used to evaluate the bond strength of the luting material-dentine and luting material-post interfaces.^{7,31,36} In push-out tests, the bond strength was evaluated by the retention created not only by the luting agent but also through micro- and macro-retention due to the surface roughness and frictional fit between the two surfaces, respectively.²⁰

With the advent of new resin materials in dentistry, it has become important to analyze evolutionally the bond strength through microtensile tests. The purpose of this study was to determine the microtensile bond strength of two non-metallic posts cemented with self-adhesive and self-etching resin cements in different root regions. Stereomicroscopic evaluation of failure modes of the systems was performed and scanning electron microscope (SEM) was used to detect the characteristics of bonding the posts with resin cements. The null hypothesis was that no statistically significant differences in bond strength values would be found between the fiber and FRC posts.

MATERIALS AND METHODS

Sixty freshly extracted single-rooted human were selected for this study. The crowns were removed at the cement-enamel junction using a low-speed diamond disk (Isomet III; Buehler, Lake Bluff, IL, USA) under constant water cooling.

The root canals were prepared 1 mm from the apex using rotary nickel-titanium instruments (ProTaper System; Dentsply, Tulsa, OK, USA) and shaping (S1, S2, Sx) and finishing (F1, F2, F3) instruments. The irrigation solution between instrumentations was performed with 2 mL of 2.5% sodium hypochlorite. The canals were then rinsed with distilled water, dried with paper points, and obturated with gutta-percha cones using a lateral condensation technique (Dentsply-Herpo) and AH-Plus sealer (Dentsply DeTrey, Konstanz). The specimens were then stored at 37°C and 100% relative humidity for a period of 24 hours.

The appropriate drill supplied by the Exacto post (#2 drill, Angelus; Londrina, Brazil) was used to a length of 10 mm, leaving 4 to 5 mm of gutta-percha remaining in the apical third. The drill was replaced every five posts during space preparation. Table 1 shows the features of nonmetallic posts.

The teeth were randomly assigned to four equal groups according to the type of post [glass fiber (GF) and fiber-reinforced composite (FRC)] and resin cement [self-adhesive (SA) and self-etching (SE)].

The luting materials and adhesive application protocols are described in Table 2. Before the application of the resin cement systems, the root canals were irrigated with distilled water and dried using paper points (Dentsply Maillefer). The posts were luted according to the manufacturers' instructions. The cervical region of the roots was sealed with composite resin TPH Spectrum Compule (Dentsply Caulk, Milford, USA) applied in 2 mm increments. The light-cured materials were light activated with Optilux 501 (Demetron Kerr, Orange, CA, USA). Before each bonding procedure, the power density of the light activation was checked with a digital radiometer. The mean power density of the light activation was 500 ± 10 mW/cm².

Specimens were fixed with sticky wax into a device adapted to the cutting machine (Isomet III; Buehler, Lake Bluff, IL, USA) and perpendicularly sectioned into approximately 1-mm-thick sections using a low-

Table 1: Features of nonmetallic posts used in this study

<i>Post</i>	<i>Manufacturer</i>	<i>Post type and design</i>	<i>Post composition</i>	<i>Batch number</i>
Exacto post	Angelus, Londrina, Brazil	Opaque Cervical diameter, 1.8 mm Middle diameter, 1.8 mm Apical diameter, 1.1 mm	Glass fiber: 87% volume Epoxy resin: 13% volume Internal filament: stainless steel	2070814-P3-036
Everstick post	StickTeck Ltd, Turku, Finland	Individually formed electrical glass fiber mean diameter, 1.5 mm	Semi-interpenetrating polymer network of polymethylmethacrylate, Mw 220.000 and 2.2-bis [4-(2-hydroxy-3-methacryloxypropoxy) phenyl] propane	8217

Table 2: Composition of resin cements and adhesive application procedures

Product name (Manufacturer)	Composition	Dentin pretreatment	Luting agent mixing	Batch no.
Breeze self-adhesive resin cement (Pentron Clinical Technologies, Wallingford, USA)	BISGMA, UDMA, TEGDMA, HEMA, & 4-MET resins, silane-treated, bariumborosilicate glasses,* silica with initiators, stabilizers and UV absorber, organic and/or inorganic pigments, opacifiers ^a	No pretreatment	Dispense the cement, light cure for 1s from each side after removal of excess cement	161489
Panavia F 2.0 dual cure resin cement (Kuraray, Osaka, Japan)	Primer A: HEMA, 10-MDP, 5-NMSA, water, accelerator ^a	Mix one drop of each ED Primer liquids A and B for 5 seconds, apply undisturbed for 30 seconds, air-dry gently	Mix paste A and B for 20 seconds, light cure for 20 seconds from each side after removal excess cement, apply oxyguard for 3 minutes	00243B
	Primer B: 5-NMSA, water, sodium benzene ^a			00121B
	Paste A: 10-MDP, 5-NMSA, silica, dimethacrylate monomer, photo-initiator, accelerator ^a			00265B
	Paste B: barium glass, sodium fluoride, dimethacrylate monomer, BPO ^a			00043B
	Oxiguard II: glycerol, polyethyleneglycol, initiators, accelerators, dyes, others ^a			00564B

*Contains a small amount of aluminum oxide; HEMA: 2-hydroxyethyl methacrylate; MDP: 10-methacryloyloxydecyl dihydrogen phosphate; 5-NMSA: N-Methacryloyl 5-aminosalicylic acid.^a Composition and pH values according to the manufacturers

speed diamond disk under constant water cooling. This procedure resulted in six serial slices for each root.

The slices of 10 specimens from each group were trimmed using a cylindrical diamond burr (#1090, KG-Sorensen, Barueri, SP, Brazil) under water cooling in the proximal surfaces until the post was touched.

A digital caliper (Deigimatic Caliper, Mitutoyo, Kawasaki, Japan) with 0.01 mm precision was used to measure the thickness of each slice. Specimen sections were attached into a device (Bisco Inc.) with cyanoacrylate glue (Zapit; Dental Ventures of America Inc, Corona, CA, USA), which were then mounted on a strength tester (Bisco, Inc., Schaumburg, IL, USA) and loaded in tension at a speed of 0.5 mm/min until failure. The failure loads were recorded in N, and microtensile bond strength was calculated in MPa as follows in Figure 1.

The bond strength data obtained was submitted to two-way ANOVA and was used to compare variables

(post/cement and root third). Post-hoc tests were conducted using a Tukey’s multiple comparison test at $p < 0.05$. The slices were examined under a 25× stereomicroscope and failure modes were classified into five types, adapted from the classification by Perdigão et al.³⁴ (1) adhesion between post and resin cement, (2) mixed with resin cement visible around the post, (3) adhesion between resin cement and root canal, and (4) cohesive in dentin.

One specimen from each group was used for scanning electron microscope observations of the dentin cement and post-cement interfaces at a magnification of 300×.

RESULTS

Statistical analysis indicated that the types of resin cement and the types of posts, as well as the different root canal thirds, significantly affected the bond strength values ($p < 0.05$). However, there is no interaction between them ($p = 0.7604$) (Table 3). The bond strength values

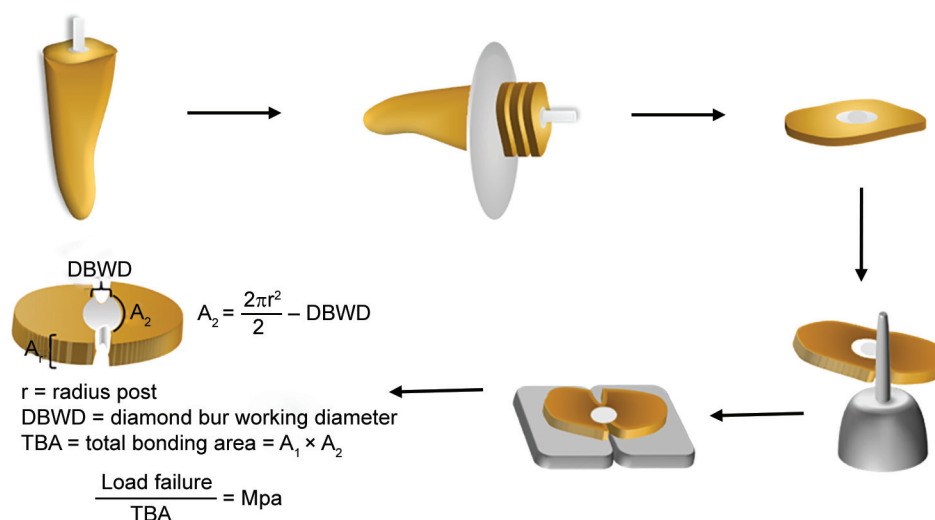


Fig. 1: Schematic of the experimental design

Table 3: Two-way analysis of variance for cements/posts and thirds

Variable (source)	df	Sum of squares	Mean squares	F	p-value
Thirds	2	2562	1281	0.56	0.7604*
Cements/posts	3	975.8	325.3	48.36	<0.0001*
Interaction	6	22.68	3.779	190.42	<0.0001*
Residual	288	1534	6.726		

*Significantly different at p < 0.05

Table 4: Mean push-out bond strength (MPa) ± SD for experimental groups according to the thirds

Thirds	GF/SA	GF/SE	FRC/SA	FRC/SE
Cervical	14.32 ± 2.84 ^{a,AC}	11.56 ± 4.13 ^{a,B}	16.89 ± 2.66 ^{a,A}	13.69 ± 3.26 ^{a,C}
Middle	10.69 ± 2.72 ^{b,AC}	6.49 ± 2.54 ^{b,B}	13.18 ± 2.19 ^{b,A}	9.58 ± 2.23 ^{b,C}
Apical	6.77 ± 2.17 ^{c,AC}	3.60 ± 1.29 ^{c,B}	8.45 ± 1.77 ^{c,A}	5.62 ± 2.12 ^{c,BC}

*Different letters, lowercase in columns and uppercase in rows, indicate statistical difference between the values; SD: Standard deviation

obtained for the cervical, middle, and apical regions for experimental groups are displayed in Table 4.

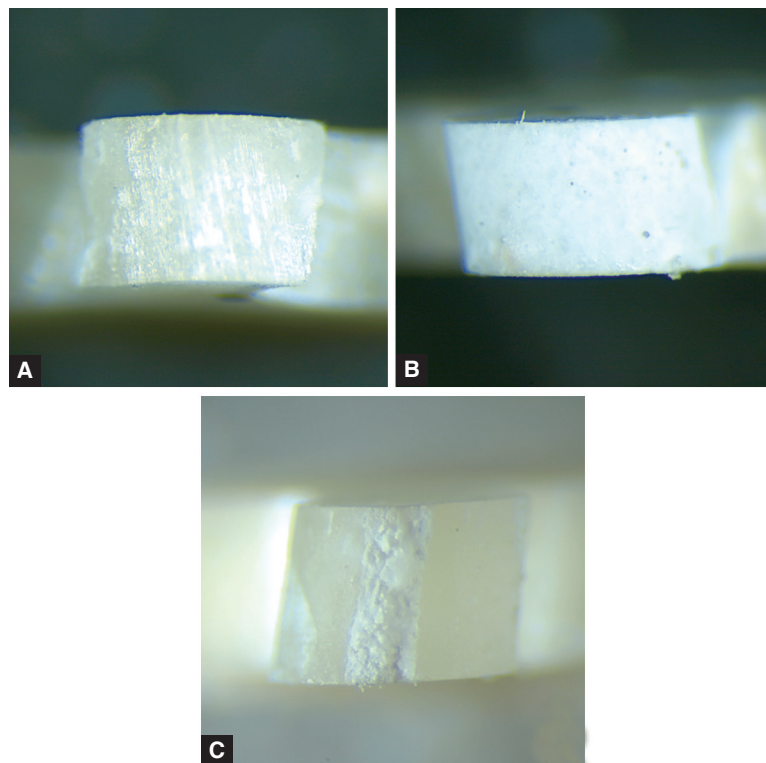
The difference among the regions was statistically significant for all groups (p < 0.05). For all groups, the bond strength was statistically higher (p < 0.05) in the cervical third. The self-adhesive resin cement showed better results than the self-etching resin cement when compared to each post (p < 0.05). No statistically significant differences in bond strengths of the resin cements existed after comparing each post (p > 0.05).

Analyses of the specimens under stereomicroscope are displayed in Figures 2A to C. A prevalence of adhesive failures between cement and dentin were found (Table 5). The failures mode observed were similar among the specimens tested for regions.

Scanning electron microscope evaluation revealed a good adaptation of the resin cement to the post interfaces for all groups (Figs 3A to D). No defects or discontinuities occurred along the interfaces, and no significant differences in the morphology of the interface between these groups were noticed.

DISCUSSION

The data of the present study supports the hypothesis that bond strength does vary among the regions. The bond strength is higher in the cervical region compared to the apical region. Nevertheless, the hypotheses were that bond strength did not vary among the fiber posts and that bond strength did vary among the resin cement systems.



Figs 2A to C: The failure modes were found in this study: (A) adhesion between post and resin cement, (B) adhesion between resin cement and root canal, and (C) mixed with resin cement visible around the post

Table 5: Distribution of failure modes among groups

Groups	Thirds	Adhesive: cement dentin	Mixed	Adhesive: Cohesive in dentin Post-cement
GF/SA	Cervical	19		1
	Middle	17	2	1
	Apical	15	3	2
GF/SE	Cervical	15	2	3
	Middle	16	3	1
	Apical	14	3	3
FRC/SA	Cervical	18		2
	Middle	18	2	0
	Apical	15	3	2
FRC/SE	Cervical	16	2	2
	Middle	15	3	2
	Apical	15	3	2

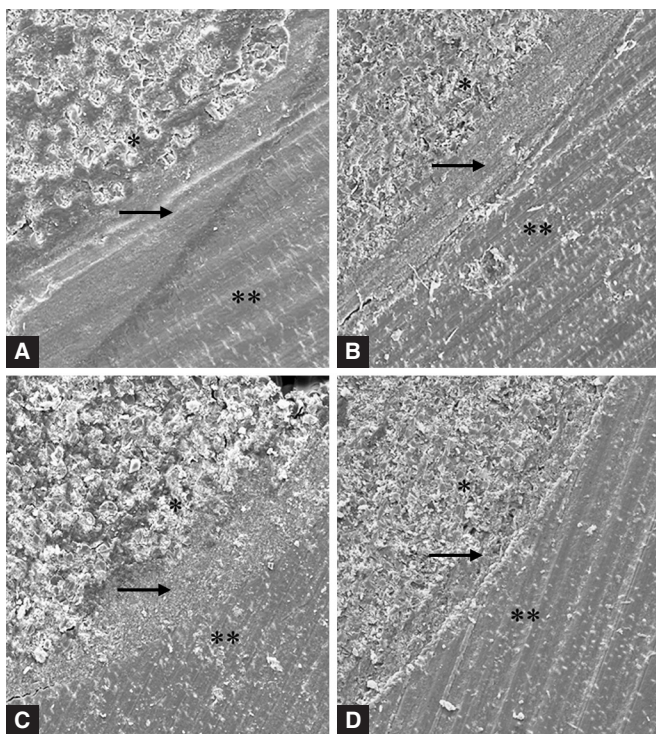
The root canals in the present study were filled with AH Plus and gutta-percha before the post space preparation, which is a more approximate clinical situation. Chieffi et al¹⁰ showed that resin sealer had no negative effect on the bond strength.

Several different laboratory assessments have been described for the evaluation of bond strength. The microtensile test places a uniform stress along the bonded interface due to the small specimen size.³² The stress distribution for pull-out and push-out tests had been reported as non-uniform when performed on root regions,^{2,20,29,33,40} and a major portion retention was created by the adhesive bonding agent and through

micro-retention from the surface roughness and macro-retention from frictional fit between two surfaces.² Thus, the microtensile test has become quite popular in dentin bond strength testing; however, the specimen preparation resulted in high rates of premature failures.^{2,20,21}

The bond strength values were found to be significantly higher for all groups in the cervical region than in the middle and apical regions. Higher bond strength in the cervical region of the root canal was frequently shown in previous studies.^{8,23} This is to be expected because of the higher density of dentinal tubules and the area of a tubular dentine.^{16,17,42} The other factor is the more difficult access of the cervical to apical region and more difficulty in the distribution of resin cement with a void formation.^{8,25} Nevertheless, the polymerization contraction of the resin cement might have influenced the bond strength values.⁸

The bond strength values were found significantly higher for the self-adhesive resin cements than for the self-etching resin cement, irrespective of the type of fiber post used. No study has investigated the bond strength of fiber posts in conjunction with the resin cements used in this present study. Some researchers showed that the self-adhesive resin cements had better results on bond strength than other resin cements.^{5,13,24,38} The composition of the self-adhesive resin cement favors good performance, because it exhibits a greater moisture tolerance than self-etching resin cements (sensitive technique). After rinsing the root canal, it is difficult to control the moisture because the visibility is poor. These findings can be explained through the pattern fractures that occurred during the microtensile bond strength test. The failure most often occurred at the interface between the resin cement and the dentin. Other adhesive failures occurred between posts and cement. Various pretreatment procedures were reported for increasing the bond strength of the post to the resin cement, as well as silanization, hydrofluoric acid etching, sandblasting, and tribochemical silica coating.^{6,9,30,43}



Figs 3A to D: Representative SEM micrographs of the resin dentin cement post interface: (A) EverStick post cemented with self-adhesive resin cement, (B) Exacto post cemented with self-adhesive resin cement, (C) EverStick post cemented with self-etching resin cement, and (D) Exacto post cemented with self-etching resin cement. *post; **dentin root; → resin cement

Fiber-reinforced composite posts are made of a material with silanted glass fibers impregnated with an interpenetrating polymer network resin matrix partially based on polymethylmethacrylate resin (Everstick Post). The ability of the bonding resins to penetrate into the FRC post may provide the opportunity to improve the bond strength of the FRC post to resin cement.²⁷ The design of the FRC post is also an important factor retention in the root canal. Parallel FRC posts have been shown to improve retention better than tapered posts.⁴¹ For this study, no significant difference was found between the posts studied, which corroborates the literature.^{1,45}

CONCLUSION

The bond strength values were significantly affected by the resin cement and the highest values were found for self-adhesive resin cement. Fracture analysis showed a predominance of adhesive fractures between the resin cement and dentin.

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