Original Article

Effect of Different Final Irrigants on Bond Strength of Resilon/Epiphany and Resilon/Epiphany Self-Etch

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Abstract

Objective: To assess the effects of different final irrigants on the bond strength of bonded root filling materials, Epiphany/Resilon and Epiphany self-etch (SE)/Resilon.

Materials and Methods: The root canals of eighty single-rooted extracted human teeth were prepared. After the smear layer was removed using 17% EDTA, the samples were randomly divided into eight groups. In groups 1 and 2, no additional irrigant was used after EDTA. In the other groups, final irrigation was performed with 2.5% NaOCl (groups 3 and 4), 2% chlorhexidine (CHX) (groups 5 and 6), and normal saline (groups 7 and 8). The root canals were obturated with Epiphany/Resilon in groups 1, 3, 5 and 7 and obturated with Epiphany SE/Resilon in groups 2, 4, 6 and 8. After the middle thirds of the roots were horizontally sectioned, the push-out bond strength of root filling materials was assessed using the universal testing machine.
The data were analyzed using Mann-Whitney and Kruskal-Wallis tests. The significance level was set at $p<0.05$.

Results: There was no significant difference between the push-out bond strength of Epiphany/Resilon and Epiphany SE/Resilon ($p>0.05$). Considering the irrigation protocols, final irrigation with 2.5% NaOCl was associated with a significantly lower bond strength of both filling materials than the other irrigants ($p<0.05$). EDTA, CHX and normal saline had similar effects on the bond strengths of filling materials ($p>0.05$).

Conclusion: Final irrigation of the root canals with 2.5% NaOCl following application of EDTA had a negative effect on the bond strength of Epiphany and Epiphany SE obturation systems.

Key Words: Chlorhexidine; Epiphany Sealer; Sodium hypochlorite

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INTRODUCTION

Epiphany (Pentron Clinical Technologies, Wallingford, CT, USA) is a dual-curable methacrylate resin sealer that was introduced for root canal obturation in combination with Resilon points (Resilon Research LLC, Madison,

Connecticut, USA) [1]. In the first generation of Epiphany obturation system, a self-etching primer is used before application of resin-based sealer [1,2]. In the second generation, acidic resin monomers have been incorporated into the sealer that is known as Epiphany self-etch (SE) [3,4]. Several investigations have compared the properties of Epiphany and Epiphany SE obturation systems [3,5]. No significant difference has been found between the bond strength of Epiphany/Resilon and Epiphany SE/Resilon [6]. However, the dentinal tubule penetration of Epiphany has been stated to be more than that of Epiphany SE [7]. Furthermore, the etching ability of self-adhesive resin sealers (e.g., Epiphany SE) has been shown to be limited [3,5]. Endodontic irrigants are essential during shaping and cleaning procedures for successful debridement of root canals [8,9]. Instrumentation of the root canals produces a smear layer on the dentinal walls [10].

Smear layer removal is recommended by manufacturers of methacrylate resin-based sealers [4]. Alternating use of ethylenediaminetetraacetic acid (EDTA) and sodium hypochlorite (NaOCl) has been suggested as an effective protocol for removing the smear layer [11,12].

There is no standard protocol for removal of the smear layer. EDTA has been used as a final irrigant in the study by Moon *et al*. [13]. However, other investigators have used different root canal irrigants following the application of EDTA [14-17].

In dynamic situations, the adhesion is necessary to avoid the root canal filling material dislodgment caused by operative procedures, tooth flexure, or post space preparation [18,19].

Chemical irrigants can alter the dentin surface composition, thereby affecting the interaction between resin-based materials and treated root canal dentin [20]. Several studies have investigated the effect of endodontic irrigants on bond strength of different types of root canal sealers [6,17,21].

However, little information is available regarding the effect of different final irrigants following the application of EDTA for removal of the smear layer on the bond strength of Epiphany and Epiphany SE obturation systems. Therefore, this *ex vivo* study used a push-out test to evaluate the effect of 2.5% NaOCl, 2% chlorhexidine (CHX) and normal saline on the bond strength of Epiphany/Resilon or Epiphany SE/Resilon to radicular dentin after smear layer removal using 17% EDTA.

MATHERIALS AND METHODS

A total of 80 extracted single-rooted human teeth stored in 0.5% chloramine T were selected. Teeth with caries, cracks, and resorptive defects in the roots were excluded. The crowns were cut below the cementoenamel junction to a standardized root length of 15 mm. The teeth were randomly assigned into eight groups of ten each. After determination of the working lengths, the root canals were prepared using Mtwo Ni-Ti rotary instruments (VDW, Munich, Germany) to apical size #40, 0.04 taper. The coronal and middle thirds of the roots were shaped using size #2 and #3 Gates Glidden burs. The root canals were irrigated using 2 mL of 2.5% NaOCl between each instrument during canal preparation. After canal preparation, the root canals were irrigated with 3 mL of 17% EDTA (Meta Biomed Co., Ltd., Mandaluyong, Korea) for 1 minute. In test groups, final rinsing and obturation were performed as follows:

Groups 1 and 2: In these groups, no additional irrigant was used after application of EDTA.

Groups 3 and 4: The root canals were finally irrigated with 3 mL of 2.5% NaOCl.

Groups 5 and 6: Final irrigation was performed using 3 mL of 2% CHX (Consepsis, Ultradent, South Jordan, UT).

Groups 7 and 8: The root canals were finally irrigated with 3 mL of normal saline.

The root canals were consequently dried with paper points (ARIA DENT, Iran) and obturated as follows:

In groups 1, 3, 5, and 7, the root canals were obturated with Epiphany/Resilon obturation system (Pentron Clinical Technologies, LLC. Wallingford, CT). The self-etch primer was introduced into the root canal with a microbrush. After 30 seconds, the excess primer was removed with paper points. Epiphany sealer was mixed on a mixing pad. Resilon master cone (size 40/.02) was then coated with Epiphany sealer and inserted into the working length. After completion of canal obturation using the cold lateral compaction technique, the excess Resilon was removed and the coronal surface of the obturation was light-cured for 40 seconds according to the manufacturer's instructions.

In groups, 2, 4, 6 and 8, obturation of the root canals were performed using Resilon/ Epiphany SE sealer (Pentron Clinical Technologies, LLC. Wallingford, CT) using the cold lateral compaction technique. Epiphany SE sealer was mixed on a mixing pad. Resilon master cone (size 40/.02) was coated with Epiphany SE sealer and then inserted into the working length. The root canals were obturated as described for the other groups.

Radiographs of the specimens were taken to confirm the quality of the root canal fillings. The specimens were incubated for 7 days at 37ºC with 100% humidity.

Preparation of specimens for push-out test

The middle third of each root was horizontally sectioned into two 1.00 ± 0.05-mm slices using a water-cooled precision saw (Isomet, Buehler Ltd., Lake Bluff, Illinois, USA). Twenty slices per group were achieved.

Apical and coronal aspects of each slice were then digitally photographed.

Afterwards, the circumferences of the filling material from the coronal and apical aspects of each slice were calculated using an AutoCAD software program (version 16.0, Autodesk, Inc., San Rafael, CA, USA).

Push-out test

After the thickness of the root slices were measured using a digital caliper, the filling material was then loaded with a 0.7-mm diameter cylindrical stainless steel plunger. Loading was applied on a universal testing machine (Z050, Zwick/Roell, Ulm, Germany) at a speed of 0.5 mm/min in an apical-coronal direction to avoid any interference because of the root canal taper during push-out testing. The bond strength was determined using a computer software program connected to the universal testing machine.

The maximum load applied to the filling material before debonding was recorded in Newtons.

The load at failure recorded in Newtons (N) was divided by the interfacial area to express the bond strength in megapascals (MPa).

The interfacial area (in mm^2) was calculated by 0.5 (circumference of the coronal aspect + circumference of the apical aspect) ×thickness [22]. After the bond strength test was performed, both sides of the root slices were examined under a light microscope at 25× magnification to determine the failure mode.

Modes of bond failure were considered as follows: (1) adhesive; at filling material-dentin interface, (2) cohesive; within filling material, and (3) mixed failure.

The data were analyzed using Mann-Whitney and Kruskal-Wallis tests considering the obturation system and type of final irrigations, respectively.

A dunnett T3 post hoc test was used for pairwise comparison between final irrigants. The significance level was set at P=0.05.

RESULTS

The mean (± standard deviation) values of bond strengths recorded for different groups are presented in Table 1.

Comparing the root canal obturation system, there was no significant difference between the push-out bond strength of Epiphany/Resilon and Epiphany SE/Resilon ($p>0.05$). Considering the root canal irrigation protocols, application of 2.5% NaOCl following EDTA was associated with a significantly lower bond strength of both filling materials than the other irrigants ($p<0.05$). The use of EDTA as a final rinse or followed by CHX or normal saline had similar effects on the bond strengths of the filling materials ($p>0.05$).

Inspection of the samples revealed the bond failure to be mainly adhesive for all groups (Table 1).

DISCUSSION

Various irrgants have been used following EDTA before obturation of the root canals with Epiphany or Epiphany SE obturation systems in studies on the sealing ability or bond strength of these obturation systems [16,19, 22, 23].

In the present study, smear layer was removed using 17% EDTA for 1 min. To minimize destructive effects such as excessive dentin demineralization that can interfere with the infiltration of acidic resin monomers to the depth of demineralization [24], EDTA was used for a short application time. The effectiveness of a 1-minute irrigation of 17% EDTA on the smear layer removal has been shown [13].

In this study, the root canals were irrigated with 2.5% NaOCl during instrumentation.

According to the Epiphany/Epiphany SE manufacturer's instructions, NaOCl should not be eliminated from the irrigation protocol.

However, the manufacturer recommends the use of EDTA as the last irrigant followed by rinsing of the canal with sterile water or 2% CHX. It has been stated that exposure to NaOCl results in reduced bond strengths of Epiphany self-etch sealer [25].

On the other hand, studies by Farina *et al*. [26] and Vilanova *et al*. [27] showed the bond strength of resin-based materials in samples

Table 1. Push-Out Bond Strength Values (Mean ± SD) and Modes of Bond Failure for Different Groups

Group (n = 20)	Mean ± SD (MPa)	Failure Mode		
		Adhesive	Cohesive	Mixed
Group 1: EDTA /Epiphany	0.31 ± 0.15 *	15	3	2
Group 2: EDTA/Epiphany SE	0.32 ± 0.18 *	15	2	3
Group 3: EDTA- NaOCl/Epiphany	0.16 ± 0.13 **	13	2	5
Group 4: EDTA- NaOCl /Epiphany SE	0.15 ± 0.13 **	14	0	6
Group 5: EDTA- CHX/Epiphany	0.33 ± 0.18 *	14	2	4
Group 6: EDTA- CHX/Epiphany SE	0.46 ± 0.2 *	16	2	2
Group 7: EDTA- NS/Epiphany	0.32 ± 0.29 *	12	0	8
Group 8: EDTA- NS/Epiphany SE	0.30 ± 0.21 *	18	2	0

treated with NaOCl was not different from those treated by EDTA or CHX. Stratton *et al*. [28] also found no significant difference between the sealing ability of Epiphany/Resilon after the use of NaOCl or CHX as the final irrigant following removal of the smear layer using EDTA. Contrarily, the results of the present study showed that the bond strengths of Epiphany/Resilon and Epiphany SE/Resilon after using 2.5% NaOCl as the final rinse were significantly lower than those of the other test groups. Adverse effects of NaOCl on the bond strength of resin sealers have been attributed to inhibition of resin polymerization caused by an oxygen-rich layer on dentin surfaces following the use of NaOCl [29,30].

These controversial results might be partially explained by differences in the methodology such as the volume, concentration, and application time of NaOCl and accompanying irrigants during the irrigation process.

According to the findings of Nassar et al. [25], use of 10% sodium ascorbate (Na-Ascr) for 10 minutes was proved to effectively reduce the adverse effect of NaOCl on the bond strength of Epiphany SE sealer to dentin by conversion of oxidized dentin matrix exposed to NaOCl, thereby facilitating the resin polymerization.

Some studies used EDTA as the final rinse before filling the root canals with Epiphany/Resilon [14,22]. Distilled water has been used after EDTA by other investigators [6,19,23]. There is no information towards the comparison of different irrigants after removal of the smear using EDTA on the bond strength of Epiphany and Epiphany SE.

The results of the present study showed no significant difference between the bond strength of Epiphany and Epiphany SE when EDTA was used alone or following the use of 2% CHX or normal saline. However, it has been shown that final irrigation with 2% CHX after 17% EDTA resulted in a significantly higher bond strength of ActiV GP, an adhesive root canal filling material, compared to when 17% EDTA was used alone [31].

Furthermore, Erdemir *et al*. [32] found that irrigation with 0.2% CHX significantly increased the bond strength of an adhesive material. The positive effect on adhesion of materials has been attributed to the increase of surface energy and wetting ability of dentin by CHX [31] which may favor resin infiltration into the dentinal tubule [32].

Chlorhexidine has been suggested to be used as a final rinse because of its sustained antimicrobial activity [8]. Furthermore, CHX has been shown to inhibit the matrix metalloproteinases (MMPs), resulting in improvement of the hybrid layer integrity and further resin dentin bond stability in a long term period [33]. The short time between the application of CHX and testing the bond strength in this study might explain the equal results for CHX and normal saline or EDTA alone. Further studies are needed to evaluate the effect of CHX on properties of adhesive materials for long periods of times.

In the present study, observation of the root slices showed that the bond failure was mainly adhesive for all groups, which means that the dentin surface appeared clean.

This finding is in agreement with several studies regarding the type of bond failure of Epiphany or Epiphany SE/Resilon root canal fillings that revealed the failure modes to be mostly adhesive [15,23,34]. Debonding of the root filling materials from the canal walls as a whole might be related to the strong chemical link between Resilon and Epiphany [35].

CONCLUSION

Under the conditions of this *ex vivo* study, final irrigation of the root canals with 2.5% NaOCl following the application of EDTA had a negative effect on the bond strength of both Epiphany and Epiphany SE obturation systems.

The bond strength of Epiphany or Epiphany SE/Resilon to root canal dentin after using EDTA as a final rinse or followed by CHX or normal saline did not differ significantly.

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