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Original Article

Evaluation of the effectiveness of reciprocal and conventional shaping systems and EDDY and CanalBrush activation systems in calcium hydroxide removal

Neslihan Büşra Keskin[1], Selen İnce Yusufoğlu[1]

[1] Ankara Yıldırım Beyazıt University, Faculty of Dentistry, Department of Endodontics, Ankara, Turkey

Abstract

Aim: To compare the effectiveness of two preparation systems and two irrigation techniques in calcium hydroxide removal from straight root canals.

Methodology: Forty-four mandibular premolar teeth were included in this study. The teeth were filled with a calcium hydroxide-based paste and randomly divided into two different preparation groups (Reciproc 50 (R50; VDW, Munich, Germany) and ProTaper Universal F5 (PTU; Dentsply Maillefer, Ballaigues, Switzerland). Subsequently, the groups were divided into two subgroups and irrigated using EDDY (VDW, Munich, Germany) and CanalBrush (CB; Roeko, Langenau, Germany) irrigation activation systems. The percentage of calcium hydroxide removed from the canal walls was analyzed using a dental operating microscope (DOM) at 25× magnification. An independent samples t-test, a Mann-Whitney U, Wilcoxon's tests were used for statistical analysis.

Results: There was no significant difference in calcium hydroxide removal throughout the root canal using the R50 and PTU F5 preparation systems (P = 0.847). Both activation systems significantly increased the amount of calcium hydroxide removed from the root canal.

Conclusion: EDDY and CB significantly improved calcium hydroxide removal. There was no significant difference between the R50 and PTU F5 systems in calcium hydroxide removal.

Keywords: Calcium hydroxide, CanalBrush, EDDY, Reciproc, root canal dressin

Correspondence:

Dr. Neslihan Büşra KESKİN
Ankara Yıldırım Beyazıt University, Faculty of Dentistry, Department of Endodontics, Ankara, Turkey.
E-mail:ozerolbkeskin@gmail.com

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Introduction

Root canal dressing plays an important role in endodontics. In root canal treatment, it acts as an antiseptic in root canals and eliminates microorganisms and their by-products (1). Calcium hydroxide is commonly used between treatment sessions in teeth with pulpal necrosis due to its biocompatible, antimicrobial, and tissue-dissolving (2,3). In addition, calcium hydroxide plays an important role in inactivating lipopolysaccharides produced by gram-negative bacteria (4,5). Complete removal of calcium hydroxide before root canal filling is important for the success of the treatment (6,7). Previous studies reported that calcium hydroxide residue on root canal walls adversely affected the binding force of dentin and penetration of sealer into dentinal tubules, in addition to increasing marginal leakage (6,8,9).

The standard procedure for calcium hydroxide removal is re-preparing with a master apical file and irrigation with sodium hypochlorite (NaOCl) (10). Removal of calcium hydroxide from root canals with complex anatomies (e.g., flattened areas, irregularities, and isthmuses) is limited by manual irrigation alone (11). Thus, NiTi rotary systems, supplementary files, sonic and ultrasonic systems, and CanalBrush (CB; Roeko, Langenau, Germany) systems have been developed to remove calcium hydroxide from root canals. However, no protocol is able to completely remove calcium hydroxide from root canals, and new techniques are under investigation (12,13).

EDDY (VDW, Munich, Germany), which is claimed to be effective in removing calcium hydroxide (13,14), is a sonic activation system used at 6,000 Hz. Previous research concluded that the level of organic tissue dissolution in root canals achieved using EDDY was similar to that of passive ultrasonic activation (PUI) (15) and that EDDY was effective in root canal cleaning (16) and removal of root canal filling material (17).

No studies in the literature have compared the use of reciprocal and conventional movements using different irrigation activation systems in calcium hydroxide removal from root canals. The aim of this study was to compare the removal of calcium hydroxide used as a medication during root canal treatment sessions using NiTi canal files working with reciprocal (Reciproc 50 (R50; VDW, Munich, Germany)) and conventional motion (ProTaper Universal F5 (PTU; Dentsply Maillefer, Ballaigues, Switzerland)) and to evaluate the effectiveness of calcium hydroxide removal from root canals using two activation systems (EDDY and CB), as assessed by a dental operating microscope (DOM; Leica, M3, Germany). The first null hypothesis of our study was that there would be no difference between the calcium hydroxide removal efficacy of R50 and PTU F5 files. The second null hypothesis was that use of the EDDY and CB activation systems would not increase the effectiveness of removing remaining calcium hydroxide.

Materials and Methods

Selection and preparation of samples

Forty-four single-rooted mandibular premolar teeth were included in the study. Debris and soft tissue residues on the root surfaces were removed with the aid of periodontal curettes (Golgran-Millennium, Sao Paulo, SP, Brazil). The teeth were kept in 0.9% saline solution until use. The crowns of the teeth were removed under water cooling, and their root lengths were standardized to be 15 ± 1 mm. Teeth with an apical foramen, which was not wider than stainless steel K-files (size 15) (Dentsply Sirona, Ballaigues, Switzerland) were used in this study. The working lengths were determined to be 1 mm shorter than the apical foramen. The samples were prepared using PTU (Dentsply Maillefer, Ballaigues, Switzerland) files until an F4 40.06 apical width was obtained. An endodontic motor (VDW; Munich, Germany) was used according to the manufacturer's instructions (torque setting: 4–5.2 Ncm, speed setting: 300 RPM). After each file change, the root canals were irrigated with 3 ml of 2.5% NaOCl (CanalPro; Coltene-Whaledent, Allstetten, Switzerland). At the last irrigation stage, all the samples were washed for 1 min with 5 ml of 17% EDTA (CanalPro; Coltene-Whaledent, Allstetten, Switzerland) solution. The irrigation protocol was completed by irrigating the root canals with 3 ml of distilled water. Briefly, each sample was fixed in silicone, placed in an Eppendorf tube, and then split longitudinally in a bucco-lingual direction using a diamond disk. The two separated samples were combined by applying a small amount of cyanoacrylate gel adhesive (Loctite Super Glue Gel; Loctite, Munich, Germany) using a microbrush (FGM, Joinville, SC, Brazil) and placed in microcentrifuge tubes. Calcium hydroxide was not placed in two teeth as a negative control group.

First, 0.65 g of calcium hydroxide powder was mixed with 0.5 ml of glycerol (two glycerin, three serum physiological ratio) in a 2:1 ratio. The paste was then placed in each of the 42 root canals using a Lentulo 40 (Dentsply) 1 mm shorter than the working length. Two untreated samples (no paste applied) serve as a positive control. The teeth were closed temporarily (Cavit G; 3M Espe, Seefeld, Germany) using a filling material. The samples were then stored at 37° C and 100% humidity environment for 2 wk.

Root canal preparation and group allocation

To remove calcium hydroxide, the teeth were irrigated with 1 ml of 5.25% NaOCl, and the coronal part was softened using a file No.25. The teeth were then randomly divided into two groups (n = 10 in each group) (F5 and R50) and prepared as described below:

PTU F5 group: The canals were prepared using the PTU F5 (Dentsply) instrument until the working length was reached.

R50 group: The canals were prepared using the R50 (VDW) instrument in accordance with the manufacturer's instructions. The samples were dried with paper points (Diadent; Diadent Group International, Burbany, BC, Canada) through the working length. The samples were then divided into two in the bucco-lingual direction. Both halves of the roots were viewed at 25× magnification under a DOM (Leica), and photographic recordings were taken. The samples were then numbered, and the groups were divided into two subgroups according to the irrigation activation system applied. The following four groups were created: PTU F5 + CB, PTU F5 + EDDY, R50 + CB, and R50 + EDDY.

In all the groups, a total of 15 ml of solution was used (10 ml of 2.5% NaOCl and 5 ml of final irrigation with saline).

Activation systems

EDDY

A 28-mm-long polyamide-tipped tip with a 25.04 taper was adapted to TA-200 (Micron, Tokyo, Japan) and used at 6,000 Hz, the maximum speed setting. It was placed in the canal 2 mm shorter than the working length. Then, 6 ml of 2.5% NaOCl was delivered to the canal in 20 cycles of irrigation at a 2 ml/min flow rate, with three cycles of no irrigation for 20 sec each time.

CB

The CB (Roeko) irrigation system with a 25.04 taper was attached to an endodontic motor and used at 600 rpm with torque of 2.00 n-cm. At the end of the first and second (activation for 20 sec) phases, it was used as three cycles in the working length to touch the canal walls.

DOM analysis of calcium hydroxide removal

After all the samples were dried with paper points at the working length, the notch was opened with a diamond separator in the bucco-lingual direction, and each sample was then divided into two halves. Both halves of the roots were then viewed at 25× magnification under a DOM, and photo recordings were taken.

The canal lumen area and area of calcium hydroxide removal were calculated in millimeter squared using ImageJ (Wayne Rasband, National Institute of Health, Bethesda, MD, USA) software. The percentage of calcium hydroxide removal was calculated using the following formula: [(The mean area of calcium hydroxide before removal- the mean area of calcium hydroxide after removal). 100/the mean area of calcium hydroxide before removal] (18).

Eight pieces of roots (two pieces from each group) were examined under a scanning electron microscope (SEM; Quanta 400 F Field Emission) (Fig 1) to detect remaining calcium hydroxide, and photomicrographs of the canal surfaces were taken. The samples were coated and examined under 2000x magnification.

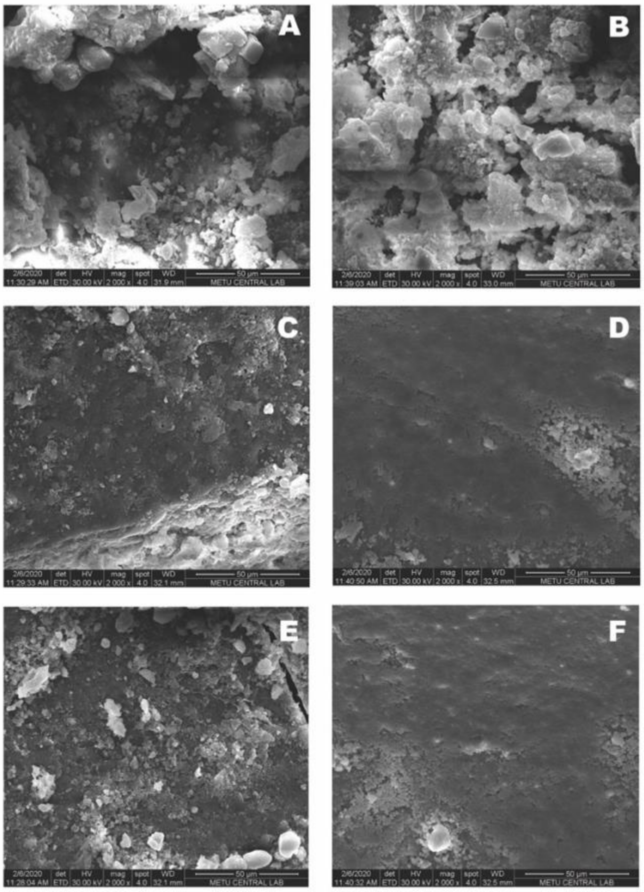
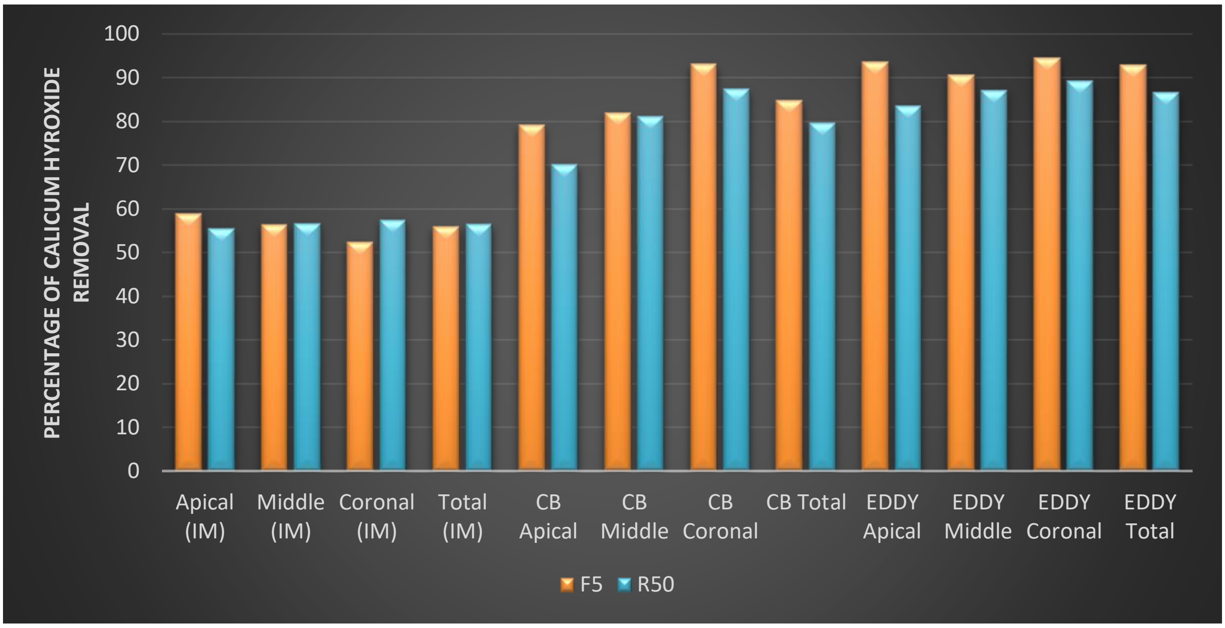


Fig 1. Scanning electron micrographs of detect remaining calcium hydroxide: A- PTU F5 (2000 X Magnification); B- R50 (2000 X Magnification); C- PTU F5-CB (2000 X Magnification); D- PTU F5-EDDY (2000 X Magnification); E- R50- CB (2000 X Magnification); F- R50- EDDY (2000 X Magnification).



Graphic 1. Scanning electron micrographs of detect remaining calcium hydroxide: A- PTU F5 (2000 X Magnification); B- R50 (2000 X Magnification); C- PTU F5-CB (2000 X Magnification); D- PTU F5-EDDY (2000 X Magnification); E- R50- CB (2000 X Magnification); F- R50- EDDY (2000 X Magnification).

Statistical analysis

The data were analyzed using the Statistical Package for Social Sciences, version 22.0 program (IBM SPSS Inc., Armonk, NY, USA). The compatibility of the data with a normal distribution was examined using the Shapiro-Wilk test. An independent samples t-test and a Mann-Whitney U test were used according to the normality distribution in the evaluation of independent data between groups. In the evaluation of the dependent variables, Wilcoxon's test and a repeated measures variance analysis were used according to the normality distribution. The results are presented as the mean ± standard deviation. A significance level of 0,001 and 0.05 were used for all statistical tests.

Results

The means and standard deviations of the percentage of calcium hydroxide removal (% ± SD) in the experimental groups using the different preparation systems are presented in Table 1.

There was no statistically significant difference in the apical, middle, and coronal thirds using the PTU F5 and R50 files in terms of calcium hydroxide removal from the root canals ($P > 0.05$).

The two activation systems significantly increased the amount of calcium hydroxide removed, with 79.5% removed in the R50 + CB group ($P < 0.001$), 86.6% removed in the R50 + EDDY group ($P < 0.001$), 84.7% removed in the PTU F5 + CB group ($P < 0.001$), and 92.9% removed in the PTU F5 + EDDY group ($P < 0.001$).

The means ± standard deviation and percentage of calcium hydroxide remaining in the canal thirds in the various groups after cleaning using the two activation systems are shown in Table 2.

Table 1. The means and standard deviations of the percentage of calcium hydroxide removal (% ± SD) in the experimental groups using the different preparation systems

	F5	R50	p*
Apical (IM)	58,9±11,8	55,4±8,0	,286*
Middle (IM)	56,4±11,1	56,6±18,6	,959*
Coronal (IM)	52,4±9,3	57,5±15,5	,218*
Total (IM)	**55,9±8,1**	**56,5±12,1**	**,847***
CB Apical	79,1±16,9	70,1±12,5	,193*

CB Middle	81,9±18,0	81,1±18,0	,579
CB Coronal	93,1±9,2	87,4±8,6	, 052
CB Total	**84,7±13,6**	**79,5±8,0**	**,314***
EDDY Apical	93,6±9,2	83,6±6,8	,013*
EDDY Middle	90,6±9,8	87,0±15,4	,529
EDDY Coronal	94,6±6,7	89,2±7,5	,043
EDDY Total	**92,9±6,0**	**86,6±9,0**	**,105**

* Independent samples t test

Table 2. The mean volume and standard deviation (mm2) of the initial reduction percentage of calcium hydroxide material (IM), reduction percentage of calcium hydroxide after applying the additional irrigation activation system (EDDY and CB) according to the groups studied in all canal thirds.

	F5 (n=10)				R50 (n=10)		
	IM	CB	p		IM	CB	p
Apical	60,5±15,3	79,1±16,9	<,001	Apical	54,7±8,2	70,1±12,5	<,001
Middle	56,0±14,0	81,9±18,0	<,001	Middle	56,4±12,7	81,1±18,0	,005
Coronal	50,8±12,0	93,1±9,2	<,001	Coronal	56,6±10,2	87,4±8,5	<,001
Total	**55,8±10,8**	**84,7±13,6**	**<,001**	**Total**	**55,9±6,0**	**79,5±8,0**	**<,001**
	F5 (n=10)				R50 (n=10)		
	IM	EDDY	p		IM	EDDY	p
Apical	57,3±7,2	93,6±9,2	<,001	Apical	56,2±8,3	83,6±6,8	<,001
Middle	56,8±7,8	90,6±9,8	<,001	Middle	56,9±23,9	87,0±15,3	,005
Coronal	54,1±5,8	94,6±6,7	<,001	Coronal	58,5±20,1	89,2±7,5	<,001
Total	**56,1±4,7**	**92,9±6,0**	**<,001**	**Total**	**57,2±16,6**	**86,6±9,0**	**<,001**
	F5 (n=10)				R50 (n=10)		
	CB	EDDY	p		CB	EDDY	p
Apical	79,1±16,9	93,6±9,2	,063	Apical	70,1±12,5	83,6±6,8	,008
Middle	81,9±18,0	90,6±9,8	,247	Middle	81,1±18,0	87,0±15,3	,971
Coronal	93,1±9,2	94,6±6,7	,481	Coronal	87,4±8,5	89,2±7,5	,622
Total	**84,7±13,6**	**92,9±6,0**	**,123**	**Total**	**79,5±8,0**	**86,6±9,0**	**,015**

Discussion

The aim of our study is to compare the calcium hydroxide removal using NiTi root canal files that work with reciprocal and conventional motion and to evaluate the effectiveness of two activation systems (EDDY and CB) in calcium hydroxide removal from root canals. In previous studies, the amount of calcium hydroxide remaining in root canals was calculated by scoring the area of residue on the canal walls in millimeter squared (19) and then assessing the amount of calcium hydroxide remaining using a scanning electron microscope, microscope (20), or micro-CT (mm^3)(21). Kenee et al. calculated the total area and residual area of calcium hydroxide remaining on root canal walls in mm^2, and the results were evaluated with the percentage of decrease (10).

In our study, root canal preparation was completed using 40.04, after which root canal files with a 50.05 taper were used due to the necessity of free ends of the tip of the activation systems to provide efficacy to irrigants to remove calcium hydroxide. To provide standardization, the amount of irrigation solution and taper and the application times of the activation systems were kept equal.

NaOCl is used as an irrigant to prevent chemical dissolution of calcium hydroxide and to make no mass difference between the activation techniques of this dissolution (13). In our study, calcium hydroxide was not completely removed in any group. Both file systems (reciprocal and conventional) removed calcium hydroxide from the root canal system, and there was no statistically significant difference between the two systems in terms of removing calcium hydroxide from the apical, middle, and coronal thirds of the root canal. Our results support those of previous studies (21–23). Thus, the primary hypothesis of our study was accepted.

Zorzin et al. (24) concluded that PUI was superior to using a CB in terms of calcium hydroxide removal. Görduysus et al. (25) reported that a CB and Manuel irrigation were similar in the coronal and middle thirds of the root canal and superior to Manuel irrigation in the apical region. In a study in which a CB and PUI were used, together with NaOCl, the authors reported that NaOCl extracted more calcium hydroxide than alone, but there was no difference between two systems (26).

In a previous study (27), increasing the flow rate of irrigation agents in root canal systems with complex anatomies via sonic activation facilitated the removal of medicaments and increased the effectiveness of the irrigants (27). Other research concluded that EDDY was superior to other sonic systems due to its cavitation effect (15,16). In our study, in both the R50 and PTU F5 groups, the amount of calcium hydroxide removed by the EDDY (VDW) and CB (Roeko) activation systems was statistically significant. For this reason, the secondary hypothesis of our study was rejected. In both the R50 and PTU F5 groups, the EDDY activation system removed more calcium hydroxide than the CB activation system. The superiority of the EDDY system may be attributed to its mode of action (sonic activation at 6,000 Hz). In contrast, the CB system operates at 600 rpm.

The present study has some limitations, including dividing the roots into two halves. To minimize the removal of calcium hydroxide during separation of the samples, the samples were split into two halves after the first preparation. In this study, only the amount of calcium hydroxide remaining on the superficial parts of the root canals was visualized and recorded using a DOM at 25× magnification. However, Calcium hydroxide residue visible in dentinal tubules was not recorded. To support the findings of our study, comprehensive studies using more advanced imaging techniques and different root canal anatomies are needed to determine the calcium hydroxide removal effectiveness of different activation systems.

Conclusions

Within the limitations of our study, there was no difference in calcium hydroxide removal using reciprocal and conventional file systems. The use of the EDDY and CB activation systems significantly reduced the amount of calcium hydroxide residue on canal walls. No kinematic movement and activation system was able to completely remove calcium hydroxide.

Ethical Approval: Ethics committee approval was received for this study from Ankara Yıldırım Beyazıt University University, Ethics Committee in accordance the World Medical Association Declaration of Helsinki, with the approval number: 2019/458.

Peer-review: Externally peer-reviewed.

Author Contributions: Conception – N.B.K.; Design – S.İ.Y., N.B.K.; Supervision – S.İ.Y.; Materials – S.İ.Y., N.B.K.; Data Collection and/or Processing – S.İ.Y., N.B.K.; Analysis and/or Interpretation – S.İ.Y.; Literature Review – S.İ.Y., N.B.K.; Writer – S.İ.Y.; N.B.K.; Critical Review –N.B.K.

Conflict of Interest: No conflict of interest was declared by the authors.

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