Influence of irrigation protocols on the bond strength of fiber posts cemented with a self-adhesive luting agent 24 hours after endodontic treatment

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The aim of this in vitro study was to evaluate the influence of different irrigation protocols on the bond strength, at different root depths, of fiber posts cemented with a self-adhesive cement 24 hours after endodontic treatment. Fifty-six bovine incisor roots were endodontically prepared and separated into 7 groups (n = 8) according to irrigation protocols: group 1, sterile saline (control); group 2, chlorhexidine (CHX) gel 2% and saline; group 3, sodium hypochlorite (NaOCl) 5.25% and saline; group 4, CHX and saline (final irrigation with ethylenediaminetetraacetic acid [EDTA] 17%); group 5, NaOCl and saline (final irrigation with EDTA); group 6, CHX and saline (final irrigation with NaOCl and EDTA); and group 7, NaOCl (final irrigation with CHX and EDTA).

No statistically significant difference was found among the groups. Within the limitations of this study, it can be concluded that the different irrigation protocols did not influence the bond strength of self-adhesive resin cement, which presented similar behaviors at the 3 root depths studied.

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Patients who have had endodontic treatment frequently present with problems such as extensive coronal damage from caries, internal resorption, incorrect endodontic access, and need for restoration replacement.[1] Most of these clinical situations require the use of intraradicular retentive strategies to stabilize the restoration due to the inability of the remaining coronal structure to protect the restorative procedure.[2]

The use of prefabricated posts has been widely adopted to facilitate restoration of these teeth.[3] These posts enable easier installation, require less clinical chair time than custom cast cores, and may increase the success rate of endodontic treatment, since they—unlike custom cast cores—do not require temporary restorations that could increase the risk of fluid infiltration in the treated canal.[4,5] The placement of these posts is based on bonding to the root canal with (most frequently) adhesive systems and resin luting agents.[6]

Variables that can influence the quality of post-cement-dentin interfaces include the agent used to etch the substrate, the polymerization shrinkage of the resin cement, the chemical and physical properties of the posts, and the endodontic auxiliary chemical substances.[7,8] Nevertheless, factors such as endodontic auxiliary chemical substances cannot be avoided, since they are essential to the success of the endodontic treatment.

Sodium hypochlorite (NaOCl) is commonly used as an irrigant during endodontic treatment.[9-11] However, it can impair the bond strength of adhesive systems to root dentin. An alternative is 2% chlorhexidine (CHX) gluconate, which is chosen because of its antimicrobial action, substantivity, and low toxicity. The most important property of this irrigant is that it does not interfere with the bond strength of resin agents to root dentin.[11,12]

In some situations, fiber posts are cemented in a subsequent procedure after endodontic treatment, which can modulate the influence of the irrigants on the bond strength of the resin materials to root canals. Although some studies have evaluated the bonding of fiber posts to root canals, the influence of endodontic irrigants on the bond strength of such posts fixed with a self-adhesive resin cement has not been evaluated.[11,13,14] Thus, the aim of this in vitro study was to evaluate the influence of different endodontic irrigation protocols on the bond strength of glass fiber posts luted with a self-adhesive resin cement 24 hours after endodontic treatment; bond strengths were evaluated at different root depths (cervical, medial, and apical). The null hypothesis of this study was that the irrigation protocol performed on the endodontic treatment would influence the bond strength of fiber posts luted with a self-adhesive cement.

Materials and methods

The crowns of 56 bovine incisors were cut off at the cementoenamel junction. The inclusion criteria for the incisors were 17-mm-long roots, a canal diameter less than 1.5 mm, and a circular format. Roots with a curvature more than 10 degrees and/or open apices were not included in this study. The roots were randomly divided into 7 groups (n = 8), according to the irrigation protocol to be performed before cementation of the posts (Table 1).

Root canal preparation

A step-back technique was used to instrument the root canals. K-files (DENTSPLY Maillefer) were used at the working length (16 mm), until the initial anatomic file (IAF) length was reached. From the IAF, the apical region was enlarged with 3 files larger than the IAF, to establish the apical stop. Step-back flaring of the canal was performed using larger files at 1-mm intervals. The file initially used to prepare the apical stop

Table 1. Irrigation protocols for groups in the study.

Group	Irrigation protocol
1	Sterile saline (control)
2	CHX 2.0% and sterile saline
3	NaOCl 5.25% and sterile saline
4	CHX and sterile saline; final irrigation with EDTA
5	NaOCl 5.25% and sterile saline; final irrigation with EDTA
6	CHX and sterile saline; final irrigation with NaOCl 5.25% and EDTA, used separately
7	NaOCl 5.25%; final irrigation with CHX and EDTA, used separately

Abbreviations: CHX, chlorhexidine; EDTA, ethylenediaminetetraacetic acid; NaOCl, sodium hypochlorite.

Table 2. Results of push-out tests for bond strength (in MPa),[a] according to groups and root depths.

	Mean depth (SD)		
Group	Cervical	Medium	Apical
1	4.95 (2.2)	4.08 (1.4)	5.54 (1.9)
2	3.89 (1.5)	2.25 (1.4)	3.93 (2.0)
3	4.75 (2.2)	3.92 (2.3)	2.64 (1.7)
4	4.53 (2.0)	3.29 (1.7)	3.30 (1.7)
5	5.69 (2.0)	4.12 (1.7)	3.62 (1.6)
6	3.64 (0.9)	3.55 (2.0)	3.98 (1.7)
7	5.30 (3.6)	5.60 (2.6)	5.34 (2.1)

Abbreviation: SD, standard deviation. [a]No statistically significant differences were found among the groups, regardless of the irrigation protocol or root depth (1-way split-plot analysis of variance, $P > 0.05$).

was then used again, and the step-back preparation was completed after the use of files 5× larger than the initial file.

The canals were irrigated in accordance with the protocol corresponding to each group. For the NaOCl and sterile saline groups, 5 mL of each irrigant was used at a constant rate for 1 minute between each file change. For the CHX groups, the teeth were filled with CHX gel during instrumentation, and the gel was removed with 5 mL of sterile saline at a constant rate for 1 minute between each file change. For the remaining groups, 3 mL of ethylenediaminetetraacetic acid (EDTA) was applied and remained undisturbed in the root canal for 5 minutes. After preparation, the canals were dried with absorbent paper points (DENTSPLY International), filled with gutta percha (DENTSPLY International), and sealed with a zinc oxide sealer (Coltosol, Coltene/Whaledent, Inc.) 1 mm below the cervical region of the root. Each root was stored in 1.5 mL of distilled water at 37°C for 24 hours.

Next, to obtain an exact preparation of the canal, the post spaces were prepared with a No. 5 Largo drill (DENTSPLY Maillefer), which has a 1.5-mm diameter, in accordance with the selected fiber post manufacturer's recommendations.[15] This procedure was performed without use of any irrigant solution and was followed by rinsing with 5 mL of distilled water and drying with paper points.

Post cementation

A self-adhesive resin cement (RelyX Unicem Aplicap, 3M ESPE) was used for cementation of the posts. The external regions of the roots were covered with polyvinylsiloxane (Aquasil, DENTSPLY International) so that only the cervical region of each root was exposed to the light emitted from the light-curing unit, avoiding the improvement of light curing by the light diffused by the root dentin. The resin cement was manipulated according to the manufacturer's instructions and inserted in the root canal with a fiber post tip (3M ESPE).[16] This was followed by placement of a fiber post (Reforpost No. 3, Angelus Industria de Produtos Odontologicos S/A). Light curing was performed for 40 seconds on the buccal side and 40 seconds on the lingual side; the tip of the light-curing unit (Optilux 501, Kerr Corporation) was angled at 45 degrees to the fiber post. After cementation, each root was stored in 1.5 mL of distilled water at 37˚C for 24 hours.

The roots were then sectioned to obtain three 1-mm-thick slices categorized according to location along the root: cervical (1 mm), medial (5 mm), and apical (9 mm).

Push-out test

The specimens were fixed in a metal base with a 3-mm central hole in a load-testing machine (DL 500, EMIC Equipamentos e Sistemas de Ensaio LTDA) and were stressed to failure at a crosshead speed of 0.5 mm/min.

The failure mode was analyzed under a stereoscopic microscope at 45× magnification (Meiji 2000, Meiji Techno America), and classified according to the following criteria: type I, interface failure (post-cement); type II, mixed failure (>50% dentin-cement); type III, mixed failure (>50% post-cement); type IV, interface failure (dentin-cement).

Some slices were fixed in stubs, gold sputtered, and observed in a scanning electron microscope (JEOL-JMS-T33A, JEOL Ltd.), allowing observation of characteristics of the interfaces of resin cement, post, and root dentin.

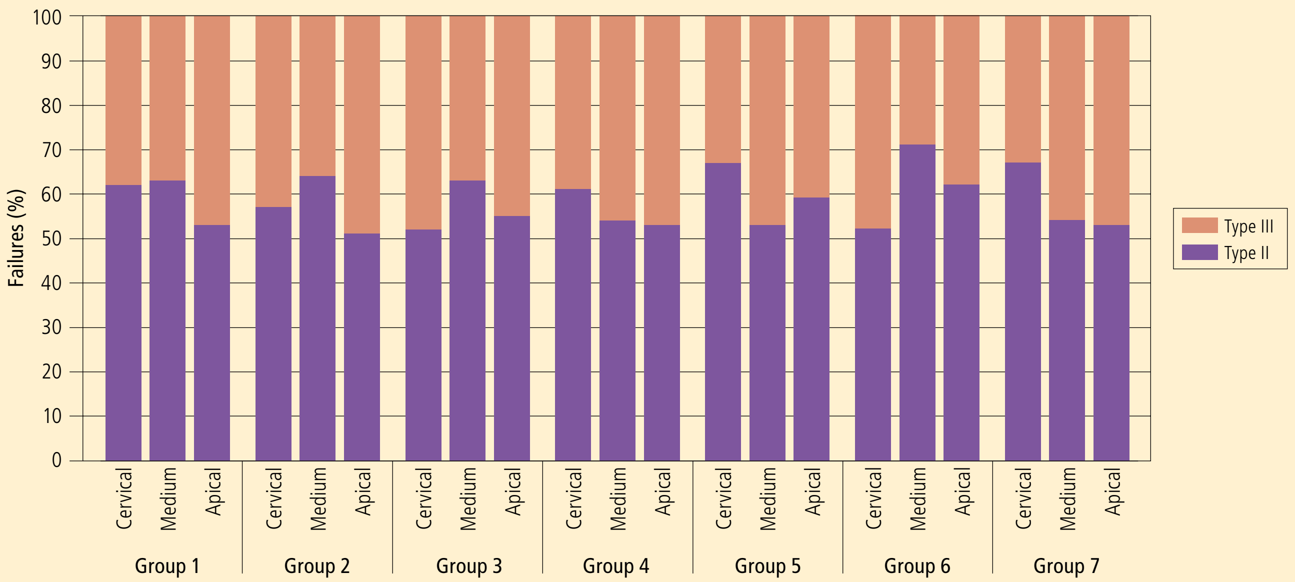
Statistical analysis

After exploratory data analyses to evaluate the additivity of the model, homogeneity of variances, and normality of errors, the data obtained from the push-out test were analyzed statistically with 1-way split-plot analysis of variance. The statistical analysis was carried out with statistical software (version 9.1, SAS Institute, Inc.) with a confidence interval of 95%.

Results

The data were tabulated and the statistical analysis was performed according to different irrigation protocols and root depths (cervical, medial, and apical). The results are presented in Table 2. No statistically significant differences were detected among the groups, independent of irrigation protocols or root depth.

Chart. Failure mode distribution according to groups and root depths studied.



Group 1, sterile saline (control); group 2, chlorhexidine (CHX) gel 2% and saline; group 3, sodium hypochlorite (NaOCl) 5.25% and saline; group 4, CHX and saline (final irrigation with ethylenediaminetetraacetic acid [EDTA] 17%); group 5, NaOCl and saline (final irrigation with EDTA); group 6, CHX and saline (final irrigation with NaOCl and EDTA); group 7 NaOCl (final irrigation with CHX and EDTA).

When failure mode was investigated under the stereomicroscope, types I and IV were not found. Only mixed failures were observed (types II and III) in variable distributions from group to group. However, a higher prevalence of type II failure was observed in all groups (Chart).

Discussion

According to the results, the null hypothesis of this present study was rejected, since the groups presented similar values for bond strength ($P > 0.05$) independent of irrigation protocol and root depth.

Several studies have been performed to evaluate the bond strength of fiber posts to root dentin.[10,11,14,17-19] Nevertheless, most of them have evaluated the adhesive protocols used to perform the cementation, and only a few studies have assessed the effect of irrigation technique on the bond strength of fiber posts luted with resin cement. The effect of auxiliary chemical substances on bond strength is important because of the key roles these agents play in reducing microorganisms in infected root canals and removing dentin debris and tissue during instrumentation.

In the present study, the effect of different irrigation protocols on the bond strength of fiber posts—cemented with a self-adhesive luting agent 24 hours after endodontic treatment—was evaluated. A self-adhesive luting agent was chosen for its ease of application and the small number of critical steps inherent to the adhesive procedure, such as acid-etching and application of the adhesive system.[16]

In the present study, all groups showed similar bond strengths, regardless of irrigation protocol and root region evaluated. This result differs from those of other studies, in which NaOCl reduced the bond strength or canals irrigated with 2% CHX gave the highest bond strengths.[9-11]

The method used in the present study to prepare the root canal can explain this difference. In the present study, the auxiliary chemical substances were applied during and after completion of the root canal instrumentation, simulating endodontic treatment. The roots were prepared and posts cemented 24 hours later, to simulate cementation performed at a subsequent session after endodontic treatment. During gutta percha removal, the diameter of the root canal was increased to prepare the canal for post cementation. This procedure may have removed the dentin affected by the irrigants, allowing for cementation on an unaltered substrate without agents that could influence the bond strength of the resin cement to the root dentin, thereby promoting an effective bond even in groups where NaOCl was applied. In studies where NaOCl interfered with the bond strength of resin adhesives to intraradicular dentin, irrigation of the canal preparation was carried out at the moment of cementation, simulating a restorative procedure performed during the same visit as the endodontic treatment and allowing the auxiliary chemical substances to remain latent on the root dentin in contact with the resin cement.[9-11]

In all groups in the present study, the bond strength was similar in the 3 regions evaluated (cervical, medial, and apical), despite the light attenuation in the medial and apical regions. The chemical bonding of the self-adhesive RelyX Unicem to hydroxyapatite (HAp) may be responsible for these results through the interaction of carboxyl functional groups with HAp, which is caused by ionic bonds between the carboxylic groups of polyalkenoic acid and the calcium of HAp.[20]

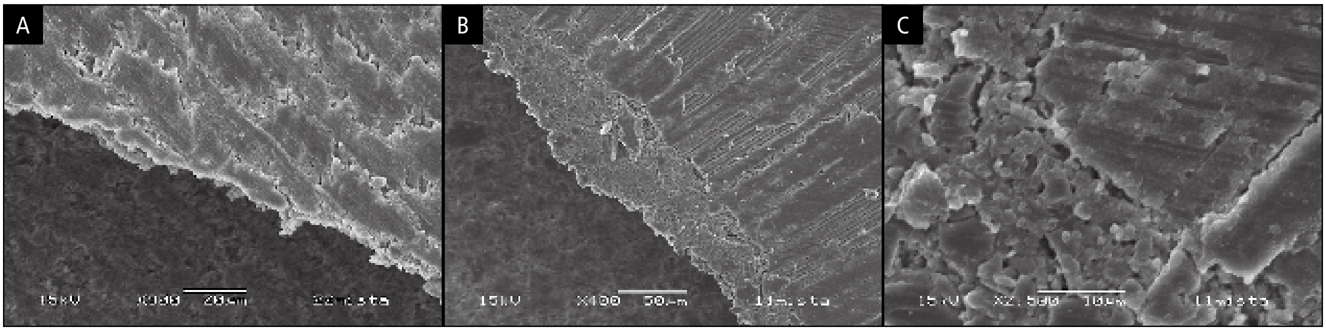


Figure. Scanning electron microscopic (SEM) images of the failure interface. A. A complete rupture of the luting agent from the dentin observed in a mixed failure with only the wall of the root canal preparation remaining (magnification 900×). B. Resin cement adhered to the dentin in a specimen with type III (>50% post-cement mixed) failure (magnification 400×). C. Same specimen as in B at 2500× magnification, showing the absence of a hybrid layer.

The similarity of results, for both different root depths and different irrigation protocols, was corroborated by data obtained after analysis of the failure modes. Only mixed failures were observed, and type II failures prevailed in all groups. In the scanning electron microscopic analysis, the hybrid layer could not be observed, even at high magnification (Figure). This was in accordance with the findings of previous studies, indicating that chemical adhesion is probably the main mechanism of the bond of this self-adhesive resin cement.[21,22]

The results of the present study are important, since they demonstrate that after the mechanical removal of dentin exposed to different endodontic auxiliary chemical substances—which occurs in some clinical situations when fiber posts are cemented—the irrigants had no observable influence on the bond strength of the posts luted with self-adhesive cement. The cementation of fiber posts in a later session after endodontic treatment is a routine clinical practice, and the present study provides important results demonstrating that the root canal preparation can remove the dentin affected by irrigants, promoting adequate cementation, independent of the irrigation protocol used in the treatment.

The results of this study do not, however, disqualify previous studies, which have demonstrated the negative impact of NaOCl on bond strengths of resin cement to root dentin.[9-11] Nevertheless, the present results demonstrate that each case must be considered individually; in situations similar to the conditions in this study, the irrigant does not affect the luting of posts with self-adhesive resin cements. In situations where post cementation is performed without the mechanical removal of the dentin that was in contact with the auxiliary chemical substance, the use of 2% CHX is more desirable, because this agent is inert or even beneficial to the bond between the composite resin and root dentin.[10,11]

Conclusion

According to the results obtained and the statistical analysis performed, it is possible to conclude that the various irrigation techniques did not exert any influence on the bond strength of intraradicular posts luted with a self-adhesive luting agent 24 hours after endodontic treatment when the dentin affected by the auxiliary chemical substance was removed before cementation. The results also demonstrated that the 3 root regions studied (cervical, medial, and apical) presented similar values of bond strength.

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Disclaimer

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Manufacturers

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