Original Article

Comparative Effects of Chlorhexidine, Sodium Hypochlorite, and Ethylene Diamine Tetra-Acetic Acid as Root Canal Irrigants on Pushout Bond Strength of Resil Experimental Sealer and AH26 to Root Dentin

Saeede Zadsirjan[1], Hengameh Ashraf[1], Mahshid Kosari[2], Mostafa Alizadetalarposhti [2], Sepideh Salimnezhad[1]

[1] Department of Endodontic, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran

[2] School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran

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Abstract

Introduction: We compared the effects of chlorhexidine (CHX), sodium hypochlorite (NaOCl), and ethylene diamine tetra-acetic acid (EDTA) root canal irrigants on the pushout bond strength of Resil experimental sealer and AH26 to root dentin. **Methods:** In this in vitro study, 65 teeth were assigned to six groups based on the choice of final irrigant and sealer: (I) CHX and AH26, (II) CHX and Resil, (III) NaOCl and AH26, (IV) NaOCl and Resil, (V) NaOCl plus EDTA and AH26, and (VI) NaOCl plus EDTA and Resil. The teeth were decoronated and underwent chemomechanical preparation. In each group, half of the root canals were filled with AH26 and the other half with Resil plus gutta-percha by the lateral compaction technique. In the control group, the root canals were rinsed with saline and obturated without sealer. The roots were sectioned perpendicular to the longitudinal tooth axis at 3, 7, and 11 mm from the apex (apical, middle, and coronal thirds). The pushout bond strength of sealer to root dentin was measured by a universal testing machine and recorded in Newtons (N). **Results:** AH26 plus CHX, as well as AH26 plus NaOCl and EDTA, yielded the maximum pushout bond strength (*P<0.05*). The pushout bond strength in the apical third was higher than that in the middle and coronal thirds. The mean pushout bond strength of both sealers in NaOCl irrigation groups was lower than that in CHX and EDTA plus NaOCl groups. **Conclusion:** Resil experimental sealer had a lower pushout bond strength than AH26.

Keywords: AH26, Push-out Bond Strength, Resil

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Introduction

Successful endodontic treatment requires optimal chemomechanical preparation, disinfection, and three-dimensional sealing of the root canal system (1). Root canal irrigants have a major role to play in the enhancement of the seal and reduction of microleakage. An ideal irrigant should optimally clean the root canal system without any adverse effects. It should be able to aid in the elimination of debris, decrease the friction of instruments during root canal preparation, enhance the removal of debris, dissolve the mineral tissue, penetrate the root canal space, dissolve the organic residues, and eliminate the bacteria and fungi. It should not irritate the periapical tissue or attenuate the root structure (2). It appears that the use of irrigating solutions enhances the penetration of sealer into dentinal tubules and improves the adhesion of sealer to root dentinal walls (3).

In dentistry, chlorhexidine (CHX) is used for microbial plaque control due to its optimal antimicrobial activity (4-6). Unlike sodium hypochlorite (NaOCl), CHX does not dissolve the organic and inorganic residues;

therefore, its application alone is not sufficient for root canal irrigation (7). Ethylene diamine tetra-acetic acid (EDTA) is among the most commonly used root canal demineralizing agents and plays an essential role in cleaning of root canals due to its high chelating effect on the mineralized tissue (8). Among the optimal physical properties of root canal filling materials, adhesion and optimal bond strength to root dentin is highly important for a successful root canal treatment. An ideal endodontic sealer should perfectly seal the root canal space and optimally adhere to both gutta-percha and root canal walls (9).

On the other hand, the application of gutta-percha and sealer is still the standard technique for root canal obturation. Epoxy resin sealers, such as AH Plus and AH26, are extremley popular for this purpose due to their low solubility, optimal physical properties and biocompatibility, as well as the provision of apical seal and microscopic retention (10-12). The AH26 sealer is among the sealers that provide maximum bond strength to dentin. It has an optimal flow and perfectly seals the root canal dentinal walls (13).

Despite the availability of new mineral trioxide aggregate, silicone, and calcium phosphate-based ceramic sealers, resin sealers are still more commonly used in dental clinics. Therefore, researchers are striving to develop new resin-based sealers. Resil experimental sealer is composed of the constituents of the commercially available sealers plus calcium tungstate and zirconium oxide (14). Nonetheless, this experimental sealer has not been adequately studied and requires further investigations.

The identification of the best root canal irrigant, evaluation of the effect of endodontic sealers, as well as the interaction effect of irrigant and sealer on pushout bond strength, can be of great help to dental clinicians and endodontists. In light of the aforementioned issues, the present study aimed to compare the effects of CHX, NaOCl, and NaOCl plus EDTA as root canal irrigants on the pushout bond strength of AH26 and Resil experimental sealer to root dentin.

Materials and Methods

This in vitro experimental study was conducted on 65 extracted teeth in six groups (n=10) based on the choice of final irrigant and sealer: (I) CHX and AH26, (II) CHX and Resil, (III) NaOCl and AH26, (IV) NaOCl and Resil, (V) NaOCl plus EDTA and AH26, and (VI) NaOCl plus EDTA and Resil. Five teeth were also assigned to the negative control group that underwent root canal irrigation with saline (14). Freshly extracted single-rooted and single-canal maxillary anterior teeth and mandibular premolars that had been extracted for orthodontic treatment or due to periodontal problems were evaluated. The teeth were cleaned and debrided immediately after extraction and immersed in 5.25% NaOCl (Shimin, Tehran, Iran) for 30 min. The teeth were then stored in 0.9% sterile saline (0.9% NaCl, DaruPakhsh, Iran) at room temperature until the experiment.

The teeth were first decoronated at the cementoenamel junction perpendicular to their longitudinal axis using a cutter (Nonstop) and a diamond disc such that 16±1 mm of root length remained. Following that, K-file sizes #10 and #15 (MANI Inc. Japan) was passed through the apex to ensure patency. In order to decrease the effect of confounding factors, all canals were chemo-mechanically prepared by the same operator. Coronal preflaring of the root canals was passively performed with #2 and 3 Gates-Glidden drills (MANI Inc. Japan) with no lateral pressure using a pecking motion. The canals were prepared by the crown-down technique using FlexMaster rotary file size #30 with 0.06 taper (VDW, Germany) and hand K-files such that a #40 hand K-file as the master apical file easily reached the working length. In the process of root canal treatment, recapitulation was performed and the root canals were rinsed with 3 mL of saline after the application of each file. The teeth were then randomly assigned to six groups for final irrigation as follows:

The root canals were rinsed with 3 mL of 5.25% NaOCl (n=20 teeth), 3 mL of 2% CHX (n=20 teeth), or 3 mL of 5.25% NaOCl+3 mL 17% EDTA (n=20 teeth) using sterile insulin syringe. Subsequently, in each group, half of the root canals were obturated with gutta-percha (Meta Biomed, Korea) and AH26 sealer (Dentsply, Germany) and the other half with gutta-percha and Resil experimental sealer using lateral compaction technique. In the control group, the root canals were rinsed with saline and obturated with gutta-percha without sealer. Thereafter, the teeth were stored in 100% humidity at 37°C for 24 h and were then sectioned perpendicular to their longitudinal axis under water spray. Three sections were made at 3, 7, and 11 mm from the apex (representing apical, middle, and coronal thirds) in each root.

In order to assess the pushout bond strength, each slice was fixed in a universal testing machine (Z020; Zwick Roell) between the metal supports. The load was applied to the center of specimens by a cylindrical plunger with a 1 mm diameter at a crosshead speed of 0.5 mm/minute. Care was taken to prevent contact of the plunger with the surrounding dentin. The maximum load causing the debonding of sealer from the dentinal walls was determined for each section (3, 7, and 11 mm) and recorded in Newtons (N). The following formula was used to convert the bond strength to megapascals (MPs): MPa = N /2 πrh

where N is the maximum load in Newtons, r signifies the root canal diameter in millimeters, h refers to the thickness of specimens in millimeters, and π = 3.14. Data were analyzed in SPSS software (version 22) using one-way ANOVA at a 0.05 level of significance.

Results

Table I presents the results of the mean pushout bond strength values in the apical, middle, and coronal sections in the study groups. The results pointed out that in the coronal section, AH26 plus CHX, as well as AH26 plus NaOCl and EDTA, yielded the maximum significant pushout bond strength (*P<0.05*). Resil sealer plus NaOCl and the control group demonstrated the lowest pushout bond strength (*P<0.05*). Other groups illustrated similar pushout bond strength values. In the middle section, AH26 plus NaOCl and EDTA displayed the maximum significant pushout bond strength value (*P<0.05*). Resil sealer plus NaOCl and the control group exhibited minimum pushout bond strength (*P<0.05*). In the apical third, AH26 sealer plus CHX, as well as AH26 plus NaOCl and EDTA, displayed the highest pushout bond strength (*P<0.05*). Resil with NaOCl and the control group showed the lowest pushout bond strength (*P<0.05*). Other groups demonstrated similar pushout bond strength values. Furthermore, in all groups, except for Resil sealer plus NaOCl and the control group, the pushout bond strength in the apical third was significantly higher than that in the coronal and middle thirds.

Table I. Comparison of the pushout bond strength of the study groups in the apical, middle, and coronal thirds

Group	Coronal third	Middle third	Apical third	P- value
	M±SD	M±SD	M±SD	
Resil.CHX	1.01±0.19 $^{b\,c}$	0.97±0.29 ^{b}	1.68±0.90 ^{b} ≠	0.013
Resil.Naocl	0.92±0.32 ^{c}	0.77±0.25 ^{c}	1.20±0.41 $^{b\,c}$	0.109
Resil.NaOCl.EDTA	1.11±0.26 ^{b}	1.08±0.36 ^{b}	1.74±0.91 ^{b} ≠	0.031
AH26.CHX	1.23±0.19 ^{a}	1.14±0.35 ^{b}	2.01±0.92 ^{a}≠	0.004
AH26.Naocl	1.14±0.13 ^{b}	1.16±0.44 ^{b}	1.58±0.73 ^{b} ≠	0.021
AH26.NaOCl.EDTA	1.25±0.19 ^{a}	1.35±0.25 ^{a}	2.10±0.86 ^{a} ≠	0.002
Control	0.71±0.18 ^{c}	0.86±0.11 ^{c}	0.96±0.15 $^{c+3}$	0.066
P value	0.001	0.043	0.032	

M: Mean; SD: Standard deviation; a, b, c: Duncan's post-hoc test. Similar lowercase letters indicate absence of a significant difference; ≠: Significant difference in the apical, middle, and coronal sections

Discussion

As evidenced by the results of this study, AH26 plus CHX, as well as AH26 plus NaOCl and EDTA, showed maximum mean pushout bond strength compared to other groups. In addition, the pushout bond strength in the apical section was higher than that in the middle and coronal sections. The pushout test is among the methods employed to assess the quality of filling materials (15). It can also measure the bond strength of materials with a low bond strength to dentin (16, 17). Therefore, the pushout test was used in the present study to measure the bond strength of sealers to root dentin.

Sound extracted human teeth were also used in this study to simulate the clinical setting as much as possible. Moreover, the collected teeth were stored in saline since it has no significant effect on the bond strength of resin to dentin (18, 19). Furthermore, attempts were made to standardize the groups in this study. For this purpose, single-rooted teeth with a similar apical diameter and root length, as well as round cross-sections, were selected. In addition, the root canals were obturated by the lateral compaction technique since according to Cameiro et al, (20), this technique provides a higher bond strength to root dentin compared to the thermomechanical method.

In the present study, the mean pushout bond strength was lower in the use of both sealers following final irrigation with NaOCl, compared to CHX and EDTA plus NaOCl. The reason is irrigation with NaOCl since a number of studies (21-23) have reported that root canal irrigation with NaOCl or its application for final irrigation significantly decreases the bond strength to root dentin. Final root canal irrigation with NaOCl decreases the bond strength of epoxy resin to dentin, and subsequently increases the leakage (24). NaOCl removes organic materials from the exposed dentin surface (25) and breaks them down into sodium chloride and oxygen. Oxygen inhibits resin polymerization (26). The generation of oxygen bubbles at the dentin-resin interface may directly interfere with resin penetration into dentinal tubules and intertubular dentin (27). Nonetheless, the application of NaOCl during instrumentation and along with decalcifying agents positively affects the seal and pushout bond strength since NaOCl removes the organic residues that interfere with the optimal bond of sealer to root canal wall (24).

Both AH26 and Resil sealers yielded a higher bond strength when applied following root canal irrigation with EDTA plus NaOCl. Several studies (14, 24, 28) have reported that the application of NaOCl plus EDTA yielded a higher bond strength than NaOCl or EDTA alone. The EDTA can effectively eliminate the smear layer and debris from the surface of dentinal tubules. Due to the low pH of EDTA, it serves as *a* calcium chelator and causes root dentin demineralization. A recent study demonstrated that the application of 5.25% NaOCl plus 17% EDTA effectively eliminated the smear layer and increased the bond strength of dental substrate (29). In their study, Wachlarowicz et al. (30) indicated that the application of EDTA and NaOCl significantly increased the bond strength. Moreover, Ari et al. (31) reported that the use of NaOCl alone had a negative effect on bond strength.

In contrast to the present findings, Mozayeni et al. (32) pointed out that the application of EDTA and NaOCl as the final root canal irrigant yielded a lower bond strength compared to MTAD. They attributed this difference to the superior performance of MTAD in the protection of collagen matrix compared to NaOCl and EDTA. In line with the findings of the present study, Garcia et al. (33) demonstrated that root canal irrigation with EDTA and NaOCl yielded a higher bond strength compared to the use of NaOCl alone. They explained that NaOCl could eliminate the organic substances, dissolve type I collagen fibers, and cause root dentin resorption.

The reduction in bond strength to root dentin in canals irrigated with NaOCl alone is explained by the proteolytic activity of NaOCl. This function alters or eliminates the organic constituents of root dentin and impairs the integrity of collagen, which performs a vital role in the adhesion mechanism. Moreover, they ascribed the increase in bond strength following root canal irrigation with EDTA plus NaOCl to the erosional activity caused by EDTA etching and subsequent proteolytic activity of NaOCl, which opens the dentinal tubules and enhances the penetration of sealer into root dentin (33).

In accordance with the results of the present research, several studies that used methacrylate-based sealers (21, 22, 28) reported superior results in CHX groups and attributed this finding to the hydrophilic nature of methacrylate-based sealers since CHX makes the dentin surface more hydrophilic since it does not have any proteolytic activity. In addition, CHX inhibits matrix metalloproteinases (a group of enzymes that regulate the physiological and pathological metabolism of collagen-based tissues) and has a high penetration depth into dentinal tubules (21).

The sealers used in this study have an epoxy resin base. In contrast to resin monomers and methacrylate bases, these sealers have functional carboxyl or phosphate groups in their composition, while epoxy resin sealers have hydroxyl groups in their structure (34). The hydrophilic groups present in epoxy resin-based sealers create hydrogen bonds in the resin network and cause its gradual dissolution by water sorption (34). The AH26 sealer optimally flows in the root canal system, seals the dentinal walls, has adequate working time, and its radiopacity is similar to that of gutta-percha (35). Regarding Resil experimental sealer, Ashraf et al. (14) evaluated the physical and biological properties of this sealer and its characterization in comparison with AH26. They reported that the composition of the Resil experimental sealer was almost similar to that of resin sealers, such as AH26. They concluded that the properties of the Resil experimental sealer met the ISO standards (14).

Unlike the present findings, Topcuoglu et al. (36) reported higher bond strength in the coronal and middle thirds compared to the apical third and attributed it to inadequate or low penetration of irrigant to the apical region. In addition, low bond strength in the apical third may be due to the composition and structure of dentin in the apical region. The apical third has a significantly smaller number of dentinal tubules compared to the middle and coronal thirds (37, 38). The small number of dentinal tubules, the irregular structure of secondary dentin, and the presence of cementum-like tissue on the root dentinal walls in the apical third decrease the adhesion of sealer in the apical third compared to the coronal third (39).

In line with the findings of the current study, Mathew and Kumar reported maximum bond strength in the apical third, which may be due to the accumulation of sealer in the apical region in the process of root canal obturation. Moreover, the presence of tug-back in the apical third when placing the gutta-percha can affect the bond strength. This study had an in vitro design. Possible operator errors in the process of root canal cleaning and shaping, as well as an inability to collect exactly similar teeth belonging to patients of the same age, were among the notable limitations of this study. According to the obtained results, further studies are recommended regarding the compressive and flexural strengths of Resil experimental sealer following the use of different concentrations of root canal irrigants.

Conclusion

As evidenced by the results of this study, resil experimental sealer had a lower pushout bond strength than AH26.

Conflicts of Interest

The authors deny any conflicts of interest related to this study.

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None

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Corresponding Author
Sepideh Salimnezhad
School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran
Tell: +989141191932
Email: sepidehsalimnezhad94@gmail.com