Effect of different surface treatments on the push-out bond strength of fiber posts into the root canal

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ABSTRACT

The aim of this study was to evaluate the effects of different surface treatments on the bond strength of fiber posts into root canal. Forty-four recently extracted human mandibular premolars were instrumented by K3™ rotary system. The root canals were filled with gutta-percha and Sealapex™ sealer. Post spaces were prepared, and root canals subjected to one of the following four surface treatments: irrigation with 0.9% sodium chloride (NaCl), 2.5% sodium hypochlorite (NaOCl), 2% chlorhexidine gluconate (CHX), or 17% ethylenediamine tetraacetic acid (EDTA). Fiber posts were cemented with self-adhesive resin cement RelyX™ (Unicem). From the coronal part of each root, three slides with 1 mm in thickness were obtained. A push-out bond-strength test was performed with the aid of a universal testing machine at a crosshead speed of 0.5 mm/min. Data (in MPa) were subject to statistical analysis by two-way ANOVA and *post hoc* Tukey's test ($p < 0.05$). Results revealed no significant differences between the different chemical solutions used as surface treatments before the luting procedure. EDTA elicited the highest bond strength. The results also showed that surface treatment with NaOCl or EDTA increased bond strength to dentin, as compared with the control group. The bond strength of fiber posts to root canal dentin was not significantly affected by surface treatment with 2.5% NaOCl, 2% CHX solution, or 17% EDTA.

Keywords: Endodontics. Bonding agents. Dentin.

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Introduction

In recent years, the increasing demand for esthetic posts and crowns has led to the development of metal-free post and crown systems, especially with zircon dioxide and fiber-reinforced posts.[1] Resin luting agents are required for luting porcelain veneers, all-ceramic crowns, indirect composite or ceramic restorations, metal castings, and endodontic posts. A strong and durable bond is necessary to ensure the biomechanical aspect of the restorations when such cements are used.[2] Appropriate treatment of the tooth substrate is also essential.[3,4]

The strength of adhesion to dentin is influenced by many factors. The use of some chemical solutions or medications during root canal preparation may have an adverse effect on the bond strength of posts to root canal dentin.[5] While using resin cements with root posts, it is important to maximize the bond strength between the resin and dentin and between the resin and the post.[5,6] Adhesion between resin and dentin is undesirable for luting a fiber post.

During preparation of the post space, drills create a new smear layer that is rich in sealer and gutta-percha remnants and is plasticized by the heat derived from the friction with a drill.[7] The complete removal of the smear layer, which contains microorganisms, infectious deteriorated dentin, and canal sealer remnant, is essential to the bonding of the post to dentin with resin.[8,9] Chemical agents are used to increase the micromechanical retention of the cement by removing the smear layer.[7,10] As a result, the cement can penetrate into the dentinal tubules.[1]

NaOCl, EDTA, and CHX are chemical irrigating solutions. Various results have been reported regarding the influence of irrigating solutions on the bond strengths of resin materials to dentin.[11-14]

The present study evaluated the effects of different root canal surface treatments, used for removal of remnants of canal sealers, on the bonding strength between fiber posts and tooth dentin. The null hypothesis was that no significant differences would be found among push-out bond-strength values after different root canal surface treatments were performed.

Material and Methods

This study protocol was approved by the local Ethics Committee (CAAE - 0192.0.362.000-10).

Endodontic procedures

Forty-four human mandibular single-rooted premolars, with fully developed apices extracted for periodontal or orthodontic reasons, were used in this study. The teeth were obtained in accordance with the guidelines of the local Human Research Ethics Committee. Freshly extracted teeth were immediately placed in 5.25% NaOCl for 5 minutes and then stored in 0.9% saline solution at room temperature prior to use.

The following inclusion criteria were applied: single-rooted teeth; without lateral canals; with completely formed apices; without any cracks or caries, previous endodontic treatment, posts or crowns. Tooth length, diameter, conical shape and root straight shape were also considered.[15]

The soft tissue covering the root surface was removed with an ultrasonic scaler. Buccolingual and mesiodistal radiographs of all teeth were taken and examined to evaluate root integrity and the number of canals present. All teeth used in this study had 1 canal in each root with a curvature of less than 5°.[15]

The crowns were removed using a slow-speed diamond disc (KG Sorensen, São Paulo, SP, Brazil) under copious water cooling, and the root lengths were standardized to 15 mm (Fig 1A). Root canals were prepared 1 mm short of the apex with K3 system (Sybron Endo; Orange, CA, USA) up to file size 40/0.06. K3 instruments were used in a crown-down manner according to the manufacturer's instructions. The root canals were irrigated with 1 mL of 0.9% NaCl prior to the use of each instrument and then dried with sterile absorbent paper points (Konne Ind. Ltd., Belo Horizonte, MG, Brazil).

Root canals were obturated with gutta-percha cones (Tanari™; Tanariman Ind. Ltd., Manacapuru, AM, Brazil) and Sealapex™ sealer (SybronEndo Corporation, Orange, CA, USA) by means of the lateral compaction technique. Temporary filling material (Cavit G; 3M Espe, Seefeld, Germany) was used to seal the coronal orifice. All specimens were stored in 100% relative humidity for seven days at 36.6 °C.

Post space preparation

The sealing material was removed using a diamond bur (1012; KG Sorensen, Brazil) under high-speed spray water cooling. The post space of each specimen was enlarged 10 mm deep with a #2 Exacto

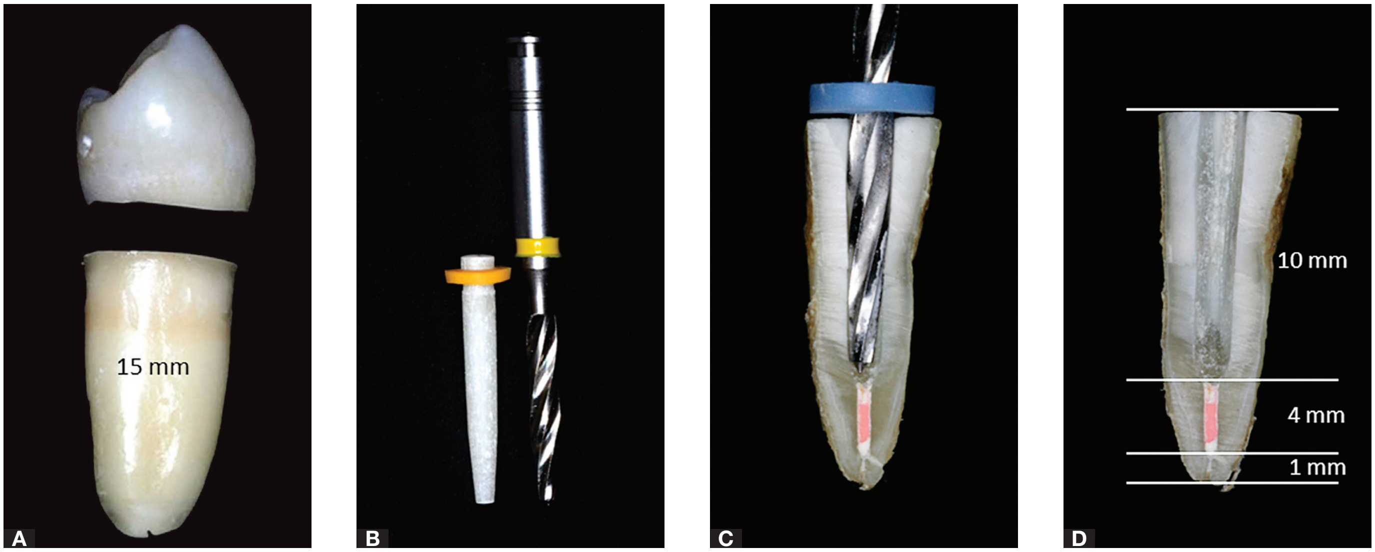

Figure 1. A) Crowns were sectioned transversely and removed; **B**) A #2 Exacto drill and fiber post (Exacto #2; Angelus, Londrina, SP, Brazil); **C**, **D**) Post space preparation.

drill from the fiber posts system (Exacto #2; Angelus, Londrina, SP, Brazil), as measured from the cement-enamel junction on the buccal aspect of the tooth (Fig 1B-D).[16] All treatments were applied by the same operator, in an effort to standardize procedures. Following post space preparations, specimens were randomly divided into four groups of 11 teeth each:

» Group 1 (control): the canals were rinsed with 10 mL of 0.9% saline solution for 10 seconds.
» Group 2: the canals were rinsed with 10 mL of 2.5% NaOCl for 15 seconds, followed by 10 mL of distilled water for 10 seconds.
» Group 3: the canals were rinsed with 10 mL of 2% CHX gluconate for 15 seconds, followed by irrigation with 10 mL of distilled water for 10 seconds.
» Group 4: the canals were rinsed with 0.5 mL of 17% EDTA for 15 seconds, followed by irrigation with 10 mL of distilled water for 10 seconds.

Bonding of fiber posts

Fiber posts were luted according to the manufacturer's instructions for RelyX™ Unicem Aplicap sealer (3M ESPE AG, Seefeld, Germany). A silane coupling agent (Angelus Soluções Odontológicas, Londrina, PR, Brazil) was applied to the surface of the glass fiber posts (Exacto #2; Angelus, Londrina, SP, Brazil) for 60 seconds and gently air dried. The capsule of the dual-cured self-adhesive resin cement RelyX™ Unicem Aplicap was activated and triturated for 15 seconds.

RelyX™ Unicem Aplicap sealer was applied to the fiber post and introduced into the canal with a Lentulo spiral drill #50 (Dentsply Maillefer, Ballaigues, Brazil) at low-speed. The posts were positioned, and excess was removed with a microbrush before chemical curing. Specimens were stored in a humidified incubator at 36.6 °C for seven days.[17]

Push-out test

Specimens were attached to the arm of a low-speed saw (Isomet; Buehler Ltd., Lake Bluff, IL, USA) and sectioned perpendicular to the long axis under water cooling. Three sections, each 1-mm thick, were obtained from the coronal part of each root (Fig 2A-C). The first section was not included in order to avoid the influence of excess coronal material. Using this procedure, 22 sections were available for each group for the push-out test.

The post segments were loaded with a 1-mm diameter cylindrical plunger centered on the post segment, and any contact with the surrounding dentin surface was avoided (Fig 2D, E). Push-out bond strengths were measured with a universal testing machine (DL2000; Emic, São José dos Pinhais, PR, Brazil) at a crosshead speed of 0.5 mm/min. The peak force, which was the force applied at the point of extrusion of the post segment from the test specimen, was taken as the point of bond failure and was recorded in Newtons (N) (Fig 2F). The bond strength was calculated in MPa by dividing the load at failure (in N) by the area of the bonded

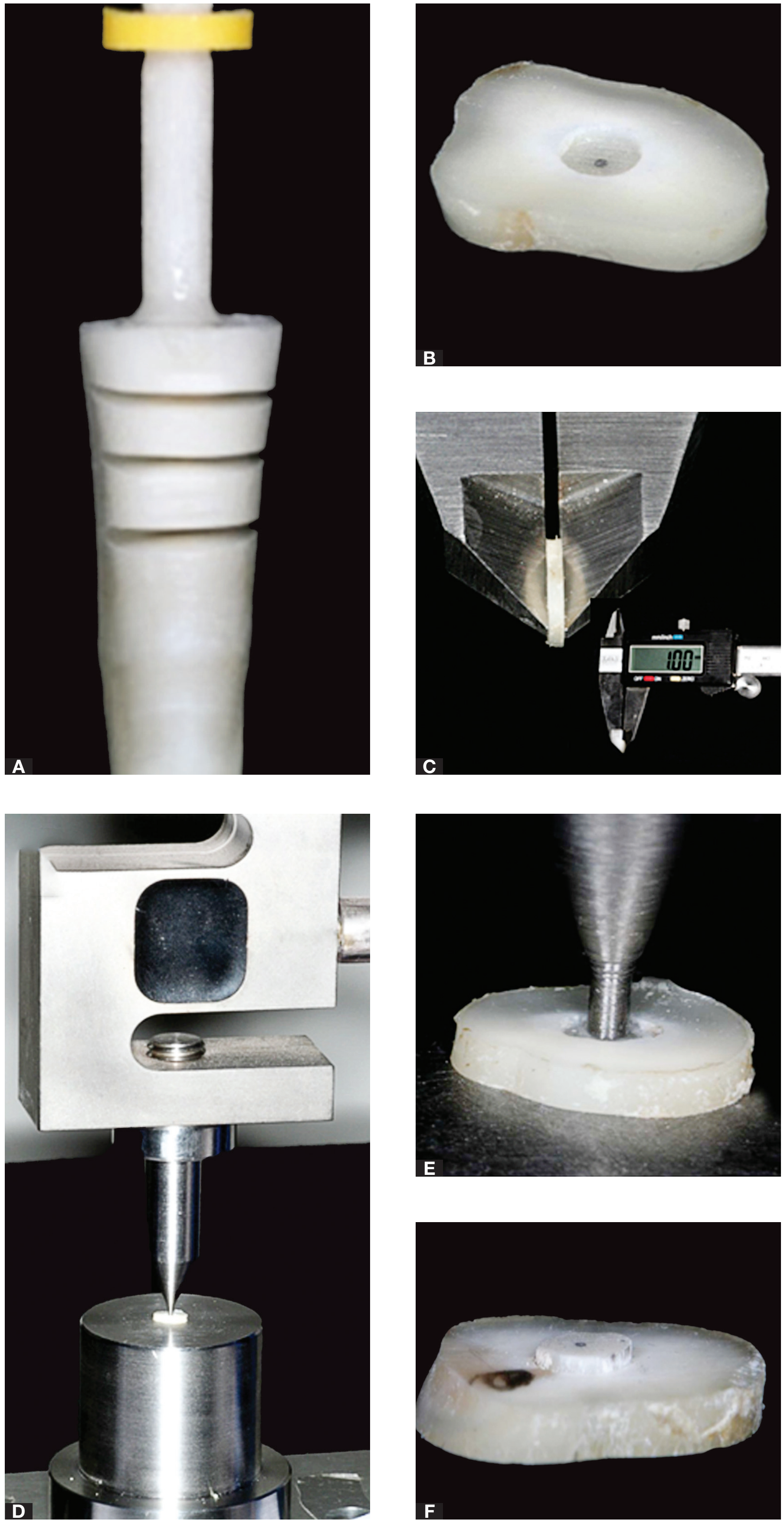

Figure 2. A, B) Sample preparation; **C**) Measuring the thickness of each disc with a digital calliper (1-mm thick discs); **D**) Test specimen mounted on a universal testing machine for push-out bond strength test; **E**, **F**) Push-out test.

interface.[16] The area of the bonded interface was calculated as follows: $A = 2\varpi rh$, where $\varpi = 3.14$, r is the radius of the post segment (mm), and h is the thickness of the post segment (mm).

Statistical analysis

Means and standard deviations of bond strengths were calculated. Preliminary statistical tests indicated the homogeneity and normality of the sample. Data (in MPa) were subjected to statistical analysis by two-way ANOVA (Pacotico; Microsoft Visual FoxPro, Rights: Eymar Sampaio Lopes) followed by *post-hoc* Tukey's test ($p < 0.05$).

Results

The results of the push-out bond-strength measurements are presented in Table 1 and Figure 3. ANOVA showed no significant differences ($p > 0.05$) among the four chemical solutions evaluated.

The highest bond-strength was obtained in the EDTA group. Results also showed that surface treatment with NaOCl or EDTA increased the bond strength to dentin when compared with the control group, but without statistical difference. Surface treatment with CHX revealed lower bond strength to dentin as compared to the other groups, but without statistical difference.

Table 1. Mean and standard deviation in MPa for the push-out bond strength observed for different surface treatments.

Group	Treatment	Means*	SD	n	*p* value
Group 1 (Control)	0.9% NaCl	3.57[a]	0.57	22	0.1234
Group 2	2.5% NaOCl	3.88[a]	0.47	22	
Group 3	2.0% CHX	3.53[a]	0.79	22	
Group 4	17.0% EDTA	4.02[a]	0.58	22	

*Same letters indicate no statistical difference among groups ($p > 0.05$).

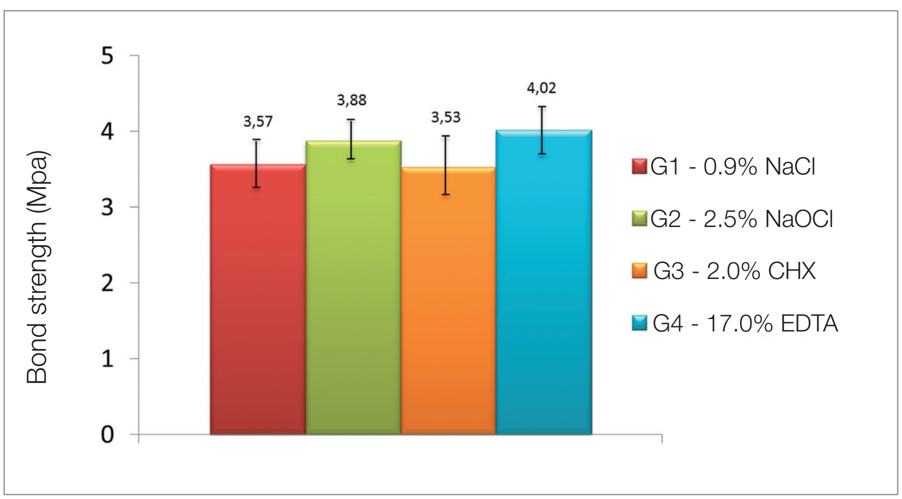

Figure 3. Comparison of the means of the push-out bond strength among groups.

Discussion

Several different mechanical testing methods have been used to measure the strength of bond between fiber posts and intraradicular dentin, including microtensile bond-strength testing,[18] pull-out tests[19] and push-out tests.[20,21] For bond strength testing in our study, dentin surfaces were used to standardize the substrate as much as possible, as required by ISO standards (#11405 / 2003).[22]

The push-out test has been widely used in laboratory research to evaluate multiple variables potentially affecting the retention of intracanal posts, such as root canal treatment prior to the cementing of posts,[23] and the properties of the luting agent.[16] The type of post,[20,24] the treatment of the post,[25] and different composite resins[24] have also been studied with the push-out test. Similar to the current study, previous studies also used the push-out test to test the effect of different irrigating solutions on bond strength.[14,26] Chemical solutions promote changes in dentin substrate; therefore, it is possible that these changes differ between solutions.[9-12,26,27,28]

A manufacturer (3M ESPE) recommends the pretreatment of dentin with sodium hypochlorite (NaOCl) at concentrations of 2.5%–5.25% before post cementation. Further, they contraindicate the use of hydrogen peroxide as a final rinsing agent, desensitizing agent, disinfectant, or hemostatic agent because debris deposited on the surface can compromise the bond strength or the setting reaction of the cement.

The effects of irrigants such as NaOCl, H_2O_2, and EDTA on dentin collagen depend on particular conditions of hydration in root canal dentin, resulting from pulp removal, the type of agent used for substrate conditioning, the polymerization stress of resin cement in root canals with unfavorable cavity configuration, and the chemical and physical properties of the posts. In addition, these variables may influence the quality of adhesion at the post-cement-adhesive-dentin interfaces.[9,16]

It is known that when NaOCl solution is used, it releases active chlorine, which combines with the amine group of proteins to form chloramines. This oxygen can cause strong inhibition of polymerization at the interface of adhesive materials.[29] Moreover, the effects of sodium hypochlorite on dentin can be minimized or reversed.[26,30] NaOCl applied to dentin etched with phosphoric acid increased the bond strength in some adhesive systems,[27,28] in contrast to what occurs when NaOCl is used before applying acid to the dentin.[10,31]

Previous studies have shown that irrigation with 5% NaOCl reduces the bond strength of resin cements to dentin.[5,32] In the present study, a concentration of 2.5% did not affect bond strengths.

EDTA, is accepted as the most effective chelating agent and it is recognized as having prominent lubricant properties; thus, it is widely used in endodontic therapy. It assists with the enlargement of canals using instruments, removal of the smear layer, and preparation of the dentinal walls for better adhesion of filling materials. In the present study, no significant difference was found between the control group and the groups with application of 17% EDTA for 15 seconds, followed by 10 mL of distilled water for 10 seconds. Despite lack of statistical significance, the highest bond strength was obtained with the use of EDTA (Table 1).

Some previous studies[10,33,34,35] reported that there is no reduction in adhesiveness to dentin when CHX is used. However, Wachlarowicz et al[17] found significant reduction in adhesiveness in teeth irrigated with CHX compared with NaOCl. Hiraishi et al[12] also found that application of 2% CHX decreased the bond strength of RelyX™ Unicem to the coronal dentin. We speculate that the decrease in strength can be attributed to a possible contamination of the dentin surface by residues of CHX. Although in the present study, CHX decreased the bond strength of the radicular dentin, this decrease was not statistically significant.

Conclusions

Within the limitations of this *in vitro* study, it may be concluded that radicular dentin surface treatment with 2.5% NaOCl, 2% CHX solution, or 17% EDTA did not affect the bond strength of a fiber post luted with self-adhesive resin cement (RelyX Unicem™).

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