

Effects of Internal Bleaching on the Adhesion of Glass-Fiber Posts

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Abstract: *Objective:* We evaluated the effects of internal bleaching on the adhesion of glass-fiber posts (GFPs) luted with different resin cements. *Methods:* Forty extracted human single-root teeth were endodontically treated and divided into four groups (n=10): G1- conventional resin cement (CRC); G2- self-adhesive resin cement (SARC); G3- bleaching + CRC; and G4- bleaching + SARC. Specimens were sectioned transversally into three slices to perform the push-out test at the coronal, middle and apical regions of the root canals. Data were analyzed using analysis of variance and Tukey's test ($p < 0.05$). *Results:* The push-out bond strength of GFPs luted with SARC after bleaching (G4) was significantly lower than that of the other groups ($p < 0.001$). We found no statistically significant differences in push-out bond strength among the other groups. *Significance:* Internal bleaching reduced the adhesion of GFPs luted with SARC. The adhesion of GFPs luted with CRC was not decreased after bleaching.

Keywords: Dental bleaching, dental bonding, dentin-bonding agents, hydrogen peroxide, resin cements, tooth bleaching.

INTRODUCTION

Fiber posts are non-metallic alternatives that increase the optical effect of the restoration, providing better aesthetics [1, 2]. As advantages have mechanical characteristics approaching to dentin, furthermore, the fiber posts have biocompatibility, mechanical strength and resistance to corrosion [2, 3]. The use of this material reduces the probability of root fracture and reduces the time required to complete the restoration eliminating the laboratory procedures [4, 5]. The retention of glass-fiber posts (GFPs) in the root canal depends on the quality of the hybrid layer [6].

Certain endodontically treated teeth might require internal bleaching before coronal reconstruction to obtain satisfactory aesthetic results. However, the application of hydrogen peroxide to tooth structures has been shown to decrease the microhardness [7], and modulus of elasticity [8], produce morphological alterations in the dental surface [9], affect the intertubular and peritubular dentin [10] and cause structural alterations to the hydroxyapatite due to ionic bonds that weaken its structure [11].

Several studies have investigated the relationship between the bonding effectiveness of GFPs and resin cement types [3, 12-15] and application modalities [1, 16-19]. However, to date, no information is available on the combined effects of bleaching agents on the adhesion of GFPs luted with resin cements.

The present study evaluated the influence of internal bleaching with 35% hydrogen peroxide on the adhesion of GFPs luted with two different resin cements (conventional versus self-adhesive). The null hypothesis was that 35% hydrogen peroxide would not affect the adhesion of GFPs cemented with the various luting agents.

MATERIALS AND METHODS

Human Tooth Specimens

Following approval of our investigation by the local ethics committee, informed consent was obtained from all of the subjects. Forty extracted single-rooted human teeth with intact crowns and similar root sizes and lengths were selected for this study. Radiographs were obtained to ensure the presence of straight single main root canals and completely formed apices in all of the teeth. After the teeth were cleaned of adhering tissue remnants from their surfaces, they were rinsed and stored in distilled water until use. The specimens were randomly assigned to one of the four groups (n=10) characterized by resin cement (conventional or self-adhesive) and bleaching procedure (Table 1).

Endodontic Treatment

The coronal access opening was prepared using a diamond burr under high-speed water spray cooling. The working length of the tooth was established 1 mm from the root apex. All of the canals were instrumented by the step-back technique using K-files. All of the enlargement procedures were followed by irrigation with 2.5% sodium hypochlorite solution. The prepared root canals were filled with gutta-percha cones (Kerr/Sybron, Corp, Romulus, MI, USA) using the lateral condensation technique and resin sealer

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Table 1. Distribution of the groups according to treatment received before bonding and luting agent tested.

Type	Group	N	Luting Agent	Manufacturer
Control	G1	10	RelyX ARC	3M, ESPE, St Paul, MN, USA
(Unbleached teeth – immersed in distilled water)	G2	10	RelyX Unicem	3M, ESPE, St Paul, MN, USA
Experimental	G3	10	RelyX ARC	3M, ESPE, St Paul, MN, USA
“Walking bleach” (35% hydrogen peroxide)	G4	10	RelyX Unicem	3M, ESPE, St Paul, MN, USA

Table 2. Luting agents used and their application modes according to the manufacturer’s instructions.

Luting Agent	Application Mode
Scotchbond Multipurpose + RelyX ARC (Conventional resin cement)	Apply 35% phosphoric acid for 15 s; rinse with water for 15 s, followed by air drying for 2 s; remove excess moisture with paper points; apply activator of the adhesive system in the canal and then apply the primer; apply the catalyst; mix the cement for 10 s; apply cement in and around the canal; place a thin layer of mixed cement on the post and seat the post; remove the excess while holding the post in place; light-polymerize for 40 s from the occlusal direction
RelyX Unicem (Self-adhesive resin cement)	Irrigate the canals with distilled water; remove excess with paper points; mix the cement for 20 s; apply cement in and around the canal; place a thin layer of mixed cement on the post and seat the post; remove the excess cement while holding the post in place; light-polymerize for 20 s from the occlusal direction

(Sealer-26, Dentsply Ind. Com. Ltda, Petrópolis, RJ, Brazil). Gutta-percha excess was removed 2 mm below the cemen-toenamel junction (CEJ) after obturation was completed.

Bleaching Procedure

The bleached teeth received 2-mm-thick cervical seals of glass ionomer cement (Vitro Fil, DFL, Rio de Janeiro, RJ, Brazil) at the CEJ. The teeth were stored at 37°C for 45m to ensure the complete setting of the glass ionomer cement. The “walking bleach” technique was performed. A 35% hydrogen peroxide gel (Whiteness HP, FGM, Joinville, SC, Brazil) was applied to the buccal surface and in the pulp chamber. A tiny cotton pellet was placed into the gel and the teeth were sealed with provisional restorations. This procedure was repeated three times with a five-day bleaching interval. Between sessions, the teeth were stored in 100% relative humidity at 37°C. After the bleaching treatment, we applied a cotton pellet with a calcium hydroxide powder paste and distilled water into the pulp chamber; the pulp chamber was then temporarily sealed. The teeth were stored in distilled water at 37°C for 14d [20, 21].

The crowns were removed using a low-speed diamond disc under water cooling. Each root canal was enlarged with a low-speed drill provided by the manufacturer of the post system (White Post DC, size 2, FGM, Joinville, SC, Brazil). The post space preparation was 8-mm deep, leaving at least 4-mm of gutta-percha inside the canal to guarantee an apical seal. The posts were cleaned with 70% alcohol and received a layer of silane (3M ESPE); the excess silane was removed with compressed air applied for 5s. The GFPs were cemented according to the guidelines of the manufacturer of the resin cement (Table 2). After cementation, the roots were maintained in 100% relative humidity at 37°C for 24h before testing.

Push-out Bond Strength Test

The post of each root containing the fiber post was sectioned transversally into three slices with a water-cooled low-speed diamond saw (Micromet, Remet, Bologna, Italy); the first section was made 1-mm away from the CEJ. Each slice was approximately 2.5-mm thick. The first slice represented the coronal region, the second slice the middle region and the third slice the apical region of the post space preparation.

Each post was carried with a cylindrical plunger (2-mm diameter) connected to a universal testing machine (DL 2000, Emic, São José dos Pinhais, São Paulo, Brazil). The plunger tip was sized and positioned such that it was in contact with only the fiber post. A load was applied on the apical aspect of the root slice in the apical-coronal direction. The load was applied at a speed of 0.5 mm/min until failure, defined as the extrusion of the post segment from the root slice [22, 23].

The maximum failure load was recorded in newtons (N) and converted into megapascals (MPa) by dividing the applied load by the bonded area (SL). The bonded area represents the lateral surface of a truncated cone and was therefore calculated with the following formula: $SL = \pi(R+r)(h^2 + [R-r]^2)^{0.5}$, where $\pi = 3.14$, R = coronal post radius, r = apical post radius, and h = root slice thickness.

Statistical Analysis

Statistical analyses of the data were performed using a statistical software package (SPSS, version 16.0, SPSS Corp., Chicago, IL, USA). The Shapiro-Wilk and Levene tests were used to verify normality and homogeneity. Analysis of Variance (ANOVA) was used to analyze the data, followed by Tukey’s multiple comparison test. For all analyses, the level of significance was 5%.

Table 3. Push-out bond strength in megapascals (MPa) (Mean, SD and CI 95%) for the groups evaluated in different regions.

Group	Region					
	Cervical		Middle		Apical	
	$\bar{\chi} (\pm SD)$	CI 95%	$\bar{\chi} \pm SD$	CI 95%	$\bar{\chi} \pm SD$	CI 95%
G1	17.33 (5.31) ^{A,a}	6.71 - 27.95	9.8 (3.39) ^{A,b}	3.02 - 16.58	5.47 (4.07) ^{A,b}	-2.67 - 13.61
G2	11.65 (5.08) ^{A,a}	1.49 - 21.81	8.97 (3.25) ^{A,a}	2.47 - 15.47	12.40 (4.80) ^{B,a}	2.80 - 22.00
G3	11.43 (3.68) ^{A,a}	4.07 - 18.79	8.69 (2.73) ^{A,a}	3.23 - 14.15	9.24 (3.12) ^{A,B,a}	3.00 - 15.48
G4	5.43 (1.80) ^{B,a}	1.83 - 9.03	4.27 (1.46) ^{B,a}	1.35 - 7.19	5.33 (2.24) ^{A,a}	0.85 - 9.81

Note: Different superscript case letters indicate statistically significant differences within columns, and different lower letters indicate significant differences within rows ($p \leq 0.05$) by Tukey test for multiple comparisons.

RESULTS

The descriptive statistics for the push-out bond strength and the results of Tukey test for multiple comparisons between groups are presented in Table 3. The push-out bond strength of GFPs luted with self-adhesive cement after bleaching (G4) was significantly lower than that of the other groups in the cervical and middle slices ($p < 0.001$). The location within the root region appeared to influence bond strength, as significant differences were observed in the conventional cement group (G1) between the cervical and middle slices ($p < 0.001$) and between the cervical and apical slices ($p < 0.001$). In this group, the cervical slices had greater push-out bond strength. We found no statistically significant differences in bond strength between the root regions of the other groups ($p > 0.05$).

DISCUSSION

To our knowledge, this was the first study to assess the impact of internal bleaching on the push-out bond strength of GFPs luted with two types of resin luting agent. The null hypothesis was partially rejected because GFPs luted with self-adhesive resin cement had the lowest push-out bond strength values.

This result could be due to alterations in the organic substance of dentin after bleaching. The residual oxygen from the bleaching agent might interfere with resin attachment and inhibit resin polymerization, thus increasing the porosity of the resin material and producing poorly formed and undefined interfaces [24]. Hydrogen peroxide was also shown to oxidize organic dentin compounds and modify their mineral components [25]. Hydrogen peroxide generates free radicals that combine with hydroxyapatite and produce a structure known as apatite peroxide that degrades calcium and phosphate, the two primary mineral components of dental hydroxyapatite [26].

Some studies have reported that bleaching results in the removal of calcium, phosphate and other ions from dental structures [27-30]. During the bonding process of self-adhesive resin cement, the calcium present in the dentin hydroxyapatite acts as an electron acceptor, promoting chemical union between the acidic resin monomers and the hard dental tissues [31]. The calcium ions are responsible for the neutralization of the phosphoric acidic components. There-

fore, greater losses of calcium ions probably result in greater amounts of unreacted monomers and therefore in the higher sorption and greater solubility of the self-adhesive resin cement. Sorption and solubility can influence the strength of the resin cement [32]. Moreover, the self-adhesive cement had higher hydrophilicity than more hydrophobic conventional composite cements [33].

Bleaching procedures have been shown to increase metalloproteinase-mediated collagen degradation in dentin [34]. Metalloproteinases (MMPs) produce collagen degradation at the dentin-resin bonded interfaces, jeopardizing the efficacy of bonded restorations [34]. In addition, dentin demineralization by acidic monomers could release sequestered growth factors that could then diffuse through the dentinal tubules along with unpolymerized acidic monomers, stimulating the expression of MMP by odontoblasts [35] and possibly contributing to bond degradation [31]. These related adverse effects, the relatively high viscosity of self-adhesive resin cement and the low demineralizing capacity of the cement contribute to low monomer infiltration into dentin, thus reducing micromechanical retention [36].

In contrast, we found no significant decrease in the push-out bond strength of GFPs luted with conventional resin cement after bleaching [37, 38]. These results could be explained by differences in the compositions of the luting agents. These luting agents had distinct viscosities and different bonding mechanisms [39]. For example, the Scotch-bond Multipurpose is an alcohol-based adhesive, and studies have concluded that alcohol-based adhesives could increase the bond strength for bleached teeth [38, 39]. Alcohol-based dental bonding agents can also reduce or eliminate the detrimental effects of residual oxygen on the bonding process. The high volatility, the solvent and hydrophobic nature of these bonding agents and the rapid evaporation of the agents into the environment facilitates the removal of residual oxygen from the tubules, thus contributing to increased bond strength between the adhesive composite and the teeth [37].

Despite the fact that the teeth were unbleached, our results are in agreement with those of previous studies that reported that self-adhesive cement and conventional resin cement had similar push-out bond strengths [12, 14, 16]. However, the push-out bond strength values obtained for resin cements in the literature have been quite controversial. Some studies have found that self-adhesive resin cement has

greater push-out bond strengths than other types of resin cements [15, 19, 13]. Other investigations have reported greater bond strength for conventional resin cements [17, 18, 30]. One possible explanation for these results is the different protocols and variables adopted in other investigations. In addition, the size and shape of the root canals and the texture and properties of the inner surfaces of the root canals may have differed among the teeth used [38]. This variability, however, also occurs in clinical situations [38].

Significant differences in push-out bond strength were observed between the root sections only for GFPs cemented with conventional cement in unbleached teeth; coronal sections, in particular, demonstrated greater bond strength. This observation might be due to the fact that this adhesive requires more complex procedures, resulting in compromised moisture control in the apical third [4]. Some studies have demonstrated that the bond strengths of conventional resin cements in root canals are greater in cervical areas and lower toward the apical third [1, 4, 13, 29,]. However, no differences were found between the slices in the other groups.

The preliminary findings of this *in vitro* report could be confirmed with *in situ* evaluations.

CONCLUSION

Internal bleaching with 35% hydrogen peroxide reduced the adhesion of GFPs luted with self-adhering resin cement. The adhesion of GFPs luted with conventional resin cement was not decreased after bleaching.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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