Original Article

Efficacy of EndoActivator, CanalBrush, and Passive Ultrasonic Irrigation in the Removal of Calcium Hydroxide Paste with Iodoform and p-chlorophenol from Root Canals

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ABSTRACT

Aims: We evaluated and compared EndoActivator, CanalBrush, and passive ultrasonic irrigation (PUI) in the removal of calcium hydroxide and calcium hydroxide with iodoform and p-chlorophenol paste (Calcipast Forte) from artificial standardized grooves in the apical third of root canals. **Materials and Methods:** A total of 34 mandibular premolars were prepared and then split longitudinally. A standardized groove was prepared in the apical part of both segments. The grooves were filled with either calcium hydroxide or Calcipast Forte, and the segments were reassembled. CanalBrush, EndoActivator, or PUI were used. The amount of remaining medicament was evaluated using a four-grade scoring system. **Results:** None of the irrigation methods could completely remove the pastes from the grooves. More Calcipast Forte paste was detected compared with calcium hydroxide ($P < 0.01$). PUI was the least effective method in removing Calcipast Forte. **Conclusions:** It was more difficult to remove Calcipast Forte than a water-based calcium hydroxide paste.

Keywords: *Calcipast, Calcium hydroxide, CanalBrush, Endoactivator, Iodoform, Ultrasonication*

Introduction

Chemomechanical debridement and root canal disinfection are the most critical factors that affect the outcome of endodontic therapy.[1] Irrigation and intracanal dressing to obtain clean root canals and to eliminate bacteria prior to final obturation is a fundamental step for successful root canal treatment.[2] Because of its good antimicrobial properties against the majority of endodontic pathogens, inhibition of osteoclast activities, mineralization activity, and tissue dissolving capacity, calcium hydroxide is the most commonly used intracanal dressing material. The basic principle action of calcium hydroxide involves the ionic dissociation into hydroxyl ions and calcium ions which diffuse into dentinal tubules and effectively kill microorganisms.[3]

Several works[4,5] have studied the mixture of other substances to calcium hydroxide with the purpose of improving its properties. Iodoform is composed of some powder with bright hexagonal crystals of lemon yellow color, with penetrating and persistent smell, little soluble in water, soluble in alcohol and ether.[4] Over the years, pastes containing iodoform were exhaustively indicated as antiseptics due to iodine release in nascent state when in contact with secretions or endodontic infections. In pediatric dentistry, iodoform is commonly used as a radioopacifier for root canal sealers. But its use in endodontics is controversial because of its potential toxic effects.

Calcipast Forte (Cerkamed, Stalowa Wola, Poland) is a product intended for use during endodontic treatment as a dressing material to improve rebuilding of damaged periapical tissues. It is claimed to have a drying effect

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on the exudate in the root canal. Calcipast Forte contains calcium hydroxide (10%), iodoform (73%), and p-chlorophenol (2%).[6]

Despite the benefits of calcium hydroxide, its residue may prevent the penetration of sealers into the dentinal tubules, resulting in apical leakage.[7] Complete removal of calcium hydroxide procedure includes the use of master apical file (MAF) at working length combined with the use of sodium hypochlorite (NaOCl) irrigation and ethylenediamine tetraacetic acid (EDTA),[5] the use of rotary instruments,[8] and the use of sonically or ultrasonically activated tips and devices such as CanalBrush in conjunction with irrigation techniques.[9]

The EndoActivator System (Dentsply Tulsa Dental Specialties, Tulsa, OK) was introduced as a sonic-activated device to improve the irrigation phase. This device allows activation of various intracanal agents and produces vigorous intracanal fluid agitation.[10] Passive ultrasonic irrigation (PUI) is based on the transmission of energy from an ultrasonically oscillating instrument to the irrigant in the root canal.[11] Khaleel and Al-Ashaw[12] showed that sonic and ultrasonic agitation techniques were more effective in removing intracanal medicaments than the use of ProTaper rotary file and needle irrigation in all thirds of the canals. It has also been reported that using sonic and ultrasonic techniques removed calcium hydroxide from the root canals effectively.[13,14] The CanalBrush (Roeko Canal Brush, Coltene/Whaledent, Langenau, Germany) is a highly flexible endodontic microbrush which can be used manually with a rotary action. Garip *et al*.[15] reported that compared to irrigation alone, the CanalBrush was more effective in removing the smear layer in the narrower parts of the root canal where it was in better contact with the root canal surface. To date, little data are available about the use of CanalBrush for calcium hydroxide removal.

Considering the importance of the complete removal of intracanal dressing material before root canal filling, the aim of this study was to evaluate the efficacy of EndoActivator, CanalBrush, and PUI in the removal of calcium hydroxide with iodoform and p-chlorophenol paste (Calcipast Forte) from mechanically inaccessible irregularities in the apical parts of straight root canals. The null hypotheses evaluated in this study were that removal of the intracanal dressing would not be affected by (i) the irrigation methods applied or (ii) the intracanal medicaments used.

Materials and Methods

Preparation of specimens

After obtaining the ethical approval, 34 extracted human single rooted mandibular premolar teeth with fully formed apices and no previous endodontic treatment were collected. Teeth were intact and free of visible cracks. Collected teeth were cleaned, and they were stored in tap water at room temperature until used. Teeth were decoronated with a diamond disk under water cooling to a standardized root length of 18 mm. The working length was established with a size #15 K-file until the tip of the file was visible at the apical foramina, then subtracting 0.5 mm from this length.

Canals were instrumented with the ProTaper Universal System (Dentsply, Maillefer, Ballaigues, Switzerland), with the finishing file 3 (F3) so that the MAF would be size 30. Between each file, root canals were irrigated with 5 ml 2.5% NaOCl. After instrumentation, a final irrigation protocol was performed for all canals using 10 ml 2.5% NaOCl followed by 5 ml 17% EDTA. The canals were then dried with paper points (Dentsply Tulsa Dental Specialties, USA).

The teeth were split longitudinally. This technique was previously described by Lee *et al*.[16] To facilitate splitting of the roots, two longitudinal grooves were prepared on the buccal and lingual surfaces with a diamond disc and the roots were then split into two halves with the help of a chisel. Standardized grooves of 4 mm in length, 0.2 mm in width, and 0.5 mm in depth was prepared in the apical part of both segments using an ultrasonic handpiece (NSK Various 2, Nakanishi, Tochigi-ken, Japan). These grooves represent a mechanically inaccessible region of the root canal where intracanal dressing may accumulate.

The roots were randomly divided into two experimental groups (n = 15), whereas the remaining roots served as a positive (n = 2) and a negative (n = 2) control group. Following removal of debris from the grooves using a tooth brush to take digital photographs, the specimens were molded into impression material. The grooves were filled with either Calcipast Forte or calcium hydroxide paste (Sultan Chemists Inc., Englewood, NJ, USA) using a finger spreader (Mani, Tochigi-ken, Japan). The roots were reassembled by means of sticky wax. Root canals were completely filled with calcium hydroxide or Calcipast Forte paste using a lentulo spiral size 35 (Mani, Tochigi-ken, Japan). The access cavities were sealed with a cotton pellet and a temporary filling material (Cavit, 3M Espe, Seefeld, Germany). The specimens were kept at 37°C with 100% humidity for 1 week.

Irrigation procedures

There were six experimental groups (n = 5) in total; half of the teeth were filled with Calcipast Forte and the remaining teeth were filled with calcium hydroxide

dressing. For each dressing group, the following irrigation procedures were applied:

- Canals were irrigated with 5 ml of 2.5% NaOCl and a medium sized CanalBrush was activated for 30 s at 600 rpm and followed by a final irrigation of 5 ml of 2.5% NaOCl
- Canals were irrigated with 5 ml of 2.5% NaOCl agitated for 60 s by a size 15/.02 tip of an EndoActivator set (Advanced Endodontics, Santa Barbara, CA) at 10,000 cycles per min
- Canals were irrigated with 5 ml of 2.5% NaOCl agitated for 60 s by an ultrasonic device (Satelec, Merignac, France) in contact with a size 15 K-file 1 mm short of working length
- No intracanal dressing was used for the negative control group and no irrigation technique was applied after intracanal dressing placement for the positive control group
- Root canals were dried with paper points and the roots were again split into two halves to take digital photographs (Canon EOS 6D, Tokyo, Japan) of the canal walls. The amount of remaining paste in the grooves was scored by two calibrated observers using a scoring system described by van der Sluis *et al*.[17]

0: cavity is empty
1: less than %50 is filled with paste
2: more than %50 is filled with paste
3: cavity is completely filled with paste. [Figure 1]

Statistical analysis

IBM SPSS Statistics 22 (IBM SPSS, Turkey) was used for statistical analysis. The interobserver reliability was analyzed with the kappa statistic. Mann–Whitney U test was applied to compare differences between the calcium hydroxide and the Calcipast Forte groups. Kruskal–Wallis test was applied to comparatively evaluate the irrigation procedures. The significance level was set at $P < 0.05$.

Results

Calibration

The blinded observers reached independent agreement on 26 of 34 digital photographs. The differences, when occurred, were no more than one score apart. The Kappa analysis showed that the interobserver reliability was 0.70 which indicated high agreement between the observers.

Investigation

The mean, median, and standard deviation values for the scores of remaining pastes were presented in Table 1. Remnants of medicaments were found in all root canals regardless of the experimental material used and the irrigation method applied. Calcipast Forte paste was associated with significantly higher scores of residues than calcium hydroxide paste ($P < 0.01$) [Table 2].

There were no significant differences between CanalBrush, Endoactivator, and PUI methods in terms of the scores of remaining pastes irrespective of the intracanal dressing applied ($P > 0.05$) [Table 2]. However, in Calcipast Forte groups, the scores of remaining pastes were significantly higher using PUI than in calcium hydroxide groups ($P < 0.05$).

Table 1: The mean, median, and standard deviation values for the scores of remaining pastes

Removal procedure	Paste	Scores of remaining pastes		*p*
		Mean values±SD	Median	
CanalBrush	Calcipast Forte	1.05±0.76	1	0.064
	$Ca(OH)_2$	0.45±0.44	0.5	
EndoActivator	Calcipast Forte	0.75±1.03	0.25	0.745
	$Ca(OH)_2$	0.5±0.67	0.25	
Ultrasonic	Calcipast Forte	1.2±0.82	1	0.011*
	$Ca(OH)_2$	0.3±0.42	0	

*$p<0.05$

Table 2: The scores of remaining pastes according to the medicaments and the activation methods applied

		Scores of remaining pastes		*P*
		Mean values±SD	Median	
1Medicament	Calcipast Forte	1±0.87	1	0.006**
	$Ca(OH)_2$	0.42±0.51	0.25	
2Activation	Canal Brush	0.75±0.68	0.75	
	EndoActivator	0.63±0.86	0.25	0.603
	Ultrasonic	0.75±0.79	0.75	

1Mann-Whitney U test 2Kruskal-Wallis test **$p < 0.01$

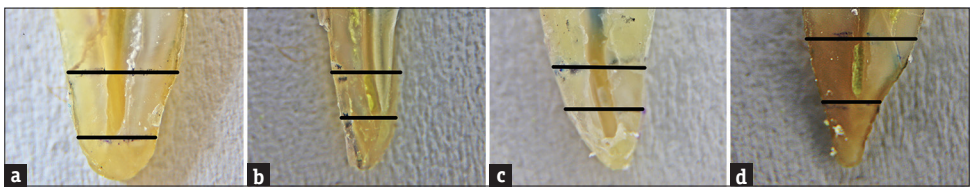

Figure 1: The amount of remaining paste in the grooves was scored as a) 0: cavity is empty, b) 1: less than 50% is filled with paste, c) 2: more than 50% is filled with paste, and d) 3: cavity is completely filled with paste

Discussion

Calcium hydroxide paste in its flowable form may penetrate canal irregularities, which increases the difficulty of subsequent removal.[18,19] The residual calcium hydroxide may influence dentin-bond strength and the penetration of sealers into the dentinal tubules.[20,21] Conventional irrigation techniques do not effectively remove calcium hydroxide from the isthmi and apical deltas.[17] In the present study, the efficacy of EndoActivator, CanalBrush, and PUI in removing two different intracanal dressing materials from the artificial standardized grooves was evaluated. Remnants of medicament were found in all canals regardless of the materials used and the irrigation methods applied. There were no significant differences between irrigation methods, and the first null hypothesis was accepted. However, the scores of remaining Calcipast Forte pastes were significantly higher than the scores of remaining calcium hydroxide pastes in all groups ($P < 0.01$). Therefore, the second null hypothesis was rejected.

The set-up of this study has been used in several other investigations.[17,19,22,23] Preparing artificial grooves with a standardized size and location helps distribute an equal preoperative quantity of calcium hydroxide before irrigation. Some of the previous studies,[5,13] did not clearly mention how much intracanal dressing was present before irrigation. Thus, it could not be established how much was removed after using different irrigation procedures. The major disadvantage of this set-up is that the standardized grooves cannot represent the complexity of root canal anatomy. Various methods have been used to investigate the amount of residues on the canal wall, such as digital photography,[5] stereo microscopy,[24] scanning electron microscopy,[9] micro-computed tomography (micro-CT),[1] and spiral computed tomography.[25] In our study, digital photographs were used at 16 magnification and the remnants of calcium hydroxide on root canal walls were evaluated by two calibrated evaluators in a blinded manner and using a four-grade scoring method similar to that used in previous studies.[15,17,22] Even though the scoring method used in the present study involved qualitative analysis; it is a simple scoring system, performed by two calibrated examiners. Calcium hydroxide remnants were found in all experimental groups irrespective of removal technique in the current study. These data are in agreement with previous studies.[1,17,22,25,26]

The antibacterial efficacy of calcium hydroxide may be dependent on the vehicle used.[3] Calcium hydroxide paste alone cannot eliminate *Enterecoccus faecalis* from the dentinal tubules.[8] However, in the treatment or retreatment of persisting apical periodontitis, a calcium hydroxide formulation that contains iodoform may be an alternative medicament for the elimination of *E. faecalis* from the dentinal tubules.[3] Thus, in the present study, a water-based and an iodoform-based calcium hydroxide pastes were used. Both Lambrianidis *et al*.[27] and Margelos[28] reported that none of the irrigation methods effectively removed the calcium hydroxide mixed with different vehicles. They suggested that the vehicles used to mix calcium hydroxide may affect the removal procedures.

We found that water-based calcium hydroxide paste was removed more effectively than iodoform-based calcium hydroxide paste ($P < 0.01$). Nandini *et al*.[25] also reported that the powder form of calcium hydroxide in distilled water was removed more effectively than Metapex (calcium hydroxide, silicone oil, and iodoform) regardless of the irrigation procedure applied. They explained that the silicone oil used in Metapex resisted dissolution in water and was retained in the canal, whereas calcium hydroxide in distilled water was easily removed. Even though Calcipast Forte does not contain an oily vehicle, the material was specified as insoluble in water in its data sheet.[6] This might also explain why the removal of Calcipast Forte was more difficult, irrespective of the irrigation methods applied.

Calcium hydroxide may not be efficiently removed from the root canals by using 15% EDTA solution or NaOCl alone[29]; however, a combination of these two irrigants improves the removal efficiency.[5] For this reason, in the current study, a combination of EDTA and NaOCl was used with the tested irrigation techniques.

During passive ultrasonic activation, the energy is transmitted from an oscillating file or a smooth wire to the irrigant in the root canal by means of ultrasonic waves. Compared with sonic energy, ultrasonic energy produces high frequencies but low amplitudes.[30] Li *et al*.[10] and Pabel and Hülsmann[19] revealed that in the apical third, ultrasonic irrigation eliminated a higher percentage of calcium hydroxide than EndoActivator irrigation. Moreover, in removing calcium hydroxide paste, Wiseman *et al*.[1] reported that ultrasonic activation was more effective than sonic activation, whereas Khaleel and Al-Ashaw[12] reported no significant differences between PUI and EndoActivator in terms of calcium hydroxide removal. Similarly, we found that there were no statistically significant differences in between sonic and ultrasonic irrigation methods in removing calcium hydroxide paste. Variations in irrigation volumes and types of irrigants used could explain the disparities in between studies.

To date, there is little information about the use of CanalBrush for calcium hydroxide removal. Our results

suggest that there were no significant differences between CanalBrush, EndoActivator and PUI in removing Calcipast Forte from the grooves. Tasdemir *et al*.[31] also reported superior results compared with syringe irrigation only, yet no significant difference was observed between PUI and CanalBrush. Garip *et al*.[15] showed that irrigating with CanalBrush tended to produce cleaner canal walls than syringe irrigation; however, the difference was not statistically significant. In contrast, Türker *et al*.[32] reported that CanalBrush did not remove calcium hydroxide from the apical third, but conversely packed it to the apical part of the canals. In another study,[33] PUI was found superior to CanalBrush in removing calcium hydroxide paste from canals. Weise *et al*.[34] reported that the use of CanalBrush improved the removal of debris from simulated canal extensions and irregularities in the apical portions of curved canals. We used CanalBrush with a circumferential and 2- to 3-mm up-and-down motion for 30 s, in a slow-speed handpiece and no significant difference was recorded between CanalBrush and PUI. Different results may have been obtained if the brush had been used for a longer period or the brush size had been different.

Conclusion

None of the techniques used in this study completely removed the inter-appointment root canal medicaments. The removal of calcium hydroxide paste with iodoform and p-chlorophenol was significantly less effective than the water-based calcium hydroxide removal, whereas irrigation technique was not a significant factor.

Ethical approval

An institutional ethics committee approval (no. 10840098 604.01.01 E.1443) was granted for the use of human subjects.

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Conflicts of interest

There are no conflicts of interest.

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