The Influence of Sodium Hypochlorite and Root Canal Sealers on Post Retention in Different Dentin Regions

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SUMMARY

This study evaluated the influence of 5.25% NaOCl irrigant and root canal sealers on post retention in different dentin regions. Seventy-two human incisors were decoronated at the cemento-enamel junction and randomly divided into six groups (n=12) according to irrigant and sealer technique: G1-Distilled water (DW) without sealer; G2-DW + AH Plus (Dentsply/Maillefer); G3-DW + Endofill (Dentsply/Maillefer); G4-5.25% NaOCl without sealer; G5-5.25% NaOCl + AH Plus; G6-5.25% NaOCl + Endofill. Specimens were stored in a humid environment for 30 days at 37°C and were prepared with FRC Postec’s drills for post insertion. The posts were cemented with Excite DSC/Variolink II (Ivoclar/ Vivadent). The specimens were sectioned through their long axis into three dental slices approximately 2.5 mm each, representing the cervical (C), middle (M) and apical (A) thirds of the root preparation. After calculating the adhered area of the specimens, they were submitted to the push-out test in a universal testing machine. The data were submitted to an analysis of variance (ANOVA) at a 5% significance level and to the Tukey test (p<0.05). The mean values (MPa) obtained for cervical, middle and apical areas of the root preparation, respectively, were: G1=8.6; 12.5 and 14.3, G2=13.5; 15.4 and 16.9; G3=6.9; 10.0 and 12.1; G4=13.0; 14.9 and 15.4; G5=11.3; 13.5 and 18.0; and G6=11.0; 11.8 and 11.5. Based on the results, the eugenol-based sealer (Endofill) resulted in significantly lower mean retention strength values compared with the resin-based sealer (AH Plus). The apical region showed the greatest retention. The lowest resistance to dislodgment was found in the cervical region, mainly in the groups that used distilled water for irrigating the root canal.

INTRODUCTION

The use of pre-fabricated fiber posts adhesively cemented can potentially reduce the incidence of root fractures (Ferrari & others, 2000c). This is mainly because the elasticity modulus of fiber posts is closer to dentin than...
that of metal posts (Ferrari, Vichi & Godoy, 2000b; Heidecke, Butz & Strub, 2001).

In spite of the advantages, the indication of fiber posts for teeth with a remaining coronal structure smaller than 2 mm was limited (Ferrari & others, 2000c), mainly due to the difficulty of adhesion to intracanal dentin (Patierno & others, 1996; Manocci & others, 2001). This difficulty may be related to modification of the adhesive substrate after endodontic procedures (Goldman, De Vitre & Pier, 1984; Schwartz, Murchison & Walker, 1998; Nikaido & others, 1999; Morris & others, 2001).

Endodontic treatment includes chemical and mechanical preparation of the pericanal dentin, which is the substrate for application of the adhesive system. Sodium hypochlorite is the substance most used in root canal preparation due to its antimicrobial properties. It acts by removing organic tissues and denaturing protein, including the collagen fibers in dentin (Estrela & others, 2002). It is important to note that collagen fibers are the fundamental element for hybrid layer formation (Nakabayashi, Kojima & Masuhara, 1982). With regard to filling the root canal, the majority of the endodontic sealers used contain eugenol. These products might adversely affect the adhesion process, because residual eugenol impregnated in the root canal walls might interfere with the polymerization of resin-based materials (Tjan & Nemetz, 1992; Hagge, Wong & Lindemuth, 2002). However, this effect of eugenol has been questioned (Schwartz & others, 1998; Burns & others, 2000).

Because it is difficult to directly visualize the sealer during the adhesive procedure, especially in the middle and apical root thirds and, because of the different regional characteristics of intracanal dentin (Ferrari & others, 2000a), it becomes necessary to assess the behavior of adhesive systems at the various levels of the root. It is possible to test adhesive strength with the use of mechanical tests that analyze specimens with reduced areas (Yoshiyama & others, 1998; Gaston & others, 2001; Ngoh & others, 2001).

This study assessed the influence 5.25% NaOCl irrigant solution and different endodontic sealers on the retention of fiber posts luted with a resin-based cement.

**METHODS AND MATERIALS**

Seventy-two human incisors with root sizes ranging between 14 mm and 16 mm were selected for this study. The teeth were stored in a 0.5% chloramine T solution until they were used.

The specimens were cleaned and the crowns sectioned at the cemento-enamel junction (Patierno & others, 1996) using double-faced diamond disks (#7020, KG Sorensen Ind, Barueri-SP, Brazil) at low speed under cooling and then discarded. After the apical foramen was enlarged using K-files #15 to 30, the root canal was reamed of the initial thirds with a #12 Batt drill. During these procedures, the root canal was irrigated with 10 mL of distilled water.

The specimens were randomly divided into groups according to the factors under study (Table 1).

**Endodontic Treatment**

The working length was determined by viewing the tip of a #30 file and allowing a 1-mm withdrawal. All the teeth were instrumented with #35, 40, 45, 50 and 55 K-files, while 5 mL of the chemical substance under study was used to irrigate the preparation after each instrument (distilled water or 5.25% NaOCl). After apical preparation, instrumentation of the canal was done with #60, 70 and 80 K-files, also using 5 mL of the tested chemical substance at each change of instrument. Each file was used for three minutes, totaling 24 minutes of chemical-mechanical preparation for each tooth. Final irrigation was done with 5 mL of distilled water (Morris & others, 2001) for all groups.

The prepared canals were blotted with #55 (Dentsply/Maillefeur, Ballagues, Switzerland, lot: 2080) paper points and obturated filled with #55 gutta-percha cones (Dentsply/Maillefeur, lot: 5710) with either (1) Endofill (eugenol-based endodontic sealer), (2) AH Plus (resin-based endodontic sealer) or (3) no sealer (control condition), utilizing the lateral condensation technique. After cutting away the excess gutta-percha, the coronal access was sealed with temporary filling cement (Cotosol–Vigodent S/A Ind, Rio de Janeiro–RJ, Brazil) and stored in a humid environment at 37°C for 30 days.
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Root Canal Preparation for Posts and Adhesive Cementing

With #3 Gates Glidden drills, 11-mm to 12-mm of obturation material was removed from inside the root canal, maintaining 3-mm of gutta-percha in the apical third of the specimen. Post preparation was done with a #3 pilot reamer and a #3 reamer (Ivoclar/Vivadent, Schaan/ Liechtenstein) (Figure 1), using 5 mL of distilled water to irrigate the canal during and after modeling.

The fiberglass posts (FRC Postec–No 3, Ivoclar/Vivadent, lot: E94033) were tested inside the canal (Figure 2) and sectioned with a double-faced diamond disk (#7020, KG Sorensen Ind) 2 mm above the specimens' coronal margin. The posts were cleaned with 70% isopropyl alcohol, silanated (Monobond-S-Ivoclar/Vivadent, lot: e10084) and stored for 60 seconds in a closed receptacle. The surplus silane was removed with a short blast of air.

The resin-based system Variolink II (Ivoclar/ Vivadent) was used to cement the posts. The root canal was etched with phosphoric acid at 37% (TotalEtch, Ivoclar/Vivadent, lot: E44932) for 15 seconds, washed for 10 seconds and dried with paper points. A dual-cured adhesive agent (Excite DSC, Ivoclar/Vivadent, lot: E27904) was applied with an extra-fine microbrush (Ferrari, Vichi & Grandini, 2001), and after 20 seconds, the surplus was removed with absorbent paper tips with a short blast of air to evaporate the solvent. The prepared resin-based cement Variolink II (Ivoclar/Vivadent, lot: E14434) was placed inside the root canal with lentulo drills (#40). The post was introduced into the root canal, the surplus cement was removed from the coronal area and the exposed margins were photopolymerized (Optilight 600, Gnatus Equip Med Odont Ltda, calibrated to ±500mW/cm²) for 60 seconds. The specimens were stored for 24 hours in an environment with 100% humidity and then immersed in distilled water at 37°C for 24 hours (Patierno & others, 1996).

Obtaining the Test Specimens and Push-out Test

The specimens were sectioned perpendicular to the long axis with a diamond disk (Extec 1010 Extec Corp, Enfield, CT, USA) into approximately 2.5-mm slices under cooling (Frankenberger & others, 2000) (Figure 3).

With a digital caliper and 4x magnifying glass, the height of the slices and their internal diameters were measured, greatest base and smallest base, to calculate the adhered area of each test specimen.

The studies that use the push-out methodology tried to obtain tapered specimens to favor extrusion of the posts during mechanical testing and to reduce the difficulty of calculation of the area from mathematical formulas for regular geometrical figures (Wakefield & others, 1998; Frankenberger & others, 2000). It is not always possible to obtain these figures in the root canal and, although an attempt was made to standardize the shape of the canal preparation, many specimens in this study presented one or two elliptic-shaped bases, making it difficult to calculate the adhered area of each specimen. The lateral areas of these solids were calculated integrating complex mathematical functions used to generate the figure in the tri-dimensional space. Calculation of the double integrations was done using the computer program Maple, version 5.1 (Maple, Waterloo Inc, Waterloo, Canada).

The resultant area of the solid with circular base of ray R and elliptic top of axes $E_1$ and $e_1$ (Figure 4A) can be expressed as:

\[
\text{Lateral area} = \int_0^{2\pi} \int_0^1 f(t,s)dsdt \text{ where:}
\]

Figure 1. Modeling of the canal for the pre-fabricated post.

Figure 2. Testing the post inside the root canal and the 2-mm measurement of the post for cutting.

Figure 3. Root slabs representing the cervical, medium and apical thirds of the cemented post.
\[
f(t,s) = [R \cos(t), R \sin(t), 0] + s\left[\left((e_{1/2})-R\right) \cos(t), \left((E_{1/2})-R\right) \sin(t), h\right],
\]
\[
= [R + s\left((e_{1/2})-R\right) \cos(t), R + s\left((E_{1/2})-R\right) \sin(t), sh], s \in (0,1),
\]
\[
t \in (0, 2\pi).
\]

The lateral area of the solids with elliptic base and top of axes \(e_1\) and \(E_1\) and \(e_2\) and \(E_2\), respectively (Figure 4B), can be expressed as:

Lateral area = \[
\int_{0}^{2\pi} \int_{0}^{s} g(t,s)dsdt
\]
\[
\text{where:}
\]
\[
g(t,s) = \left[(e_{1/2}) \cos(t), (E_{1/2}) \sin(t), 0\right] + s\left[\left((e_{2/2})-(e_{1/2})\right) \cos(t), \left((E_{2/2})-(E_{1/2})\right) \sin(t), h\right],
\]
\[
s \in (0,1), t \in (0, 2\pi).
\]

The test specimens were fixed in a device fitted to the Universal Testing Machine (EMIC/Equipamento e Sistemas de ensaio Ltda, Curitiba, Brazil). A tip 0.8-mm in diameter (Figure 5) was placed over the smallest base of the test specimen and compression force was applied in an apical-coronal direction (load cell 50 Kgf) at a speed of 0.5 mm/minute until the post piece was dislocated (Patierno & others, 1996).

**Statistical Methods**

The experimental design used was a factorial Split Plot arrangement, distributing the factors irrigation solution (two conditions) and sealer (three conditions) in the main plots; as sub-plots, the factor region was considered (three levels).

Statistical analysis of the data was performed using the analysis of variance (ANOVA) and Tukey Test at the 5% level.

**RESULTS**

Statistically significant differences were found for the factors’ irrigation solution, sealer and region. The results are presented in Tables 2, 3 and 4.

The analysis of the irrigation substance (Table 2) shows lower mean retention values for distilled water in comparison with 5.25% NaOCl in the cervical third.

With regard to the endodontic sealers (Table 3), AH Plus presented greater mean retention values than Endofill in all thirds when the irrigation substance was distilled water, and in the apical third when NaOCl was used. There was no statistical difference among the groups that used the eugenol-based sealer and those that did not use sealer (control condition).

Analysis of the regions considering the different treatments (Table 4) demonstrated significant differences between the apical and cervical thirds, with better behavior of the apical third, except when NaOCl was used with Endofill or with the control condition. The comparison between the middle and cervical thirds shows greater mean values of retention in the middle third when distilled water was used with Endofill or with the control condition (without sealer). When compared to the middle third, the apical third presented greater retention mean values only in association with NaOCl at 5.25% and AH Plus.

**DISCUSSION**

In this study, the endodontic procedure and the protocol for the adhesive cementation of fiberglass posts are performed in the clinical situations, except for the use of distilled water as an irrigating solution or for filling the root canal without endodontic sealer (control conditions). Contrary to this study, some studies did not use posts to assess post retention (Gaston & others, 2001; Ngoh & others, 2001), while others used longitudinal cuts of the specimens (Burns & others, 2000). The specimen cutting methodology avoids important
factors that make intracanal cementing difficult, as it favors visualization of the space prepared for placement of the post and removal of filling sealer residues. This methodology also allows for a greater reach of light during photopolymerization and significantly reduces the cavitary factor associated with polymerization of the resin-based luting materials (Bouillaguet & others, 2003). In this study, the posts were cemented into the root canal, enabling the reproduction of polymerization shrinkage as a cavitary factor compatible with clinical procedures.

An analysis of Table 2 allows one to observe differences between 5.25% NaOCl and distilled water only in the cervical third, which may be explained by the greater dentin permeability of this region (Ferrari & others, 2000a), making it more susceptible to action of the chemical substances used in preparing the root canal. Although the substance/filling sealers interaction was not assessed in this study, analysis of the irrigation substance on the adhesive substrate should be assessed in the control group for the sealer since the filling sealer comes into contact with the dentin after action of the irrigating substances.

The lower retention values observed for distilled water in the cervical third of the tooth may be justified by the need for a mechanical preparation of the root canal, which determines the formation of scrapings of dentin which are deposited into the dentin tubules (Becker & Woollard, 2001; Estrela & others, 2002). During the experimental phase, there was great difficulty in maintaining the patency of the canal, as distilled water is not capable of dissolving organic matter, compared to 5.25% NaOCl (Guerisolli, Souza Neto & Pécora, 1998; Estrela & others, 2002). Organic tissue remaining on the teeth favors the formation of a smear layer rich in organic components, making it difficult for acid substances to act (Yamada & others, 1983). Thus, the action of 5.25% NaOCl on the organic tissue may have favored better conditioning of the dentin substrate with phosphoric acid during adhesive procedures.

Distilled water is not used as an irrigating solution in endodontic treatment. It was used in this study to establish a control, enabling assessment of the effects of the 5.25% NaOCl treatment during endodontic procedures. However, further studies should be conducted to analyze other chemical substances used in endodontic treatment, such as Chlorexidine, EDTA and NaOCl, itself, in other concentrations.

The analysis of the factor sealer (Table 3) did not show statistically significant differences between the control (without sealer) and Endofill. However, the retention means in the groups in which the sealer was not used have been shown to be greater, being close to the critical value of significance for the middle and apical thirds, when 5.25% NaOCl was used as the irrigating solution. The canal filling without sealer does not represent a clinical reality but was used to establish a control for endodontic seal-
ers, as in the work of Hagge and others (2002), who observed statistically lower retention mean values for eugenol-based sealer.

With regard to the comparison of endodontic sealers, the use of AH Plus resulted in greater retention mean values. The resin-based endodontic cement allowed for greater compatibility with the adhesive system used for post cementation, as it was not always possible to completely remove the sealer from the canal walls (Boone & others, 2001).

Considering the controversy in the literature (Tjan & Nemetz, 1992; Schwartz & others, 1998; Ngoh & others, 2001; Hagge & others 2002) and the results of this study, eugenol sealer should not be considered the best option for filling root canals where adhesive procedures are performed.

With regards to tooth regions (Table 4), greater retention means are observed for the apical third, followed by the middle third and the cervical third. In contrast to this study, Yoshiyama and others (1998) observed less bond strength in the apical region. It is worth emphasizing that the study by Yoshiyama and others uses dentin from the outside surface of the tooth and not intracanal dentin. Furthermore, the apical third studied was the apical third of the root, not the preparation for the post. As with the current study, Gaston and others (2001) divided the roots into three parts with reference to the preparation destined for cementing the post, also observing greater bond values in the apical third.

The difficulty of visualization and access to performing adhesive procedures inside the root canal increases the possibility of sealer or gutta-percha residue on the dentin canal walls, especially in the apical third, reducing the surface available for adhesion (Scotti & Ferrari, 2003). Furthermore, the uncertainty of complete polymerization of the adhesive system and contact of the post with the filling material in the apical region makes adhesion difficult in this third. Thus, how does one explain the greater retention values in the apical third found in the current study?

During endodontic treatment, it is necessary to widen the canal in its initial thirds to facilitate penetration of the irrigating solution, determining a conical shape for the canal (Becker & Woollard, 2001). Thus, post preparation will be performed with reamers that will wear the apical thirds more intensely. Therefore, the cervical region is more open to the influence of chemical substances and endodontic sealers, as greater wear of the apical third eliminates portions of the dentin that were in contact with the chemical substances, or which may still present cement residues (Boone & others, 2001).

In this study, after un-obstructing the canal with the Gates-Glidden drill, canal modeling was done with two canal reamers. This allows for more intimate contact of the post with the dentin canal walls, mainly in the apical third, forming locking areas. Thus, retention of the post in this region will occur by adhesive bonding and mechanical overlapping, which is also observed in the clinic situation. The push-out test allows for an assessment of the mechanical overlapping. However, assessment of the bond strength only, as occurs in microtensile bond strength tests, is not possible. This makes it difficult to compare the results of studies that use different mechanical test methodologies (Yoshiyama & others, 1998; Ferrari & others, 2001).

As opposed to the apical third, the cervical regions require a greater volume of cementing material, increasing stress at the adhesive interface during polymerization shrinkage (Patierno & others, 1996; Frankenberger & others, 2000). This increased stress may be critical for adhesion, taking into consideration the high cavitary factor of the root canal (Morris & others, 2001; Bouillaguet & others, 2003; Scotti & Ferrari, 2003).

Based on the retention values found in the apical third, it is probable that the adhesive has been effectively polymerized, despite the distance from the light source. The post used contains glass fibers that, according to the manufacturer, conduct light energy (Ivoclar/Vivadent), which may have helped in polymerizing the adhesive system in its most apical portions (Lui, 1994). In spite of this possibility, some authors question the capability of light conduction through the posts and polymerization of the cement and adhesive, should this light conduction occur (Ferrari & others, 2001; Morris & others, 2001; Scotti & Ferrari, 2003). It is worth emphasizing that the resin-based cement (Variolink) and adhesive (Excite DSC) used present dual cure; thus, areas where the light has not reached may have been polymerized chemically.

In spite of the advantage of the fiber posts, the cementing procedures require knowledge of the root canal and adhesive techniques. Thus, different specialties, such as Endodontics, Prosthesis and Dentistry should operate in an integrated manner in order to increase the longevity of the restorations. Endodontic treatment, according to the results of this study, seems to interfere in post retention. Thus, further studies should be carried out to establish a clinical protocol for improved retention of the posts, considering the techniques, adhesive materials and endodontic procedures.

**CONCLUSIONS**

NaOCl at 5.25% favored retention in the cervical third when compared to distilled water.

Eugenol-based sealer (Endofil) determined lower retention values than resin-based cement (AH Plus).
The retention of root canal posts was influenced by the dentin region of the preparation, the apical third being the most retentive.

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