Original Research

Efficacy of Different Irrigation Systems Used to Remove Calcium Hydroxide from the Root Canal

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Abstract

Introduction: The present study aimed to compare the cleaning efficacy of passive ultrasonic irrigation (PUI), self-adjusting file (SAF), EndoVac, and conventional syringe irrigation (CSI) techniques on $Ca(OH)_2$ removal from the root canal. **Methods:** This study was conducted on the mesial roots of 36 human mandibular molar teeth. After 1 month, the $Ca(OH)_2$ was removed from the experimental groups using four different irrigation techniques (SAF, PUI, EndoVac, and CSI). The inner surfaces of the canals were examined using a stereomicroscope at 30x magnification. The assessment of remaining $Ca(OH)_2$ medicament in the grooves was performed by three calibrated dentists using a scoring system ranged 0-3. **Results:** None of the groups showed complete $Ca(OH)_2$ removal from the root canals. The PUI technique removed significantly more $Ca(OH)_2$ from all root canals, compared to EndoVac and CSI techniques ($P<0.05$). In the apical third, SAF group results were significantly better than the CSI group results ($P<0.05$). In the middle third, the SAF technique led to significantly better results in the removal of $Ca(OH)_2$, compared to the techniques used in other groups ($P<0.05$).**Conclusion:** Currently, there is no irrigation system that can completely remove $Ca(OH)_2$ from the root canal in endodontics. Regarding the removal of $Ca(OH)_2$ from root canals, the PUI technique was significantly better than EndoVac and CSI techniques. In addition, the SAF technique showed significant efficacy in the middle third of the root canals.

Keywords: Passive ultrasonic irrigation, self-adjusting file, EndoVac, conventional syringe irrigation.

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Introduction

Calcium hydroxide [$Ca(OH)_2$] is the root canal medicament commonly used in endodontic procedures, and exhibits good antimicrobial activity against most pathogens found in the root canals. In addition, this drug is biocompatible, inhibits osteoclastic activity, and induces organic tissue solvency and hard tissue formation (1, 2).

The $Ca(OH)_2$ residues in the dentin walls may affect the dentin tubule penetration of the root canal sealers used while filling the canals and increases apical leakage (3). Therefore, $Ca(OH)_2$ should be completely removed from the root canals before filling the root canal. However, this issue can be very problematic due to $Ca(OH)_2$ attachment to the apical region of the tooth (4). Abundant irrigation with master apical file (MAF) instrumentation is the most commonly described method used to remove $Ca(OH)_2$ from the root canals (5, 6); however, canal irregularities and resorption cavities may not be accessible when using these conventional irrigation procedures. Therefore, different irrigation activation techniques have been suggested to increase the effectiveness of irrigation solutions (7). Although various irrigation methods have been proposed for the removal of $Ca(OH)_2$ from the root canals, there is still no consensus on the best-employed technique (8).

Passive ultrasonic irrigation (PUI) was first described by Weller et al. in 1980 (9). The term passive is actually used to describe ultrasonically-activated files that do not cut (10). The PUI process is based on oscillating motion and the transmission of acoustic energy to the irrigation solution in the root canals. This energy transmission causes the formation of pressurized steam with an acoustic current created in the solution by ultrasonic waves (11-13). The PUI technique is performed after the root canal is prepared for the MAF and during irrigation without instrumentation in the root canal wall (14).

A self-adjusting file (SAF), when placed in the root canal, adapts itself to both longitudinal and transverse sections of the root canal. The lattice design of the wire surface contains an abrasive removing the dentin with a back-and-forth sanding motion. Since the SAF system provides continuous irrigation during instrumentation, it deposits fresh solution into the root canal. Moreover, the efficiency of the irrigation increases due to the vibration of the file. Therefore, both debris and uniform dentin removal are facilitated in this regard (16). In a study conducted previously, it was reported that a SAF removes more regular dentin along the root canal area, compared to rotational and reciprocating motion files (17).

The EndoVac is a negative pressure irrigation device developed to remove debris from the apical region while preventing the irrigation solution from overflowing from the apex. This system consists of macrocannula and microcannulae that circulate the irrigation solution through the root canal system due to the pressure differences caused by the vacuum effects. As reported in the literature, although there was no significant difference in the debris removal 3 mm shorter than the working length, debris removal 1 mm shorter than the working length led to significant results, compared to conventional irrigation (15).

With this background in mind, there is a dearth of research on the use of SAFs for removing $Ca(OH)_2$ from root canals. Therefore, the aim of this study was to evaluate the efficacies of the SAF, PUI, EndoVac, and conventional syringe irrigation (CSI) techniques when they were used to remove $Ca(OH)_2$ from root canals. That implementation of different techniques led to no significant differences in $Ca(OH)_2$ removal..

Materials and Methods

To conduct the present study, the Local Ethics Committee of the Dicle University, Faculty of Dentistry (Diyarbakir, Turkey) evaluated the study on the first meeting dated 30.01.2019, and it was approved with protocol number of 2019/2.

The samples in this study was composed of 36 first and second mandibular molar mesial roots radiographed and stored in distilled water. For standardization, decoronization was performed under water cooling conditions using a diamond disk that was kept 12 mm from the apex in all the groups. The external root surfaces were sealed with nail polish to prevent irrigant extrusion through the apical foramen. The working length was determined by subtracting 1 mm from the length at which the tip of a size 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) extruded apically. Reciproc R25 rotary instruments (VDW GmbH, Munich, Germany) were used for root canal shaping procedures. The root canals were irrigated with 2 ml of a 1% NaOCl solution, and the final irrigation was performed using 5 ml of 5.25% NaOCl and 5 ml of 17% EDTA. After drying the canals with paper points, all canals were treated with an aqueous radiopaque $Ca(OH)_2$ paste (UltraCal XS; Ultradent Products, Inc., South Jordan, UT, USA). A size #25 Lentulo spiral (Dentsply Maillefer USA, Tulsa, OK, USA) on a contra-angle 1:1 handpiece was used to introduce the $Ca(OH)_2$ in all the investigatted groups. Access to the root canals was temporarily sealed with a cotton pellet and Cavit (3M Espe, Seefeld, Germany), and the specimens were kept at 37 °C with 100% humidity for 1 month. Subsequently, the teeth were randomly coded and blindly divided into 4 experimental groups (n= 9 for each group). In the next step, the coronal access was opened and the teeth were irrigated as follows:

Group I (PUI)

First, 5 ml of 2.5% NaOCl and 5 ml of 17% EDTA were agitated using a size 15 K-file coupled to the file-holding adapter of an ultrasonic system handpiece (NSK, Tokyo, Japan). The ultrasonic file was placed into the canal 1 mm shorter than the working length, without touching the walls, which allowed free vibration. The ultrasonic file was activated at power setting of 6 for 1 min, and the irrigants were continuously delivered at a rate of 10 ml/min through the unit. After the final irrigation, 5 ml of distilled water was used.

Group II (SAF)

The SAF (ReDent Nova Ltd., Ra'anana, Israel) was operated using a vibrating handpiece at an amplitude of 0.4 mm at 5,000 vibrations per min. It was attached to a special irrigation device that provided a continuous irrigation solution flow at a rate of 10 ml/min. The SAF was used with 5 ml of 17% EDTA for 2 min, followed by 5 ml of 2.5% NaOCl for 2 min, and 5 ml of distilled water.

Group III (EndoVac)

The canals were first irrigated for 30 sec with 5 ml of 17% EDTA using the EndoVac macrocannulae (Discus Dental Inc., Culver City, CA, USA). In the next step, the microcannulae were inserted to the full working length, and the canals were irrigated with 5 ml of 2.5% NaOCl and 5 ml of distilled water for 30 sec.

Group IV (CSI)

A 27 G irrigation syringe (Ayset, Adana, Turkey) was inserted apically as deep as possible without binding, and the canal was irrigated with 5 ml of 17% EDTA, 5 ml of 2.5% NaOCl, and 5 ml of distilled water. After the instrumentation steps, grooves were made along the buccal and lingual surfaces of each tooth using a diamond disc. Subsequently, each tooth was split into two halves along its long axis in the buccolingual direction, and the separation was performed without any penetration into the canal. The 9 roots in each group were sectioned into 2 halves, and therefore 18 samples were obtained from each group (n=18).

For the positive and negative controls, $Ca(OH)_2$ was not removed from 2 roots (positive controls), and 2 roots were not filled with $Ca(OH)_2$ (negative controls). Next, photographs were taken using a stereomicroscope (SZ40; Olympus Corporation, Tokyo, Japan) at 30x magnification, and were transferred to a computer. The selected images included the coronal (12 mm from the apex), middle (8 mm from the apex), and apical (4 mm from the apex) thirds of the root canal surfaces. Three calibrating endodontists who were blinded to the technique were employed to remove the $Ca(OH)_2$, and score the amount of remaining $Ca(OH)_2$ in the canal using the scoring system described by Van Der Sluis et al. (14; Fig. 1) as follows:

Score 0: The canal was empty;

Score 1: $Ca(OH)_2$ was present in less than half of the canal;

Score 2: $Ca(OH)_2$ covered more than half of the canal;

Score 3: The canal was completely filled with $Ca(OH)_2$.

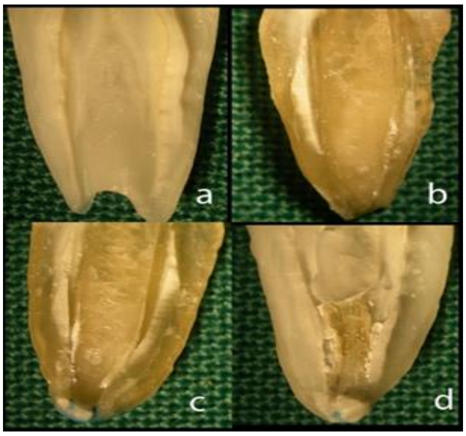

Figure 1. Images of scores (a- Score 0, b- Score 1, c- Score 2, d- Score 3).

Results

The obtained data were analyzed using IBM SPSS Statistics software for Windows (version 21.0; IBM Corp., Armonk, NY, USA) through the Kruskal-Wallis and Mann-Whitney U tests. P-value less than 0.05 was considered statistically significant. The results were presented with 95% confidence intervals.

The obtained results of kappa test showed that the interexaminer agreement was 96.5% for the $Ca(OH)_2$ medicament removal (k>0.94). Table I presents the mean scores and medians for the $Ca(OH)_2$ medicament removal. The positive control group results revealed that the canal walls were completely filled with $Ca(OH)_2$ while the negative control group results indicated no $Ca(OH)_2$ on the canal walls. None of the groups showed complete $Ca(OH)_2$ removal from the root canals (Table I). The PUI technique could significantly remove more $Ca(OH)_2$ medicament than the EndoVac and CSI techniques in all root canals (P<0.05). There were no significant difference between the SAF and PUI groups (P>0.05) or between the EndoVac and CSI groups (P<0.05) regarding $Ca(OH)_2$ removal from all the investigated root canals. In the apical third, SAF group results were significantly better than the CSI group results (P<0.05). In the middle third, the SAF technique led to significantly better results in removing the $Ca(OH)_2$, compared to other employed techniques (P<0.05). In the coronal third, the PUI technique was significantly better at removing the $Ca(OH)_2$ than the EndoVac and CSI techniques (P<0.05). There was no significant difference between the PUI and SAF groups regarding $Ca(OH)_2$ removal from the coronal third (P<0.05).

Table I. Distribution of scores for the removal of Ca $(OH)_2$ (n = 18) (p<.05)

	Scores					
	Score 0	**Score 1**	**Score 2**	**Score 3**	**Mean**	**Median**
Group 1 (PUI)						
Apical	7	6	2	3	2,0556	2
Middle	2	14	2	-	2	2
Coronal	14	4	-	-	1,2222	1
Group 2 (SAF)						
Apical	4	12	2	-	1,8889	2
Middle	16	2	-	-	1,1111	1
Coronal	8	8	2	-	1,6667	2
Group 3 (EndoVac)						
Apical	1	10	4	3	2,5	2
Middle	4	10	2	2	2,1111	2
Coronal	2	12	4	-	2,1111	2
Group 4 (CSI)						
Apical	2	8	2	6	2,6667	2
Middle	3	10	1	4	2,3333	2
Coronal	3	10	1	4	2,3333	2

PUI: passive ultrasonic irrigation

SAF: self-adjusting file

CSI: conventional syringe irrigation

Discussion

The thickness of the root canal sealer can affect the leakage of the root canal filling (18). $Ca(OH)_2$ residues can react chemically with canal sealers reducing the sealer fluidity and working time (19). As a result, different irrigation solutions, different irrigation activation techniques, and combined usages have been evaluated for $Ca(OH)_2$ removal in several studies by different researchers (5, 6, 20-22). The amount of $Ca(OH)_2$ residue in such studies was measured using direct imaging, digital microscopy, and scanning electron microscopy (SEM) (23). In the current study, the samples were photographed and visualized directly. In addition, the present study benefited from a scoring system described in previous studies, and the remaining $Ca(OH)_2$ amount was scored by three researchers independently (14, 24, 25).

Although the CSI technique is preferred by clinicians, it is ineffective for the removal of the smear layer and the debris in the apical third of the root canals (15, 22, 26, 27). In this regard, many irrigation activation methods, such as sonic, ultrasonic, and laser techniques, have been developed to achieve more successful hermetic root canal filling and to increase the effectiveness of the irrigation.

The PUI effectiveness depends on the duration of the application as well as the delivery of the fresh irrigant to the root canal (14). In the present study, the PUI was performed using 10 ml of fresh NaOCl solution for 1 min per root canal in the PUI group. In the PUI group, the amount of $Ca(OH)_2$ remaining in the coronal third was small, compared to the apical and middle thirds. The PUI group results were statistically superior to those obtained from CSI and EndoVac groups in the coronal region. In addition, the obtained results of PUI and SAF groups indicated successful results in the coronal third; however, there was no significant difference between the two groups. Yucel et al. (28) used EndoVac, ProUltra Piezoflow Ultrasonic, and CSI systems to remove the $Ca(OH)_2$. Although the employed systems (i.e., EndoVac and ProUltra Piezoflow Ultrasonic) revealed no significant difference, it was reported that the CSI technique left more $Ca(OH)_2$ in the root canals.

In addition, the comparison of the investigated groups in terms of the canal regions showed that the remaining $Ca(OH)_2$ was at its least and most amount in the coronal third and apical third, respectively. In the present study, the evaluation of results in terms of the canal regions were in line with those reported in the literature.

The success of the SAF technique in removing the debris and smear layer in the apical third depends on the vibratory action of the grating in the continuously refreshing irrigant, as well as the friction effect on the dentin (29). In the SEM study conducted by Faria et al.(30), the researchers reported that there were no statistically significant difference between the SAF and ProTaper systems in terms of $Ca(OH)_2$ removal from the apical third and middle third of the canals . However, the obtained results of the present study indicated the superiority of SAF technique in the middle third of the root canal, compared to other techniques. In their SEM study, Alturaiki et al.(31) investigated the efficacies of the CSI, EndoActivator, ProUltra Piezoflow Ultrasonic, and EndoVac techniques for $Ca(OH)_2$ removal. The EndoActivator group was found to be significantly more successful in the coronal, middle, and apical thirds than the other systems. In the EndoVac group, there were no significant difference in the coronal and middle thirds, compared to the CSI group; however, the obtained results of the apical third were statistically significant. Nonetheless, the comparison of EndoVac and CSI groups in the present study indicated no significant difference in the coronal, middle, and apical thirds of the root canals. The reasons for these different results may be attributed to anatomical differences due to the use of the mesial roots of the mandibular first molars.

Arslan et al. (27) applied $Ca(OH)_2$ to teeth in which they formed artificial grooves in the apical region, and they tried to remove the $Ca(OH)_2$ using photon-initiated photoacoustic streaming (PIPS), Ultrasonic, EndoActivator, and CSI techniques. The results showed that the PIPS technique was significantly better, compared to the other three methods. The ultrasonic irrigation technique was also superior to the EndoActivator and CSI techniques. In the current study, there were no significant differences between the groups in the apical third; however, the SAF group showed significantly better results than the CSI group.

Topçuoğlu et al. (24) showed that the SAF and PUI techniques were superior to the CSI, CanalBrush, EndoActivator, and EndoVac techniques for the removal of $Ca(OH)_2$ from artificial internal resorption cavities; however, there was no statistically significant difference between the SAF and PUI techniques . Kfir et al. (32) compared the SAF, PUI, XP-endo finisher, and CSI techniques for the removal of $Ca(OH)_2$ in teeth with oval canals for which they formed grooves in the apical third. They stated that SAF, PUI, and XP-endo finisher techniques did not significantly differ and the $Ca(OH)_2$ removal amount was the least in the CSI group . Çapar et al. (25) applied $Ca(OH)_2$ to mandibular premolar teeth by forming a lateral groove. They found that in the NaOCl and EDTA groups, the SAF and PUI systems were successful for $Ca(OH)_2$ removal with no statistically significant difference among them. Moreover, there was no statistical difference between the EndoVac and CSI groups. Likewise, the findings of the present study indicated no significant difference between the SAF and PUI groups or between the EndoVac and CSI groups.

Some studies have shown that the PUI technique provides better results, compared to other irrigation activation methods; however, it has been reported that the $Ca(OH)_2$ could not be completely removed from the root canals (14, 33). Although the employed methodology in the present study was different from those in the literature, the obtained results of the current study indicated that PUI technique was more successful for removing $Ca(OH)_2$ from the root canals than the EndoVac and CSI techniques. Furthermore, no irrigation activation group completely removed the $Ca(OH)_2$ from the root canals under our experimental conditions.

Conclusion

Within the limitations of this study, we showed that the PUI and SAF techniques were effective for removing $Ca(OH)_2$ from the root canal. However, in all the root canal, the obtained results of the present study demonstrated that none of the methods removed the $Ca(OH)_2$ completely from the root canals. The PUI technique was significantly better for removing the $Ca(OH)_2$ from root canals, compared to the EndoVac and CSI techniques. In addition, the SAF technique showed significant efficacy in the middle third of the root canals.

Conflicts of interest

The author declares no potential conflicts of interest.

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