Efficacy of XP-endo Finisher File in Removing Calcium Hydroxide from Simulated Internal Resorption Cavity

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Abstract

Introduction: The aim of this study was to evaluate the effect of supplementary use of XP-endo Finisher file, passive ultrasonic activation (PUI), EndoActivator (EA), and CanalBrush (CB) on the removal of calcium hydroxide (CH) paste from simulated internal resorption cavities. **Methods:** The root canals of 110 extracted single-rooted teeth with straight canals were prepared up to size 50. The specimens were split longitudinally, and standardized internal resorption cavities were prepared with burs. The cavities and root canals were filled with CH paste. The specimens were divided into 5 groups as follows: XP-endo Finisher, EA, PUI, CB, and syringe irrigation (SI). The root canals were irrigated with 5.25% NaOCl and 17% EDTA for 2 minutes, respectively. Apart from the SI group, both solutions were activated by using tested techniques for 1 minute. The quantity of CH remnants on resorption cavities was scored. Data were analyzed by using Kruskal-Wallis H and Mann-Whitney *U* tests. **Results:** XP-endo Finisher and PUI removed significantly more CH than SI, EA, and CB ($P < .05$), showing no significant difference between them ($P > .05$). Differences among SI, EA, and CB were also non-significant ($P > .05$). **Conclusions:** None of the tested techniques render the simulated internal resorption cavities free of CH debris. XP-endo Finisher and PUI were superior to SI, CB, and EA. *(J Endod 2017;43:126–130)*

Key Words

Calcium hydroxide, CanalBrush, EndoActivator, passive ultrasonic activation, XP-endo Finisher

Significance

This study reported that supplementary use of novel XP-endo Finisher file or passive ultrasonic irrigation to activate NaOCl and EDTA is effective for the removal of calcium hydroxide from simulated internal resorption cavities.

Root resorption occurs as a result of the osteoclastic activity of inflammatory cells, which induces demineralization and causes the loss of dental hard tissue if left untreated (1). Depending on the location of the resorption cavity, root resorptions are classified as internal or external (2). Internal root resorptions are caused by chronic infections, trauma, or inflammatory reactions of the pulp cells (3, 4). Internal root resorption is usually asymptomatic and is detected during routine radiographic examinations (4). Fortunately, internal root resorptions that are detected early have a good long-term prognosis with nonsurgical root canal treatment (5, 6).

During nonsurgical root canal treatment, the irregularity of the resorptive cavity creates challenges for effective cleaning and obturation of the pulp space. The limitations of conventional chemomechanical debridement require the use of intracanal antimicrobial medications (7). Calcium hydroxide (CH) paste is the medicament of choice during the treatment of internal root resorptions (8). However, CH should be removed completely from the root canal system before obturation because the presence of CH on the root canal walls affects the physical properties and the penetration of sealers into dentinal tubules (9, 10). Complete removal of CH from the resorption cavity presents another challenge.

Several irrigation activation devices and techniques have been developed for removing CH from the root canal system. The most common method involves mechanical preparation with a master apical file under copious irrigation with sodium hypochlorite and EDTA (11). However, in the case of internal resorption, the efficacy of conventional irrigation techniques is limited for the removal of CH from these irregularities. Passive ultrasonic activation (PUI), which generates acoustic streaming and/or cavitation within the irrigation solution, has been suggested for the removal of CH (12, 13). After the mechanical preparation of a root canal, an ultrasonic tip is inserted into the root canal filled with solution and activated by ultrasonic energy (14).

EndoActivator (EA) (Dentsply, York, PA) is a sonic activation system with a handpiece and 3 different disposable polymer activator tips that do not cut dentin (Yellow 15/02, Red 25/04, Blue 35/04) (15). The EA is suggested for irrigant agitation after the completion of root canal shaping and the flushing of root canals with a manual syringe and an irrigation needle (16). Passively fitting polymer tips are activated via a battery-operated handpiece at 10,000 cycles/min for 30–60 seconds. The CanalBrush

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(CB) (Roeko Canal Brush; Coltene/Whaledent, Langenau, Germany) is a flexible polypropylene endodontic microbrush that is used with rotary action (13). Topçuoğlu et al (13) evaluated the efficacy of PUI, EA, and CB techniques in removing CH from simulated resorption cavities and reported that none of the tested techniques rendered the resorption cavity free of CH.

XP-endo Finisher (XP) (FKG, La Chaux-de-Fonds, Switzerland) is another novel instrument presented as a final step in the disinfection protocol. XP, which is a size #25 non-tapered instrument, respects the original root canal anatomy and effectively cleans the irregular areas because of its reputed increased flexibility and its ability to expand to adapt to the root canal three-dimensionally (17). Under favor of these properties, previous studies reported that the XP effectively removed accumulated hard tissue debris and the smear layer from the root canal system (18, 19). Another recent study evaluated the efficacy of the XP file in the removal of CH paste from artificial grooves in the apical third of a root canal system (20). According to our literature research, no study has investigated the efficacy of the XP file in removal of CH from simulated internal resorption cavities. Therefore, the present study aimed to evaluate the efficacy of the XP file in the removal of CH from simulated internal resorption cavities by comparing its results with those of PUI, EA, CB, and syringe irrigation (SI) applications.

Materials and Methods

The university ethical committee board approved the study protocol. One hundred freshly extracted human single-rooted maxillary incisor teeth were selected according to the inclusion criteria. Teeth with resorption, caries, immature apices, previous restoration, cracks, and fractures were excluded. Radiographic examination was used to confirm the presence of single patient root canal. The specimens were stored at 37°C at 100% humidity for 2 weeks until the experiments. The crowns were partially removed by using sterile diamond disks under water cooling to standardize root lengths as 18 mm for each specimen. After preparation of endodontic access cavities by using sterile diamond burs, pulp tissue was extirpated by using #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland). Working lengths (WLs) were measured by introducing #15 K-file (Dentsply Maillefer) until it was visible at the apical foramen and subtracting 1 mm from that measurement. The root canals were instrumented by using Reciproc system (VDW, Munich, Germany) up to size R50 (50.05) under copious irrigation with 5.25% NaOCl solution delivered with 30-gauge needle (NaviTip; Ultradent, South Jordan, UT) irrigation. After completion of mechanical preparation, the canals were flushed with 2 mL distilled water and 2.5 mL 17% EDTA solutions, respectively. The root canals were dried with paper points.

The test apparatus was prepared as described by Topçuoğlu et al (13). The specimens were embedded in silicone impression material (Zetaplus; Zhermack, Rovigo, Italy) placed in 1.5 mL Eppendorf tubes. After setting of silicone, the specimens were removed, and longitudinal grooves were prepared alongside the roots on buccal and lingual surfaces. Two halves were split by using hammer and chisel. The lengths of the halves were measured by digital caliper, and the localizations of the resorption cavity were determined. Simulated cavities with 0.8-mm depth and 1.6-mm diameter were prepared at the level 5 mm above the anatomic apex in each halves of specimens (Fig. 1).

Five specimens were used as negative control group and did not receive any further treatment. CH powder (Sultan; Sultan Healthcare, Hackensack, NJ) was mixed with distilled water at a ratio of 1:1.5. CH paste was delivered to the root canals of remaining 95 specimens by using paper points with care to apply CH to main root canal and resorption cavities. The root halves were brought together by using small amount of cyanoacrylate glue (Scotch Super Glue gel; 3M, St Paul, MN) and remounted in silicone. The access cavities were sealed with Cavit (3M ESPE, Seefeld, Germany), and the specimens were stored at 37°C at 100% humidity for 1 week. After 1 week, temporary fillings were removed, and 5 specimens were kept as positive control group and did not receive any removal procedure. A size 15 K-file (Dentsply Maillefer) was introduced into the paste to loosen the paste and create a space for irrigation needle.

Remaining 90 specimens were divided into 5 groups randomly as follows (n = 18).

In group 1 (SI), the root canals were flushed with 5 mL 5.25% NaOCl for 1 minute, followed by 1-minute irrigation with 5 mL 17% EDTA by using 30-gauge irrigation needle (Ultradent) placed 1 mm short of the WL.

In group 2 (XP), XP-endo Finisher file was mounted in a torque-controlled endodontic motor (VDW Gold, Munich, Germany) and cooled down (Chloraethyl; Dr. Georg Henning GmbH, Walldorf, Germany), and then the file was removed from the plastic tube by applying

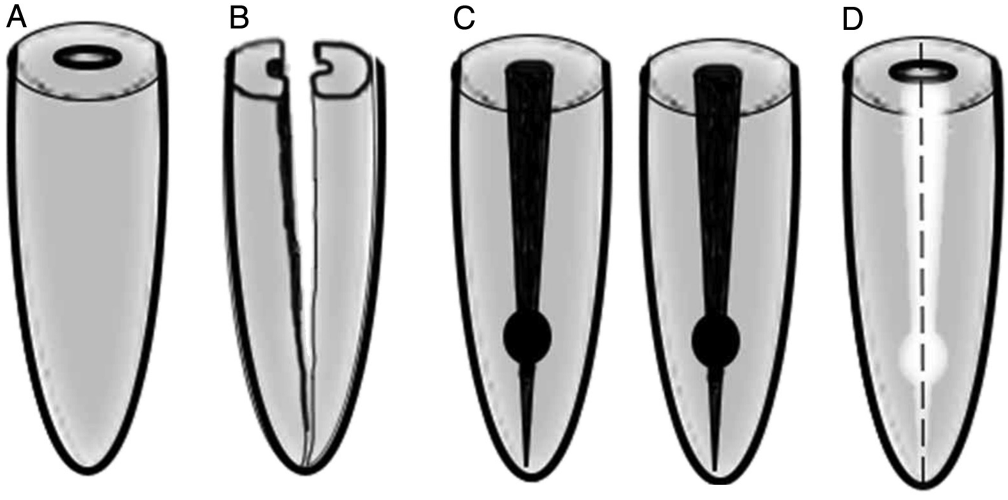

Figure 1. (*A* and *B*) Illustration of internal resorption cavity preparation. (*C*) Simulated cavities were prepared in both root halves of each specimen. (*D*) Root halves were brought together by using cyanoacrylate.

a slight lateral movement. The root canals were irrigated with 5 mL 5.25% NaOCl by using 30-gauge needle (Ultradent) and syringe. XP-endo Finisher file was inserted to the root canal filled with irrigant and operated according to manufacturer's instructions with 800 rpm speed and 1 N cm torque values for 1 minute with vertical movements of 7–8 mm to the full WL. Then the root canals were flushed with 5 mL 17% EDTA solution and instrumented with XP-endo Finisher for another 1 minute. One XP-endo Finisher file per specimen was used.

In group 3 (EA), the root canals were irrigated with 5 mL 5.25% NaOCl. EA device with 25/04 polymer tip was inserted into the root canal filled with solution 2 mm short from the WL and activated at 10,000 cycles per minute with vertical strokes with the amplitude of 2 mm for 1 minute. Then the root canals were flushed with 5 mL EDTA, which was activated with EA for 1 minute. One EA tip was used for 1 specimen and discarded.

In group 4 (PUI), 5 mL 5.25% NaOCl was flushed into the root canals and ultrasonically activated with 15.02 ultrasonic tip (ESI instrument; EMS, Le Sentier, Switzerland) mounted on a piezoelectric ultrasonic unit (EMS) with the power setting at 6. The tip was placed 1 mm short of the WL and activated for 1 minute. The root canals were flushed again with 5 mL 17% EDTA, which was activated for the following 1 minute. Each ultrasonic tip was used for 3 specimens and then discarded.

In group 5 (CB), the root canals were irrigated with 5 mL 5.25% NaOCl. Solution was agitated for 1 minute by using CanalBrush with tip diameter of 0.30 mm operated at 600 rpm. Then the root canals were irrigated by using 5 mL 17% EDTA, which was agitated by CB for following 1 minute. One CB per specimen was used.

Each specimen was irrigated with 5 mL distilled water finally. Total volume of irrigant use for each specimen in all groups was 15 mL. One experienced clinician (C.K.) performed all procedures.

The root halves were separated, and simulated internal resorption cavities of each root half were visualized under ×20 magnification under stereomicroscope. Two digital images were obtained from each specimen. Two calibrated clinicians (Ö.S. and E.S.), who were blinded to the experimental groups, scored each image according to the classification as described by Van der Sluis et al (14):

Score 0: the cavity is free of debris.
Score 1: less than the half of the cavity is filled with debris.
Score 2: more than the half of the cavity is filled with debris.
Score 3: the cavity is filled with debris completely (Fig. 2).

Shapiro-Wilk test revealed that the data were not normally distributed. Kruskal-Wallis H and Mann-Whitney *U* tests were used to analyze the differences among CH removal scores of the tested groups. The level

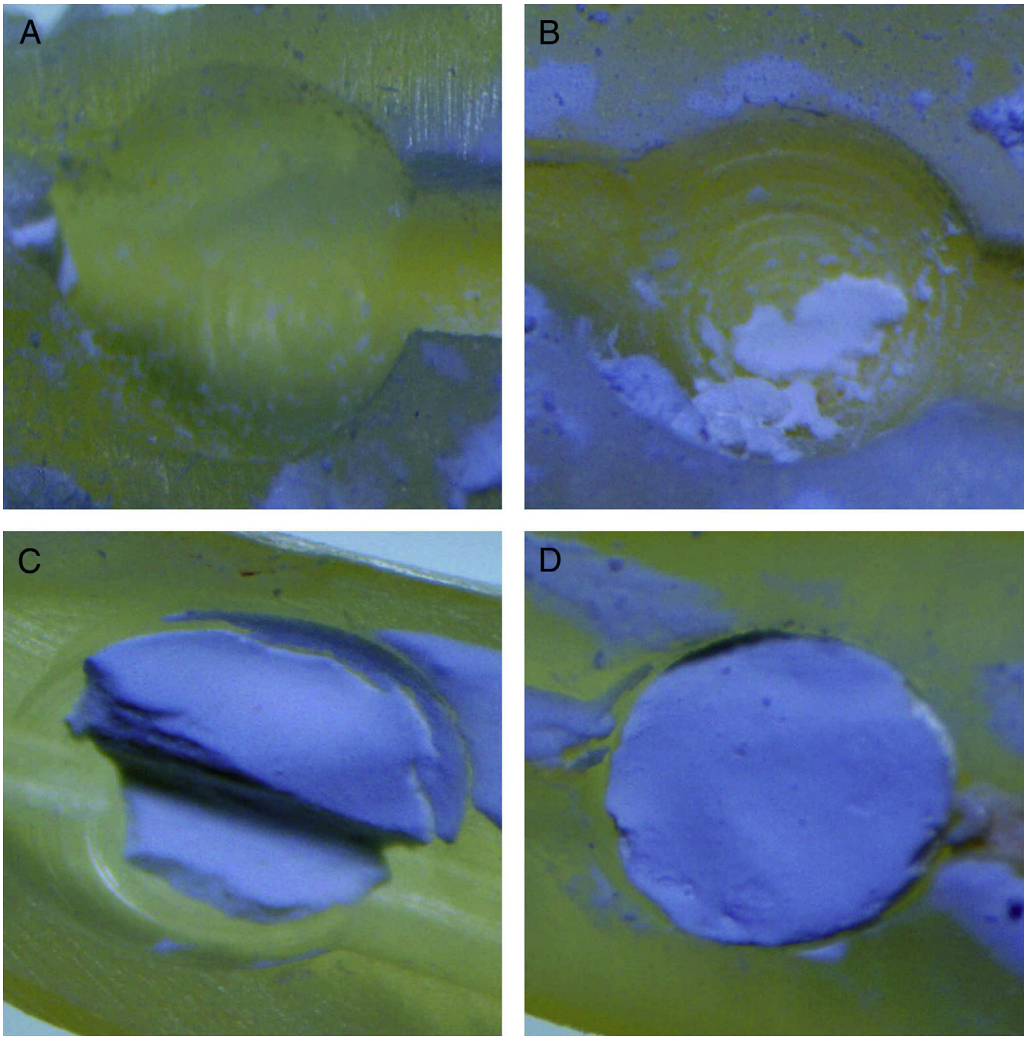

Figure 2. Representative images of scores: (*A*) Score 0, (*B*) Score 1, (*C*) Score 2, and (*D*) Score 3.

TABLE 1. Distribution and Percentage of Scores of Tested Groups

Group	No. of specimens per no. of scored specimens	CH removal scores			
		0 (%)	1 (%)	2 (%)	3 (%)
Negative control	5 of 10	10 (100)	0 (0)	0 (0)	0 (0)
Positive control	5 of 10	0 (0)	0 (0)	0 (0)	10 (100)
Group 1 (SI)[a]	18 of 36	2 (5.5)	7 (19.4)	3 (8.3)	24 (66.6)
Group 2 (XP)[b]	18 of 36	9 (25)	12 (33.3)	11 (30.5)	4 (11.1)
Group 3 (EA)[a]	18 of 36	2 (5.5)	4 (11.1)	10 (27.7)	20 (55.5)
Group 4 (PUI)[b]	18 of 36	16 (44.4)	11 (30.5)	5 (13.8)	4 (11.1)
Group 5 (CB)[a]	18 of 36	0 (0)	1 (2.7)	12 (33.3)	23 (63.8)

CB, CanalBrush; CH, calcium hydroxide; EA, EndoActivator; PUI, passive ultrasonic activation; SI, syringe irrigation; XP, XP-endo Finisher.

Groups that do not share the same superscript letter are significantly different ($P < .05$).

of significance was set at .05, and all statistical analyses were performed by using SPSS 21.0 software (SPSS Inc, Chicago, IL).

Results

Interexaminer agreement was 95.2% as determined by kappa test. Table 1 details the distribution of scores of all groups. The positive control specimens confirmed that no CH paste was removed from the cavities during disassembly and transportation processes. The scores of positive and negative control groups were significantly different from all tested groups ($P < .05$). None of the tested groups were able to remove CH paste from resorption cavities completely. Kruskal-Wallis H test showed that there was statistically significant difference in CH removal scores among the tested groups ($P < .05$). XP and PUI removed significantly more CH than SI, EA, and CB ($P < .05$). There was no statistically significant difference between XP and PUI ($P > .05$). In addition, there was no significant difference among SI, EA, and CB groups ($P > .05$).

Discussion

CH paste is the most commonly used and suggested intracanal medicament in cases of internal resorption for enhancing the disinfection of the resorption cavity (4). Remnants of intracanal medicaments jeopardize the effectiveness of root canal filling by preventing sealer penetration into dentinal tubules (9). For this reason, intracanal medicaments should be removed completely before root canal obturation. The complete removal of CH paste with conventional irrigation methods has been regarded as difficult, and supplementary irrigation activation techniques have been proposed (21). The XP-endo Finisher file was developed to access the irregular areas within the root canal system and is suggested by the manufacturer for intracanal paste removal (17). Therefore, in the present study, supplementary steps by using the XP, EA, PUI, or CB were tested for the removal of CH paste from the resorption cavity. The main finding of the present study was that the XP-endo Finisher file and PUI were superior to the use of EA and CB. The null hypothesis that there was no significant difference among tested groups was rejected.

Many studies have reported the efficacy of PUI in the removal of CH from root canal systems (22, 23). A systematic review found sufficient evidence to state that ultrasonically activated irrigation is more effective than conventional SI (24). Cavitation and microstreaming effects produced during PUI might contribute to the removal of CH from simulated internal resorption cavities by causing the solution to stream from the apical to the coronal direction (14). The crowns were not completely removed, which provided a reservoir for irrigant volume in this study. As a result, PUI removed CH completely in 44.4% of the internal resorption cavities, whereas the use of the XP removed CH completely in 25% of the cavities. No significant difference between PUI and XP was detected. The manufacturer of the XP-endo Finisher claims that this file can effectively clean inaccessible areas of the root canal system because of its transformation to A-phase, which causes the file to expand to adapt to the root canal anatomy (17). Leoni et al (18) supported that claim in their study, in which the use of XP eliminated 89.7% of accumulated hard tissue debris by means of the alloy properties, the small core size, and zero taper. Elnaghy et al (19) also reported the effectiveness of XP in removing debris and the smear layer even in curved root canals. On the other hand, Wigler et al (20) evaluated the efficacy of XP to remove CH from artificial grooves and reported that the claims of reaching irregularities of the root canal anatomy were not fulfilled. The authors reported that both XP and PUI were superior to SI with no significant difference between them, which was similar to our findings. Wigler et al also used 4% NaOCl as the sole irrigation solution, whereas in our study, the combined use of 5.25% NaOCl and 17% EDTA was tested.

Besides the activity of the supplementary systems, the chemical and mechanical properties of irrigation solutions might also play a role in CH removal by either accelerating the physical flushing effect or interacting with the CH particles. Van der Sluis et al (14) reported the superiority of NaOCl over water as an irrigant during PUI, which was explained by the presence of smaller and chlorine-including bubbles that influence acoustic microstreaming. In another study, the combined use of NaOCl and EDTA was reported to be more efficient than the use of NaOCl alone in the removal of CH particles from the root canal system (9). In the present study, the irrigation regime and irrigant volumes were standardized in all groups: 5 mL 5.25% NaOCl, 5 mL 17%

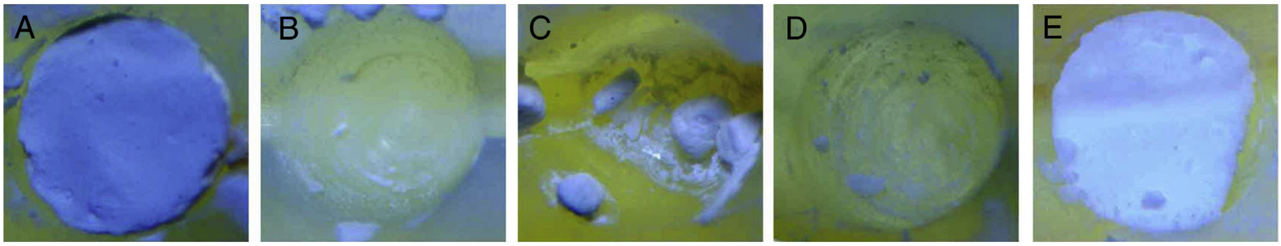

Figure 3. Representative images for the groups: (*A*) SI, (*B*) XP, (*C*) EA, (*D*) PUI, and (*E*) CB.

EDTA, and 5 mL distilled water. Moreover, Wigler et al (20) emphasized that irrigation durations longer than 1 minute, the time suggested by the manufacturer, should be tested. Our study used XP with NaOCl for 1 minute and EDTA for 1 minute. As a result, CH was completely removed from 25% of the cavities, but 11% of the cavities had a score of 3, which means a cavity completely filled with CH was observed. Thus, the supplementary use of XP with a combination of NaOCl and EDTA could improve the removal of CH from simulated internal resorptions.

The present study revealed no significant difference between EA and conventional SI. These results are in line with previous studies of CH removal from resorption cavities or main root canals, which also reported that sonic irrigation was similar to SI (13, 21). The velocity produced by sonic irrigation has been reported to be below the threshold required to create cavitation (25). This ineffectiveness of EA to remove CH might be attributed to its inability to create a cavitation effect.

In the samples from the CB group, none of the resorption cavities were completely cleaned of CH. Even in the samples where CH in the main canal appeared to be cleaned, resorption cavities were packed with CH remnants (Fig. 3). The CB might act as a file creating space by scraping the CH bulk and the packed, scattered CH in the irregularities, because it was ineffective in removing CH from the irregularities of the root canal system. Similar results were reported by previous studies (13). Görduysus et al (26) also reported that the CB packed CH debris into the apical root canal space in most of the samples.

In the present study, simulated internal resorption cavities were prepared by using burs. The advantage of this technique was the standardization of the dimensions of the simulated cavities, which allowed high reproducibility. Standardized resorption cavities prepared with burs have regular borders compared with natural resorptions, which are irregular lesions. Therefore, it might be easier to remove CH from simulated cavities than from natural internal resorption cavities. Also, the possible CH diffused into dentinal tubules was not addressed in this study.

The tested techniques were compared in simulated resorption cavities on straight root canals. Further studies are required to evaluate the efficacy of the XP-endo Finisher file in simulated resorption cavities located in curved root canals.

Conclusion

None of the tested methods could render the resorption cavity free of CH remnants. The XP-endo Finisher and PUI were superior to SI, EA, and CB techniques in removal of CH from simulated internal resorption cavities.

Acknowledgments

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

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