IEJ
Iranian Endodontic Journal

Effect of Smear Clear and Conventional Root Canal Irrigants on Push-Out Bond Strength of Resilon/Epiphany System

Farzaneh Afkhami [a], **Mona Sadegh** [b], **Aidin Sooratgar** [a*], **Elham Montazeri** [b]

a Department of Endodontics, Dental School, Tehran University of Medical Sciences, International Campus, Tehran, Iran; b Endodontists, Private Practice, Tehran, Iran

ARTICLE INFO

Article Type:
Original Article

Received: 03 Apr 2018
Revised: 02 Aug 2018
Accepted: 11 Aug 2018
Doi: *10.22037/iej.v13i4.21260*

**Corresponding author*: Aidin Sooratgar, Department of Endodontics, Dental School, Tehran University of Medical Sciences, International Campus, Tehran, Iran.

Tel: +98-915 3001744
E-mail: a-sooratgar@sina.tums.ac.ir

ABSTRACT

Introduction: The aim of the present study is to compare the effect of SmearClear and sodiumhypochlorite (NaOCl), chlorhexidine (CHX) and normal saline (NS) on the push-out bond strength of Resilon/Epiphany system to dentine. **Methods and Materials:** In this *in vitro* study; 48 single-rooted teeth were selected and decoronated from the CEJ. Then the specimens were divided into four groups (n=12). The roots were prepared by single length technique using MTwo rotary system. The final irrigations of the canals were done using 2% CHX, normal saline, 5.25% NaOCl or SmearClear. The canals were obturated by Resilon/Epiphany system. The teeth were cut perpendicular to their longitudinal axis and four 1-mm-thick sections were obtained from coronal and mid root regions. The push-out bond strength of Resilon/Epiphany system to dentin were calculated and bond failure patterns were assessed. The data were subjected to two-way analysis of variance and Tukey's tests. **Results:** The highest bond strength values were reported for SmearClear and the lowest values for the NS solutions. The effects of irrigant type (P<0.05) and canal area (P<0.0001) on the bond strength of Resilon to dentin were significant (P<0.05). Higher bond strength values were obtained in the mid root areas compared to the coronal regions. In two-by-two comparisons, significant differences in bond strength were found between SmearClear and normal saline (P<0.05) while the other irrigants showed no significant differences (P>0.05). **Conclusion:** SmearClear solution was able to increase the push-out bond strength of Resilon to the dentin similar to other irrigants (NaOCl and CHX). Therefore, it can be used for the root canal irrigation and smear layer removal in the clinical situations.

Keywords: Push-But Bond Strength; Resilon; Root Canal Irrigation; SmearClear; Smear Layer

Introduction

Root canal obturation is one of the most important steps in root canal treatment. A root filling material must be able to provide a three-dimensional obturation with full adaptation to root canal walls and create a hermetic seal. Resilon is a resin-based root filling material, which is accompanied by Epiphany resin-based sealer [1]. The Resilon/Epiphany root canal filling system can micromechanically bond to root canal surfaces, which the manufacturer claims that it can create a monoblock in the root canal system [2]. Bonding to the root canal wall is important because it can prevent coronal and apical microleakage as well as displacement of root filling material during restorative procedures [3].

Several factors, including the type of root canal irrigant and the polymerization pattern of root filling material affect the bond strength of Resilon to root dentin [1]. Irrigation of root canal system might alter chemical structure of the dentin and therefore influence on the bonding of obturation materials to its surface [4]. Several irrigants are used for irrigation of the root canal system and smear layer removal [5, 6]. Presence of smear layer would decrease the adaptation of root filling material to dentinal tubules [7]. Sodium hypochlorite (NaOCl), chlorhexidine (CHX) and ethylenediaminetetraacetic acid (EDTA) are among the most common root canal irrigants. [5].

EDTA was introduced in 1957. Contrary to NaOCl and CHX, it has high capability of smear layer removal. EDTA

reacts with the calcium ions present in dentin and results in dentin demineralization and opening of dentinal tubules [8]. Evidences show that NaOCl combined with EDTA has greater capability for smear layer removal [5]. After final rinse of the canal, residues of the irrigating solutions may remain in the canal and affect the interaction of root filling materials with root dentin or formation of the hybrid layer between dentin and resin-based material [2, 5].

SmearClear (Sybron Endo, Orange, CA, USA) is a novel root canal irrigating solution comprising of 17% EDTA and anionic and cationic surfactants [9]. Cetrimide, a quaternary ammonium compound, is the cationic surfactant in the composition of SmearClear, which has antifungal and antibacterial properties. Incorporation of this surfactant in the formulation of SmearClear decreases the surface tension and contact angle of EDTA on dentin and subsequently increases its cleaning efficiency. This irrigating solution appears to have a superior efficacy compared to EDTA [7]. According to the manufacturer's instructions, root canal should be rinsed with this product for 1 min.

Considering the gap of information and absence of previous studies on the effect of SmearClear on bond strength of Resilon to root dentin, this study designed to assess and compare the effect of SmearClear and the commonly used root canal irrigating solutions including sodium hypochlorite, CHX and saline on push-out bond strength of Resilon to root dentin.

Materials and Methods

Sample preparation

A total of 48 human maxillary incisors were included in the present study. The selected teeth had no cracks, calcification or curvature and had fully developed roots. For the purpose of standardization of root length, the crowns were cut so that the remaining root piece had 14 mm length. To determine the working length, #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was introduced into the canal until its tip was visible at the apical foramen; 1 mm less than this length was considered as working length.

Next, the root canals were prepared using Mtwo rotary system (VDW, Munich, Germany) with the single length technique as follows: 15/0.05, 20/0.06, 30/0.06, 35/0.06 and 40/0.06. The canals were irrigated with 1 mL of 2.5% NaOCl between each instrument. Finally, the canals were rinsed with saline and dried with paper points. After root canal preparation, the teeth were randomly divided into four groups (n=12) for the final rinse with four different irrigating solutions as follows: Group 1: 5.25% NaOCl, group 2: 2% CHX, group 3: 0.9% NS and group 4: SmearClear (Sybron Endo, Orange, CA, USA). In each group, final rinse was carried out using 3 mL of the solutions for 60 sec.

After the final rinse, the canals were dried with paper points and filled with Resilon and Epiphany sealer (Sybron Endo, Orange, CA, USA) using the passive-fit single-cone technique according to the manufacturer's instructions. After drying the canals, the self-etch primer was used to condition the canal walls and prepare them for bonding to the resin sealant. Three drops of primer were placed in the canals with a paper point #40 that wicked the material to the working length. Next, the epiphany sealer was applied to the canals with a lentulo spiral and excess sealer was removed using a paper point. Then, Resilon #40 cone with 0.06 taper was inserted into the canal to the working length. Resilon cone was cut using a heat carrier and was vertically condensed. Coronal part of the root was light-cured for 40 sec using ultralume2 light curing unit (Ultradent, South Jordan, Utah, USA) with 450 mw/cm2 light intensity. The quality of obturation was evaluated and confirmed radiographically.

Push-out test

The samples were incubated at 37°C and 100% humidity for 7 days and were then mounted in molds filled with acrylic resin. The roots were sectioned perpendicular to the longitudinal axis of the root using a cutting machine (Mecatome, Presi, France) with a diamond disc under copious water irrigation. Four sections with 1±0.1 mm thickness were made in each root: two sections were made in the coronal third and two in the middle third of the root. Coronal sections were made at 2 to 4 mm distance from the coronal margin. C1 section was made at 2 to 3 mm distance from the coronal margin while C2 section was made at 3 to 4 mm distance from the coronal margin. Middle sections were made at 7 to 9 mm from the coronal margin. M1 middle section was made at 7 to 8 mm while M2 middle section was made at 8 to 9 mm distance from the coronal margin.

The thickness of sections was measured by a digital caliper (Cd-15c; Mitutoyo Co., Kawasaki, Japan) with 0.001 mm accuracy. The diameter of the root filling in each sample was measured on the coronal and apical views with 50× magnification using a stereomicroscope (Stemi 2000-C, ZEISS, Germany) equipped with a digital camera (Camedia C-5060; Plympus, Tokyo, Japan).

To measure the push-out bond strength, pressure was applied by a cylindrical stainless steel piston measuring 0.7 mm in diameter in a universal testing machine (Z050, Zwick/ Roell Group, Ulm, Germany). The piston applied compressive load to the root filling in apico-coronal direction at a crosshead speed of 0.5 mm/min. Considering the tapered form of the root canal, load was applied in apico-coronal direction for the push-out test until debonding occurred. The load at debonding time was calculated by the software of the universal testing machine. The highest load applied to the root filling material right before debonding was recorded in Newtons (N). The push-out bond strength in megapascals (MPa) was calculated using the following formula: Push-out bond strength (MPa)=Maximum load (N)/Bonding area of root canal filling (mm 2).

The adhesion (bonding) surface area of each sample was calculated using the formula below: $(\pi r1+\pi r2)\times L$, where L was calculated as $\sqrt{(r1-r2)\ 2+h2}$, and π is the constant 3.14, $r1$ is the smaller radius, $r2$ is the larger and h is the thickness of the section in mm.

The mode of failure was also evaluated under the stereomicroscope (Stemi 2000-C, ZEISS, Germany) under 40× magnification and classified as: Adhesive; fracture at the material-root dentinal wall interface, Cohesive; fracture within the material such that some of the root filling material remained attached to the dentinal wall and Mixed; a combination of both adhesive and cohesive failures.

Statistical analysis

Data were analyzed using SPSS version 21.0 (SPSS Inc., IL, USA). Two-way ANOVA was applied to assess the effect of type of final irrigating solution on push-out bond strength of Resilon to root dentin. Two-by-two comparisons of irrigating solutions in terms of push-out bond strength of Resilon to dentin were carried out using Tukey's multiple comparisons test. $P<0.05$ was considered statistically significant.

Results

Two-way ANOVA showed that the effect of the type of irrigating solution ($P<0.05$) and the canal region (coronal or middle third) on push-out bond strength of Resilon to dentin was significant ($P<0.05$) while the interaction effect of these two parameters was not significant on bond strength ($P=0.38$).

In all four groups, the middle region of the root showed higher bond strength than the coronal area ($P<0.05$). Also, among different irrigating solutions, SmearClear caused the highest and saline caused the lowest bond strength. On the other hand, two-by-two comparisons of the groups revealed a significant difference between the SmearClear and saline groups (Tukey's test, $P<0.03$). No other significant differences were noted in two-by-two comparisons of the four groups ($P>0.05$).

Table 2 shows the frequency of adhesive, cohesive and mixed failures in the four groups. Table 1 shows push-out bond strength values in the coronal and middle thirds in the four groups in megapascals (MPa).

Table 1: Push-out bond strength values in the coronal and middle thirds in the experimental groups in megapascals (MPa)

Final irrigation	Root zone	Mean ± SD (MPa)	Min (MPa)	Max (MPa)
NaOCl	coronal	0.41 ± 0.26	0.14	1.08
	middle	0.59 ± 0.33	0.21	1.41
Normal saline	coronal	0.31 ± 0.19	0.08	0.81
	middle	0.48 ± 0.27	0.16	1.07
CHX	coronal	0.29 ± 0.12	0.08	0.55
	middle	0.64 ± 0.37	0.13	1.32
SmearClear	coronal	0.49 ± 0.29	0.16	1.18
	middle	0.66 ± 0.39	0.24	1.49

Table 2. Percentage of different bond failure modes in study groups

Final irrigation	Cohesive N (%)	Mixed N (%)	Adhesive N (%)
NaOCl	1 (8.33)	2 (16.66)	9 (74.99)
Normal saline	0 (0)	1 (8.33)	11 (91.63)
CHX	1 (8.33)	2 (16.66)	9 (74.99)
SmearClear	0 (0)	2 (16.66)	10 (83.33)

Discussion

This *in vitro* study was designed to assess and compare the push-out bond strength of Resilon to dentin following the use of SmearClear, CHX, NaOCl and saline irrigating solutions. The results showed that the push-out bond strength of Resilon to dentin was the highest following the use of SmearClear for canal irrigation. However, two-by-two comparisons showed no significant difference between SmearClear and other irrigants except for saline; Goncalves *et al.* [9] reported that the bond strength of Resilon/Epiphany to root dentin following irrigation with 17% EDTA was higher than irrigation with 2% CHX gel and 2.5% NaOCl. Their results were in agreement with present study probably due to the similar formulation of SmearClear and EDTA. Shokouhinejad *et al.* [5] evaluated the effects of root canal irrigants on the bond strength of Resilon/Epiphany and Resilon/Epiphany self-etch. They reported that EDTA, CHX and saline had similar effects on bond strength of root filling materials to root dentin. They also claimed that final rinse of the canals with 2.5% NaOCl had negative effects on the bond strength of Resilon/Epiphany and Resilon/Epiphany self-etch. In the present study, micro-push-out test was carried out on samples with a thickness equal or less than 1 mm. A review article showed that micro-bond strength tests are generally more reliable than macro-bond tests; although there is not a standard format for reporting bond strength. However, micro-push-out test is more reliable for assessment of bond strength of root filling materials due to high prevalence of early bond failure and high variability in the results of microtensile tests.

According to the current results, the mid-root area in all groups showed higher push-out bond strength values compared to the coronal area. Epiphany sealer is composed of methacrylates (ethoxylatedbisphenol A dimethacrylate-BisEMA) and has a dual-cure polymerization system. In addition to chemical curing, this sealer has a photo-initiator and requires light curing [10]. Therefore, difference in the level of curing and polymerization in different parts of the root results in variability in level of polymerization and degree of conversion of sealer in different parts of the root canal system. Immediate light curing of the coronal area results in rapid polymerization of resin in this area, which is followed by faster shrinkage [11]. Evidence shows that the amount of intratubular dentin and collagen fibers increases from the coronal towards the apical region in the root [9], which highlights the more significant role of the hybrid layer in forming a stronger bond at the mid-root compared to the coronal third. A previous study stated that presence of oxygen in the coronal part of the root prevents the setting of sealer and results in lower degree of polymerization of resin in this area [12]. Baldissera *et al.* [13] evaluated the bond strength of Resilon/Real Seal in different parts of the root and revealed that the mean bond strength increased from the coronal towards the apical region; it can be due to the round anatomy of the apical region compared to more coronal areas and consequently better adaptation of master cone to the canal walls. They recommended using lateral gutta-percha cones *via* the lateral compaction technique. This can explain the methodology and the results of the current study. However, in contrast to our results, Rocha *et al.* [10] reported that the bond strength of Resilon/Epiphany system decreased from the coronal towards the apical region due to less penetration of light to the apical areas.

According to the current results, the majority of bond failures in all groups were of adhesive type, which indicates that the dentin surface was free from sealer. The same results have been reported by several studies [5, 9, 10, 13]. Bulk separation of root filling material from root dentin can be explained by the strong chemical bond between the Resilon and Epiphany sealer [14].

However, further studies are suggested to assess the effects of different irrigating solutions on the success rate of endodontic treatment. Also considering Barborka *et al.* [15] study on long-term clinical outcome of teeth obturated with Resilon, that reported lower success rate of Resilon/Epiphany in comparison with gutta-percha, it is recommended for future studies to focus on finding ways such as an appropriate irrigant to somehow improve the clinical success rate of root canal treatment with Resilon/Epiphany system.

Conclusion

Generally, within the limitations of this study, it appears that the application of SmearClear as a root canal irrigant could increase the push-out bond strength of Resilon to root dentin to the level of other irrigating solutions like sodium hypochlorite and CHX.

Acknowledgement

This study was part of a thesis supported by Tehran University of Medical Sciences, International Campus, Tehran, Iran.

Conflict of Interest: 'None declared'.

References

1. Lotfi M, Ghasemi N, Rahimi S, Vosoughhosseini S, Saghiri MA, Shahidi A. Resilon: a comprehensive literature review. J Dent Res Dent Clin Dent Prospects. 2013;7(3):119-30.
2. Ungor M, Onay EO, Orucoglu H. Push-out bond strengths: the Epiphany-Resilon endodontic obturation system compared with different pairings of Epiphany, Resilon, AH Plus and gutta-percha. Int Endod J. 2006;39(8):643-7.
3. Forough Reyhani M, Ghasemi N, Rahimi S, Salem Milani A, Mokhtari H, Shakouie S, Safarvand H. Push-Out Bond Strength of Dorifill, Epiphany and MTA-Fillapex Sealers to Root Canal Dentin with and without Smear Layer. Iran Endod J. 2014;9(4):246-50.
4. Razmi H, Bolhari B, Karamzadeh Dashti N, Fazlyab M. The Effect of Canal Dryness on Bond Strength of Bioceramic and Epoxy-resin Sealers after Irrigation with Sodium Hypochlorite or Chlorhexidine. Iran Endod J. 2016;11(2):129-33.
5. Shokouhinejad N, Meraji N, Shamshiri AR, Khoshkhounejad M, Raoof M. Effect of different final irrigants on bond strength of resilon/epiphany and resilon/epiphany self-etch. J Dent (Tehran). 2013;10(4):296-302.
6. Sahebi S, Sobhnamayan F, Naghizade S. The effects of Various Endodontic Irrigants on the Push-out Bond Strength of Calcium-Enriched Mixture Cement and Mineral Trioxide Aggregate. Iran Endod J. 2016;11(4):280-5.
7. Khedmat S, Shadi A. A scanning electron microscopic comparison of the cleaning efficacy of endodontic irrigants. Iran Endod J. 2007;2(3):95-8.
8. Kandaswamy D, Venkateshbabu N. Root canal irrigants. J Conserv Dent. 2010;13(4):256-64.
9. Goncalves L, Silva-Sousa YT, Raucci Neto W, Teixeira CS, Sousa-Neto MD, Alfredo E. Effect of different irrigation protocols on the radicular dentin interface and bond strength with a metacrylate-based endodontic sealer. Microsc Res Tech. 2014;77(6):446-52.
10. Rocha AW, de Andrade CD, Leitune VC, Collares FM, Samuel SM, Grecca FS, de Figueiredo JA, dos Santos RB. Influence of endodontic irrigants on resin sealer bond strength to radicular dentin. Bull Tokyo Dent Coll. 2012;53(1):1-7.
11. Braga RR, Ferracane JL, Condon JR. Polymerization contraction stress in dual-cure cements and its effect on interfacial integrity of bonded inlays. J Dent. 2002;30(7-8):333-40.
12. Lo Giudice G, Cutroneo G, Centofanti A, Artemisia A, Bramanti E, Militi A, Rizzo G, Favaloro A, Irrera A, Lo Giudice R, Cicciu M. Dentin Morphology of Root Canal Surface: A Quantitative Evaluation Based on a Scanning Electronic Microscopy Study. Biomed Res Int. 2015;2015:164065.
13. Baldissera R, Rosa RA, Wagner MH, Kuga MC, Grecca FS, Bodanezi A, Frasca LC, So MV. Adhesion of Real Seal to human root dentin treated with different solutions. Braz Dent J. 2012;23(5):521-6.
14. Bodrumlu E, Uzun O, Topuz O, Semiz M. Efficacy of 3 techniques in removing root canal filling material. J Can Dent Assoc. 2008;74(8):721.
15. Barborka BJ, Woodmansey KF, Glickman GN, Schneiderman E, He J. Long-term Clinical Outcome of Teeth Obturated with Resilon. J Endod. 2017;43(4):556-60.

Please cite this paper as: Afkhami F, Sadegh M, Sooratgar A, Elham Montazeri. Effect of Smear Clear and Conventional Root Canal Irrigants on Push-out Bond Strength of Resilon/Epiphany System. Iran Endod J. 2018;13(4):481-5. *Doi: 10.22037/iej.v13i4.21260.*