RESEARCH ARTICLE

Effectiveness of the Severel Irrigation Techniques for Removal of Calcium Hydroxide-based Intracanal Medication from an Artificial Standardized Groove in the Apical Root Canal

Fuat Ahmetoglu, Ali Keles, Neslihan Simsek

Abstract

Background/aim: This study was aimed to evaluate the efficacy of removal of calcium hydroxide [$Ca(OH)_2$] with the apical negative pressure irrigation system (EndoVac), passive ultrasonic irrigation (PUI), and needle irrigation using sodium hypochlorite (NaOCl).

Materials and methods: The root canals of 30 freshly extracted human mandibular premolars were used in this study. Each root canal was prepared with nickel titanium rotary instruments. Each root was split longitudinally through the canal. In one-half, a standardized groove was cut in the canal wall 2–6 mm from the apex, and filled with $Ca(OH)_2$ paste. The roots were reassembled with plastic bracelets. Three techniques were used for $Ca(OH)_2$ removal: Group 1, irrigation using the EndoVac irrigation system; Group 2, PUI; Group 3, needle irrigation; all used a total of 10 mL of 5% NaOCl as the irrigant. The amount of residual $Ca(OH)_2$ in the groove was scored in accordance with previously reported criteria. The data were analyzed with the Kruskal–Wallis and Mann–Whitney U tests. The level of significance was set at $p< 0.05$.

Results: No technique removed all $Ca(OH)_2$. There were no significant differences between Groups 1 and 2, and Groups 1 and 3 ($p< 0.05$). There was significant difference between Groups 2 and 3 ($p> 0.05$).

Conclusions: PUI was more effective in removing $Ca(OH)_2$ paste from artificial root canal grooves, but the efficacy of PUI did not differ significantly from that of the EndoVac irrigation system.

Keywords: Calcium hydroxide, EndoVac system, needle irrigation, passive ultrasonic irrigation, scanning electron microscopy

Department of Endodontics, Faculty of Dentistry, Inonu University, Malatya, Turkey.

Correspondence:
Fuat Ahmetoglu
Address: Inonu University, Faculty of Dentistry, Departments of Endodontics, 44280, Malatya, Turkey.
Tel : +90 422 341 11 06
Fax : +90 422 341 11 07
E-mail : fuat.ahmetoglu@inonu.edu.tr

Introduction

The presence of microorganisms in the root canal plays a major role in the development of periapical diseases (1,2). The primary aim of endodontic treatment is to remove as many bacteria as possible from the root canal system and then to create an environment in which any remaining organisms cannot survive (3). To achieve this, thorough instrumentation and irrigation should be supported by intracanal medication (3,4). Calcium hydroxide [$Ca(OH)_2$] is used frequently as an endodontic intracanal medication because of its biological properties, antimicrobial activity, and capacity to inactivate bacterial endotoxins (5-7).

Intracanal medication can be used for disinfection, provided that any residues are removed before the root canal is filled. Residues of $Ca(OH)_2$ that remain on the root canal walls react chemically with the root canal sealer, which reduces flow and working time in sealers (8) and negatively affects treatment prognosis. In addition, medication residues hinder the penetration of root canal sealers into the dentinal tubules (9) and adhesion of the filling material to the root canal walls (10), which may compromise long-term endodontic sealing (11). Ideally, Ca(OH)2 material should be removed completely from the root canal before permanent root canal filling (9,12).

Several studies have examined techniques for the removal of $Ca(OH)_2$ from the root canal; these include hand filing, rotary instrumentation, passive ultrasonic irrigation (PUI) and CanalBrush (13-16). However, it is difficult to remove Ca(OH)2 residues from root canal walls because the structure of the canal is irregular (17). These irregularities are more problematic for certain techniques. When medication is removed from the root canal with a file, residues can remain in canal extensions or irregularities (18) and these residues can only be removed by irrigation (16).

Many researchers have found that PUI is an effective method for removing residual medication from the root canal (13-15,19,20). PUI is based on the transmission of acoustic energy from an oscillating instrument to an irrigant in the root canal (20). After the root canal has been shaped to the master apical file (MAF), an irrigation file is placed in the center of the root canal, as far as the apical region. Then, the irrigation file is stimulated to oscillate ultrasonically and activate the irrigant (21). The EndoVac System (Discus Dental, Culver City, CA, USA) is one of the apical negative pressure irrigation systems that have been showcased recently. It is designed to deliver irrigation solutions to the apical end of the canal system for suction removal of residues (22,23). The EndoVac System is expected to be successful in cleaning the oval extension of the apical root canal.

The purpose of this study was to evaluate the efficacy of removal of $Ca(OH)_2$ from an artificial standardized groove in the apical root canal with the EndoVac, PUI, and needle irrigation techniques.

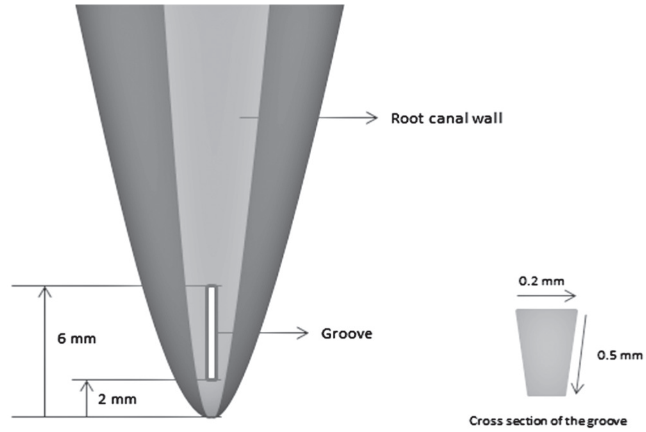
Materials and Methods

Thirty freshly extracted human mandibular premolar teeth with single root canals that had curvatures of < 10° were selected after the root canal anatomy was confirmed by buccolingual and mesiodistal radiography. The crowns of the teeth were removed 12 mm from the apex to standardize the length of the roots. A size 10 K-file (Mani, Tochigi, Japan) was placed into the canal until the tip of the file was just visible at the apical foramen. The working length (WL) was established 1 mm short of the point at which the file exited the apical foramen. The root canals were prepared by using rotary nickel titanium files (HeroShaper, Migro-Mega, Besancon, France) and with a crown-down technique. The instrumentation sequence was as follows: size 30/.06 followed by master apical file (MAF) size 30/.04. Between the use of each instrument, the root canals were irrigated with 2 mL of 5% sodium hypochlorite (NaOCl) solution using a plastic syringe with a 27-gauge closed-end needle (Irrigation Probe; KerrHawe, Bioggio, Switzerland) that was placed into the canal to the WL. After root canal preparations, each root was split longitudinally through the canal. Longitudinal grooves were cut on the buccal and lingual root surgaces without damaging the inner layer of dentine around the canal. Roots were splint longitudinally using a chisel.

The working portion of a hand spreader was removed and the end of the shank was sharpened, and then this instrument was used to create a groove. In one-half of the root, the standard groove, 4 mm long, 0.5 mm deep, and 0.2 mm wide, was created in the canal wall 2–6 mm from the apex using the modified hand spreader (19) (Figure 1), to simulate an uninstrumented canal extension (18). Created each of the groove was completely filled with Ca(OH)2 paste (MM-Paste; Migro-Mega). Subsequently, the roots were reassembled with plastic bracelets and reinforced with sticky wax, and then the apical foramen was sealed with wax. After this procedure, the Ca(OH)2 preparation was injected with equal amounts into each canal via the manufacturer's dispenser and packed to the WL with the MAF. After a radiographs were taken to confirm the complete filling of the canals, the coronal access cavities were temporarily sealed with cotton pellet and glass ionomer cement (Ionofil U, Voco, Germany) to a depth of 2 mm. The roots were then stored for 1 week at 37°C in 100% relative humidity.

After 1 week of storage, the samples were divided randomly into three groups (n = 10). For each group, a different technique was used to remove the dressing. In Group 1, the teeth were irrigated using the EndoVac System with a total volume of 10 mL of 5% NaOCl, after placement of the MAF in a cicumferential filing action to the WL (15,24,25). The delivery tip was placed above the access opening to deliver and evacuate 5 mL of 5% NaOCl constantly, and the macrocannula was moved constantly up and down in the canal from a point at which it started to bind to a point just below the orifice for 30 seconds. For microirrigation, the microcannula was positioned at the WL and then moved continuously 2 mm up and down for 30 seconds to 5 mL of 5% NaOCl had been delivered. Thus, the root canals were irrigated fully at the WL for 1 minute. In Group 2, the teeth were irrigated with 10 mL of 5% NaOCl and an power setting of ultrasonic unit (MiniPiezon; EMS, Nyon, Switzerland) using a size 15 file non-cutting ultrasonic tip (EMS, Nyon, Switzerland) that was placed at 1 mm from the WL and activated for 1 minutes in each canal, after placement of the MAF to the WL. The intensity of ultrasonic unit was used maximum 50% of power output for 1 minutes. According to the manufacturer, the freequency employed under the mentioned conditions was approximately 30 kHz. In Group 3, teeth were irrigated with 10 mL of 5% NaOCl for 1 minute by using a 27-gauge closed-end needle that was inserted into the canal without binding and within WL following the MAF. After each technique, canals were dried with paper points.

Figure 1. Schematic drawing of specimen preparation in one half of the instrumented root canal



The roots were disassembled and examined by scanning electron microscopy (SEM; LEO Evo 40 XVP; Carl Zeiss AG, Oberkochen, Germany). Digital photomicrographs were taken at ´ 40 magnification to observe the $Ca(OH)_2$ residues in the apical part of each specimen (2–6 mm from the apex). This photomicrographs were taken to include only 4 mm grooves. The images were scored in accordance with the criteria reported by van der Sluis et al. (16) (Table 1). The SEM images were separately scored by two examiners who were blinded to specimen groups. From the scores obtained before and after irrigation, the percentage reduction in Ca(OH)2 was calculated. The differences in the amount of $Ca(OH)_2$ residue between the different groups were analyzed by means of the Kruskal–Wallis and Mann–Whitney U tests. The level of statistical significance was set at $p < 0.05$.

Results

The results for the removal of $Ca(OH)_2$ in all experimental groups on the basis of the SEM observations are shown in Table 2. None of

Table 1. Scoring system for $Ca(OH)_2$ remaining

Score	Designation
0	The grove is empty
1	Less than half of groove is filled with calcium hydroxide
2	More than half of groove is filled with calcium hydroxide
3	The groove is filled completely with calcium hydroxide

Table 2. Results for removal of the $Ca(OH)_2$ in three experimental groups

	Score 0	Score 1	Score 2	Score 3
Group 1 (EndoVac System)	1	4	2	3
Group 2 (Passive Ultrasonic Irrigation)	5	1	4	0
Group 3 (Needle Irrigation)	0	2	5	3

Table 3. Score of calcium hydroxide before and after irrigation and the percentage of score reduction

		After		Percentage of score reduction	
Groups	Before	Mean	SD	Mean	SD
1	3.00	1.7	1.05	43.3	35.2
2	3.00	0.9	0.99	69.9	33.1
3	3.00	2.1	0.73	29.9	24.5

the techiques removed the $Ca(OH)_2$ dressing completely. There were significant differences between the groups in relation to the removal of $Ca(OH)_2$ (Kruskal–Wallis test, $p< 0.05$). Table 3 shows the level of $Ca(OH)_2$ before and after irrigation and the percentage reduction. The level of $Ca(OH)_2$ was reduced by 43.3% in Group 1, 69.9% in Group 2, and 29.9% in Group 3. No significant differences were observed between Groups 1 and 2 ($p> 0.05$). Group 2 showed significantly lower scores of $Ca(OH)_2$ than did Group 3 ($p< 0.05$), but there was no significant difference between Groups 1 and 3 ($p> 0.05$). Although PUI with 5% NaOCl was more effective for the removal of $Ca(OH)_2$ paste from artificial root canal grooves than the other techniques, its effectiveness did not differ significantly from that of the EndoVac irrigation system.

Discussion

The results indicate that PUI was more effective in removal of Ca(OH)2 paste from an artificial standardized groove in the apical root canal than needle irrigation, but had the same effect with EndoVac.

The most frequently described method for removing $Ca(OH)_2$ is instrumentation of the root canal using an MAF at the WL, together with irrigant solution (26-28). However, oval extensions in the apical part of the root canal can render this method unsuccessful and $Ca(OH)_2$ may remain in these locations (12). Effective removal of $Ca(OH)_2$ requires a system that delivers irrigant effectively to the WL of the apical root canal, especially the oval extensions. Syringe irrigation with needles is the standard procedure but, unfortunately, it is not effective in the apical root canal or in isthmuses or oval extensions (29,30). Current methods for the removal of intracanal medication include ultrasonic techniques and apical negative pressure systems.

During PUI, the presence of acoustic microstreaming and cavitation can result in the removal of more debris or medication from the root canal and remote locations within it than is achieved under standard irrigation conditions (16). PUI has been applied successfully to the removal of intracanal medication in many studies, and has been suggested to improve the cleanliness of dentin walls (13,15,17). The results of the present study for the PUI group were similar to those of previous studies in that most of the $Ca(OH)_2$ was removed, although not completely. This might have been because we used the lowest power intensity of the ultrasonic device. Jiang et al. (31) have shown that cleaning efficiency increases in parallel with the output of the ultrasonic device. In future research, success could possibly be achieved by increasing the output of the ultrasonic activation.

Negative pressure irrigation systems offer the possibility of safe and effective cleansing, especially in the apical region of the root canal (30,32). The EndoVac System was expected to be successful in cleaning oval extensions of the apical root canal. However, in the present study, we did not achieve complete success in relation to the removal of the $Ca(OH)_2$ paste in the apical extension space. There are two possible reasons for this failure. First, effective cleansing in the apical extension is related closely to the volume of irrigant used, with increased volumes providing more effective irrigation (33,34). The amount of irrigant that comes into contact with the canal wall decreases gradually as it nears the apical region. The manufacturer advises an apical preparation of at least size 35 but Brunson et al.(35) showed that just from size 40 /.04 there is an effective irrigant flow in the apical root canal with the EndoVac system, and achieved more effective irrigation by delivering a larger volume of irrigant to the apical region. Second, and more importantly, the macrocannulas and microcannulas were obstructed by particles of Ca(OH)2 paste, which could have caused less irrigation solution to reach the apical region.

None of the techniques analyzed in the present study were able to remove all of the Ca(OH)2 medication from oval extensions of the apical root canal. It was shown clearly that PUI removed more Ca(OH)2 than the needle irrigation method. However, there was no significant difference between the EndoVac System and PUI.

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

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