

The Effect of Calcium Hydroxide on the Bond Strength of Resilon/Epiphany Self-Etch and Assessment of Calcium Hydroxide Removal Techniques: An Ex-Vivo Study

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Abstract

Objective: Calcium hydroxide is the most widely used intracanal medicament in endodontics, which should be removed prior to permanent root canal filling to minimize its intervention with the bonding of endodontic sealers. This *ex-vivo* study aimed to evaluate the effect of pretreatment with calcium hydroxide on the bond strength of Resilon/Epiphany self etch (SE) to the radicular dentin after removing the calcium hydroxide by hand file or ultrasonic methods.

Materials and Methods: Thirty-six single-rooted human extracted teeth were used in this study. After root canal preparation, the teeth were divided into three groups. In group 1, as the control, no pretreatment was performed; while in groups 2 and 3, this was carried out using calcium hydroxide paste. After one week, the paste was removed with hand stainless steel K-files in group 2 and ultrasonic instrumentation in group 3. All samples were obturated with Resilon/Epiphany SE. One-millimeter slices of mid-root dentin were prepared for the push-out test (14 slices per group). After the bond strength was assessed, the failure modes were examined. The data were analyzed using one-way ANOVA and Dunnett Post Hoc tests.

Results: Group 2 significantly showed the lowest bond strength (0.947 ± 0.47) ($P = 0.01$). No significant differences were found between the control group (2.32 ± 1.43) and group 3 (1.78 ± 1.04) ($P = 0.01$).

Conclusions: Under the conditions of this *ex vivo* study, calcium hydroxide as the intracanal medicament and its removal using hand instrumentation adversely affected the bond strength of Resilon/Epiphany SE.

Key Words: Bond Strength; Calcium Hydroxide; Medicament; Resilon/Epiphany SE

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INTRODUCTION

Intracanal medicament has been concerned as an important procedure for reducing intracanal

bacteria and their by-products [1,2]. Due to antibacterial and biological properties of calcium hydroxide, this material has been the

most widely used as an intracanal dressing in endodontics [1,2]. The high pH of calcium hydroxide prevents dissolution of mineralized tissues and it also plays an important role in hard tissue formation [3]. In contact with water, calcium hydroxide releases calcium ions throughout ionic dissociation. The calcium ion level determines the potential of mineralized tissue formation [4].

Resilon (Resilon Research LLC, Madison, CT) is a synthetic material developed recently for obturation of endodontically treated teeth. The Epiphany obturation system consists of three components: the core material (Resilon), the sealer (Epiphany) and its bonding agent (5,6).

More recently, new Epiphany Self-Etch (SE) soft resin endodontic obturation system (Pentron Clinical Technologies, Wallingford, CT) has been marketed consisting of two items: Epiphany self-etch (SE) sealer and the core material (Resilon).

Calcium hydroxide medicament might affect the bonding capability of Resilon/Epiphany SE to radicular dentin. Barbizam *et al.* [7] showed that calcium hydroxide as an intracanal medicament adversely affected the adhesion of Epiphany sealer to the root canal walls. However, the effect of this intracanal medicament on the bond strength of Resilon/Epiphany SE is not clear. Furthermore, it is not obvious whether using different methods for removing calcium hydroxide influence the bond strength of Resilon/Epiphany SE. Therefore, this *ex vivo* study was conducted to investigate the effect of pretreatment of root canals with calcium hydroxide on the push out bond strength of Resilon/Epiphany SE and to compare the efficacy of hand files with ultrasonic instrumentation for removing this medicament.

MATERIALS AND METHODS

Sample Preparation

Thirty-six single-rooted human teeth, extracted for periodontal reasons, were selected for this study. The teeth were decoronated and the root

lengths were standardized at 16 mm. K-file #15 was introduced to the root canal until it could be seen at the apical foramen. The working length was determined by reducing this length by 1 mm. The root canals were prepared using Mtwo rotary files (VDW, Munich, Germany) up to an apical size of 35/04. The canals were irrigated between each instrument using 2 mL of 2.5% NaOCl. Consequently, the specimens were divided into three groups as follows.

Group 1 (n = 12 teeth): This group was served as control and no pretreatment with calcium hydroxide was done.

Group 2 (n= 12 teeth): The calcium hydroxide paste was prepared by mixing calcium hydroxide powder (Golchadent, Iran) and normal saline at a powder to liquid ratio of 1:1.5 (8). Twenty-four teeth were filled with the prepared calcium hydroxide paste using lentulo spiral #25 (MicroMega, Besancon, France) using a low speed handpiece at 1000 rpm to completely fill the root canal. The orifices of the filled root canals were sealed with sticky wax. The specimens were stored at 37°C and 100% humidity for 1 week. After that, calcium hydroxide was removed using hand instrument (stainless steel K-file #30) and 5 mL of normal saline.

Group 3 (n = 12 teeth): In this group, the root canals were treated with calcium hydroxide similar to group 2. After 1 week, the calcium hydroxide was removed by ultrasonic instrumentation (Various 350, NSK, Japan) for the period of 40 seconds with pull and push movements.

Obturation of the specimens

The root canals in the three groups were irrigated with 2 mL of 17% EDTA (Ariadent, Iran) for 1 minute followed by rinsing with 5 mL of normal saline. Then, the root canals were dried with paper points. Epiphany SE sealer was prepared according to the manufacturer's instructions. The root canals were obtu-

rated with a Resilon cone size 35/.02 as the master cone using the cold lateral compaction technique. The excess material was removed with a heated instrument and the coronal surface of filling material was light-cured for 40 seconds according to manufacturer.

Preparation of root slices for push-out bond strength testing

Root slices were prepared by sectioning the middle third of each root perpendicular to the root's long axis into two 1.00 ± 0.1 -mm serial slices using a water-cooled diamond blade on a precision cut off machine (Mecatome, Persi, France). In each group, 14 slices with a circular canal shape were selected for push-out testing.

The filling material was then loaded with a 0.5-mm cylindrical stainless steel plunger and apical-coronal direction to avoid any interference due to root canal tapering.

The loading was performed in a universal testing machine (Zwick-Roell Z050, Ulm, Germany) at a speed of 1 mm/min until debonding occurred.

The maximum load (Newton), which was applied to the filling material before debonding occurred, was recorded. The bond strength in megapascal (MPa) was expressed as the proportion of the recorded load to the area of bonded interface.

Analysis of failure modes

After the measurement of bond strength, the slices were examined under a stereomicroscope at $\times 25$ magnification to determine the mode of bond failure.

Examination of root canal wall after removing the calcium hydroxide

Before obturation of the root canals in groups 2 and 3, in order to evaluate the absence or presence of the calcium hydroxide remnants, four specimens (2 roots from each group) were randomly chosen for observation of their root canal walls using a stereomicroscope at $\times 25$ magnification.

Statistical analysis

The data were analyzed using one-way analysis of variance. Post Hoc pair-wise comparisons were performed using Dunnett multiple comparisons. The significance level was set at $\alpha = 0.05$.

RESULT

Table 1 shows the mean \pm SD values for bond strength in the three groups. There were significant differences between them statistically. Samples in group 2 showed the lowest bond strength. There was significant difference between group 2 and group 1 ($P = 0.01$) and group 3 ($P = 0.05$).

Table 1. Push-out Bond Strength Values (Mean \pm Standard Deviation [SD]) for Different Groups

Group	Mean Bond Strength \pm SD (MPa)
Group 1 (n=14)	2.32 \pm 1.43 ^{**}
Group 2 (n=14)	0.947 \pm 0.47 [*]
Group 3 (n=14)	1.78 \pm 1.04 ^{**}

Values with the same superscript are not statistically different at $p = 0.05$

There was no significant difference between groups 1 and 3 ($P = 0.6$).

The failure modes are presented in Table 2. Half of the failure modes in group 1 were mixed failures; while in the group 2, the majority of failure modes were adhesive.

Stereomicroscopic examination of the canal walls after removing calcium hydroxide confirmed the presence of calcium hydroxide remnants in all of the specimens, which were greater in roots selected from group 2.

DISCUSSION

Calcium hydroxide is widely being used as an inter-appointment intracanal medicament. Complete removal of calcium hydroxide dressing from the root canal system has been shown to be difficult. Neither irrigation, nor different removal methods could provide absolute elimination of this medicament from the root canal walls [8-10]. In this study, assessment of root canal walls after removing calcium hydroxide using either hand or ultrasonic instrumentation indicated remnants of this medicament on the dentinal walls.

It has been shown that Resilon/Epiphany system is able to penetrate into the dentinal tubules [11]. Therefore, any interfering factor with this process could adversely affect the strength of Resilon/Epiphany bond.

Calt and Serper [12] showed that pretreatment with calcium hydroxide decreased the penetration of root canal sealers into the dentinal tubules.

There are different methods for calcium hydroxide removal such as the conventional method using stainless steel, Ni-Ti hand K-files, rotary systems and the ultrasonic technique. Kenée *et al.* [13] showed that rotary and ultrasonic methods are more efficient compared to conventional methods, but similar to each other. In accordance to the previous studies [14-19], we used calcium hydroxide medicament for 7 days and the samples were also incubated in 37° and 100% humidity to simulate the clinical conditions. Barbizam *et al.* [7] stated that calcium hydroxide dressing adversely affected the Epiphany sealer bond strength. The bond strength of their samples, which contained calcium hydroxide, was acceptable, unlike the present study. This may be attributed to the use of chlorhexidine gel in Barbizam *et al.*'s study [7] that has been shown to improve the bond strength [20]. Furthermore, they used Epiphany sealer alone, while Resilon/Epiphany SE was used in the present study. Using the sealer with no main core has been shown to improve the bond strength [21]. In this study, the minority of failure modes in the control group (group 1) were adhesive.

Table 2. Modes of Bond Failure

Group	Adhesive	Mixed	Cohesive
Group 1 (n=14)	2 (14%)	7 (50%)	5 (35%)
Group 2 (n=14)	10 (71%)	4 (28%)	-
Group 3 (n=14)	2 (14%)	11 (78%)	1 (7%)

However, the majority of specimens in group 2 showed adhesive failure. This might be explained by the effect of calcium hydroxide remnants on the root canal walls. In fact, these remnants obstruct the tubular penetration of Resilon/Epiphany SE and the mechanical bond as well. All these would explicate the lowest bond strength observed in group 2. Ultrasonic removal of the calcium hydroxide dressing (group 3) showed failure modes more similar to those seen in the control group. This might show the greater ability of the ultrasonic technique for maximum removal of calcium hydroxide compared to the conventional method (group 2).

Jainaen *et al.* [21] stated that in case of using resin sealers, the failure mode depends on the alliance of the sealer with the smear layer. With a thin film and weak unification of the sealer and smear layer, the failure tends towards the cohesive mode (sealer/smear layer interface); a thicker layer and superior union lead the failure towards adhesive mode (sealer/dentine interface). They stated that leaving a smear layer with filler particles larger than the tubule diameter might be a reason for inferior bond strength and tubular penetration causing adhesive mode of failure. This claim may justify the weak bond and predominant adhesive failure in group 2.

There are different studies with various results discussing the failure mode of Resilon/Epiphany. Ungor *et al.* [22], for instance, revealed that the failure mode results of push out test on the Resilon/Epiphany are mainly adhesive. This controversy with the present results may be due to different used materials (epiphany rather than epiphany self-etch) and methods (coronal instead of mid-root sectioning). Ureyen Kaya *et al.* [23] using Epiphany sealer (not Epiphany SE) proclaimed that the number of cohesive failure modes is clearly more than that of adhesive failures. However, another study on bond strength of Resilon/Epiphany SE revealed the failure mode to

be mainly adhesive [24]. Beside the difference in materials used in the studies, variation in methodology might result in controversial results.

CONCLUSION

Based on the present study, it may be concluded that the remnants of calcium hydroxide as the intracanal medicament have destructive effect on the bond strength of Resilon/Epiphany SE to the root canal dentin. In addition, ultrasonic instrumentation can be considered as a suitable method for removing the medicaments.

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