International Endodontic Journal

doi:10.1111/j.1365-2591.2011.01937.x

Comparison of ultrasonic irrigation and RinsEndo for the removal of calcium hydroxide and Ledermix paste from root canals

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Abstract

Rödig T, Hirschleb M, Zapf A, Hülsmann M. Comparison of ultrasonic irrigation and RinsEndo for the removal of calcium hydroxide and Ledermix paste from root canals. *International Endodontic Journal*, **44**, 1155–1161, 2011.

Aim To compare the efficacy of ultrasonic irrigation and RinsEndo in removing calcium hydroxide and Ledermix paste from simulated root canal irregularities.

Methodology The root canals of sixty extracted single-rooted teeth were prepared using FlexMaster rotary instruments to size 60, 0.02 taper. The roots were split longitudinally, and a standardized groove was prepared in the apical part of one segment. The teeth were randomly allocated into two groups (n = 30), according to the intracanal dressing. In the first group, grooves were filled with calcium hydroxide paste (Calxyl), whereas the grooves in the second group were filled with Ledermix paste. After reassembly, the root canals were completely filled with the respective medicament using a lentulo. The removal of medicament dressing was performed after 7 days with either passive ultrasonic irrigation or RinsEndo and 1% sodium hypochlorite for 3 min. The amount of remaining medicament was evaluated under a microscope with 30 × magnification using a four-grade scoring system. A regression analysis with $P \leq 0.05$ was performed.

Results Ledermix paste removal was significantly more effective than the removal of calcium hydroxide ($P < 0.0001$), whereas irrigation technique was not a significant factor ($P = 0.3712$). The percentages of complete removal of calcium hydroxide and Ledermix paste were 11.7% and 51.7%, respectively.

Conclusions None of the irrigation techniques was able to completely remove the intracanal medicaments from the apical part of the root canal. Irrespective of the irrigation technique, significantly less Ledermix paste was detected compared with calcium hydroxide.

Keywords: calcium hydroxide, irrigation, Ledermix paste, removal, RinsEndo, ultrasonics.

Received 6 June 2011; accepted 18 July 2011

Introduction

Calcium hydroxide has been widely accepted as the most frequently used intracanal medicament (Itoh *et al.* 1999, Lee *et al.* 2009) owing to its good antimicrobial properties against the vast majority of endodontically relevant pathogens and its biocompatibility. The antibiotic-corticoid compound Ledermix paste (Riemser, Greifswald, Germany) has also been used as an intracanal dressing to relieve postoperative pain associated with acute apical periodontitis (Ehrmann *et al.* 2003) or to prevent external inflammatory root resorption in traumatically injured teeth (Pierce & Lindskog 1987, Chen *et al.* 2008). Ledermix paste contains a tetracycline antibiotic, demeclocycline-hydrochloride (3.2%) and a corticosteroid, triamcinolone acetonide (1%), in a polyethylene glycol base.

All interappointment dressings have to be removed from the root canal prior to filling (Nandini *et al.* 2006) to avoid the negative interference between medicament and material (Margelos *et al.* 1997,

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Hosoya *et al.* 2004, Contardo *et al.* 2007), which may result in increased apical leakage (Kim & Kim 2002, Contardo *et al.* 2007) or in a potential reduction of sealer adaptation (Çalt & Serper 1999) and physical properties.

The removal of a medicament is usually accomplished by irrigation in combination with instrumentation using a master apical file (Lambrianidis *et al.* 1999, Salgado *et al.* 2009). Several studies have been performed to assess the efficacy of different techniques on the removal of intracanal dressings from the root canal, e.g. using rotary NiTi-instruments (Kenee *et al.* 2006, Kuga *et al.* 2010), using a patency file (Lambrianidis *et al.* 2006) or using different devices for the activation of intracanal solution to improve the mechanical flushing action of the irrigant (van der Sluis *et al.* 2007, Balvedi *et al.* 2010, Tasdemir *et al.* 2011, Wiseman *et al.* 2011). However, conflicting results exist regarding the effectiveness of these techniques in removing calcium hydroxide.

Previous studies performed with RinsEndo, an automated irrigation device using combined irrigation and suction under hydrodynamic pressure, showed an enhanced penetration depth of a dye marked irrigant into root canal dentine (Hauser *et al.* 2007) and a superior efficacy in terms of tissue removal (Braun *et al.* 2005) compared to manual irrigation. Only one investigation compared the efficacy of RinsEndo and passive ultrasonic irrigation in removing dentine debris from straight root canals with different apical sizes and demonstrated a superior effectiveness for ultrasonic irrigation (Rödig *et al.* 2010a). No data on the effectiveness of RinsEndo concerning the removal of an intracanal medication are available. In addition, no study has been conducted on the removal of Ledermix paste.

The aim of this study was to compare the efficacy of RinsEndo and passive ultrasonic irrigation in the removal of calcium hydroxide and Ledermix paste from mechanically inaccessible regions in the apical part of straight root canals. The null hypotheses evaluated in this study were that removal of calcium hydroxide and Ledermix paste was affected by neither (i) the irrigation technique nor (ii) the type of intracanal medicament.

Materials and methods

The experimental design is based on the study by Lee *et al.* (2004) and has been used in several investigations concerning the removal of dentine debris (van der Sluis *et al.* 2005a,b, Rödig *et al.* 2010a) or calcium hydroxide (van der Sluis *et al.* 2007, Rödig *et al.* 2010b).

Preparation of specimens

Sixty extracted human single-rooted teeth with intact apices, a minimum tooth length of 19 mm and no previous endodontic treatment were collected and stored in tap water. After preparation of the access cavity, the length of the tooth was measured by inserting a size 10 stainless steel file (VDW, Munich, Germany) into the root canal until the tip of the instrument was just visible at the apical foramen. The teeth were decoronated to obtain a standardized root length of 19 mm with a working length (WL) of 18 mm. All root canals were prepared by the same operator with FlexMaster rotary NiTi-instruments (VDW) to size 60, 0.02 taper at WL using a crown-down sequence. Between each file, root canals were rinsed with 5 mL sodium hypochlorite (3%), delivered by a syringe and a 30-gauge needle (NaviTip; Ultradent, South Jordan, UT, USA). After completion of preparation, root canals were irrigated with a final sequence of 5 mL EDTA (20%) and 5 mL NaOCl (3%) and then dried with paper points. Subsequently, the specimens were fixed in modified Eppendorf vials (Eppendorf, Hamburg, Germany) with silicone (Silaplast; Dentax, Ettlingen, Germany). After removal from the impression material, two grooves were cut along the long axis of each root using a diamond disc (Horico, Berlin, Germany). The roots were split longitudinally into two halves using a waxing instrument (Le Cron; Aesculap, Tuttlingen, Germany), allowing subsequent reassembling. A modified finger spreader was inserted into an ultrasonic handpiece (Piezon Master 400, EMS Nyon, Switzerland) to cut a longitudinal groove of 4.0 mm length, 0.2 mm width and 0.5 mm depth into root canal dentine of one half per tooth with a distance of 2–6 mm from WL (Fig. 1). This groove represents a mechanically inaccessible region of the root canal where intracanal medications may accumulate.

Following careful removal of debris from the root halves and grooves using a toothbrush, the specimens were placed into silicone (Silaplast) to take digital photographs before and after irrigation from identical angles. The photographs were carried out using a microscope (MOTIC Ergonomic Trinokular Zoom Stereo Mikroskop, Motic, Wetzlar, Germany) with 30 × magnification and a digital camera (Moticam 1300, Motic) with a resolution of 1.3 megapixel. The teeth were randomly allocated into two groups (n = 30), accord-

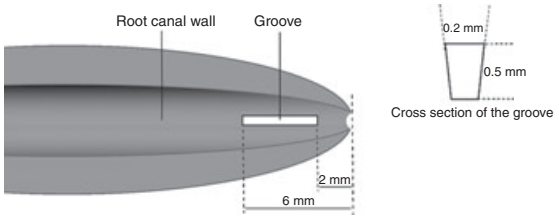

Figure 1 Schematic drawing of size and location of the longitudinal groove.

ing to the intracanal dressing. In the first group, grooves were filled with calcium hydroxide paste (Calxyl; VOCO, Cuxhaven, Germany) using paper points, whereas the grooves in the second group were filled with Ledermix paste (Riemser). All root halves were reassembled, and the apices were sealed with sticky wax to simulate the clinical situation. The specimens were remounted into the Eppendorf vials, and the root canals were completely filled with Calxyl or Ledermix paste using a lentulo size 35 (Micro-Mega, Besançon, France). The access cavities were temporarily sealed with a cotton pellet and Cavit (Espe, Seefeld, Germany). Subsequently, the specimens were stored for 7 days at 37 °C and 100% humidity.

Irrigation procedures

Temporary restorations were removed, and the teeth in each group were randomly divided into two subgroups ($n = 15$). The removal of intracanal dressing was performed with 1% sodium hypochlorite (NaOCl) according to the irrigation protocols shown in Table 1. Passive ultrasonic irrigation was performed with a stainless steel K-type file size 15 (Endosonore, Dentsply Maillefer, Ballaigues, Switzerland) driven by an ultrasonic device (Piezon Master 400) with its power set at the ¼ of the scale. Irrigation with RinsEndo (Dürr Dental, Bietigheim-Bissingen, Germany) was carried out using the needle provided by the manufacturer (needle size 45 with a 7-mm-long exit aperture). Irrigation time for each specimen was 3 min, and insertion depth of the irrigation devices was 1 mm short of WL in all groups. The amount of irrigation solution for each specimen was measured to calculate the mean irrigant volume. Root canals were dried with paper points, and the root halves were separated to take digital photographs of the canal walls.

Table 1 Experimental groups

Group	Intracanal dressing	Irrigant	Irrigation technique	*n*
1	Calcium hydroxide	NaOCl	Ultrasonic	15
2	Calcium hydroxide	NaOCl	RinsEndo	15
3	Ledermix paste	NaOCl	Ultrasonic	15
4	Ledermix paste	NaOCl	RinsEndo	15

Scoring procedure

The photographs before and after irrigation were coded to prevent identification of the specimen. The amount of remaining intracanal dressing in the grooves was scored under the microscope with 30 × magnification by two calibrated dentists using a four-grade scoring system described by van der Sluis *et al.* (2007) : 0, the groove is empty; 1, less than half of the groove is filled with medicament; 2, more than half of the groove is filled with medicament; and 3, the groove is completely filled with medicament (Fig. 2a–d). Calibration of the two scoring dentists before main evaluation of the specimens was performed with 150 root halves. After scoring, the results were discussed using reference photographs followed by the same procedure on 50 specimens. Five days later, 50 specimens were scored by both investigators again.

Statistical analysis

For the analysis of the data, SAS 9.2 (SAS Institute Inc., Cary, NC, USA) was used. Results were regarded as significant if $P \leq 0.05$. Because the response was a four-level score, the ranks of the observations were used for the regression analysis. A mixed effects model with teeth as random effect and intracanal dressing, irrigant technique and observer as fixed effects was used.

Results

During the complete scoring procedure, the inter- and intraindividual differences in scoring never exceeded one score. Interindividual agreement was 84% in the first scoring, and the final agreement was 90%. Intraindividual reproducibility was 94% for the first investigator and 92% for the second one.

The multivariate regression analysis showed significant effects for intracanal dressing ($P < 0.0001$) and observer ($P = 0.0291$), whereas no significant effect for irrigation technique could be detected ($P = 0.3712$). The interactions between intracanal dressing, irrigation technique and observer were not significant ($P > 0.2$). The results of the scoring procedure are

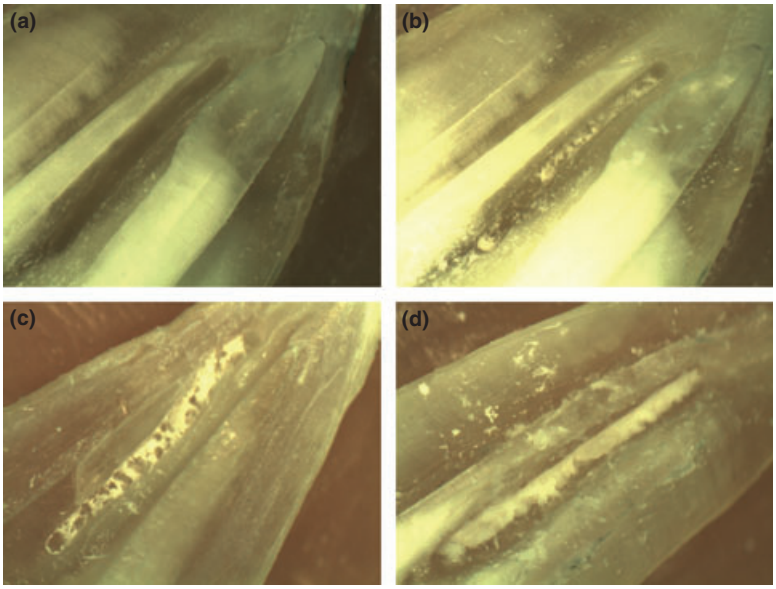

Figure 2 (a) 30 × magnification. Score 0: Cavity is empty. (b) 30 × magnification. Score 1: Less than half of the cavity is filled with medicament. (c) 30 × magnification. Score 2: More than half of the cavity is filled with medicament. (d) 30 × magnification. Score 3: Cavity is completely filled with medicament.

presented in Fig. 3. The percentages of complete removal of medication (Score 0) were 11.7% for calcium hydroxide and 51.7% for Ledermix paste. The mean volume of irrigant was 60 mL (range 44.0–66.6 mL) in group 1, 22 mL (range 17.0–30.0 mL) in group 2, 55 mL (range 42.0–66.0 mL) in group 3 and 21 mL (range 17.5–25.0 mL) in group 4.

Discussion

The experimental set-up of this study is similar to that described by Lee *et al.* (2004) and has been used in several other investigations (van der Sluis *et al.* 2006, 2009, Jiang *et al.* 2010, Rödig *et al.* 2010b). The advantage of the groove model is the standardized size and location of the grooves containing comparable amounts of medicament before irrigation. Previous studies investigated the amount of calcium hydroxide after irrigation (Balvedi *et al.* 2010, da Silva *et al.* 2011) assuming an equal preoperative quantity of calcium hydroxide, which may cause incorrect evaluation of the effectiveness of different irrigation techniques (Lee *et al.* 2004). The major disadvantage of this model is that the standardized grooves do not represent the complexity of root canal anatomy. Such limitations may be overcome by the use of microcomputed tomography, which facilitates a more precise quantification of residual medication in the root canal system (Wiseman *et al.* 2011).

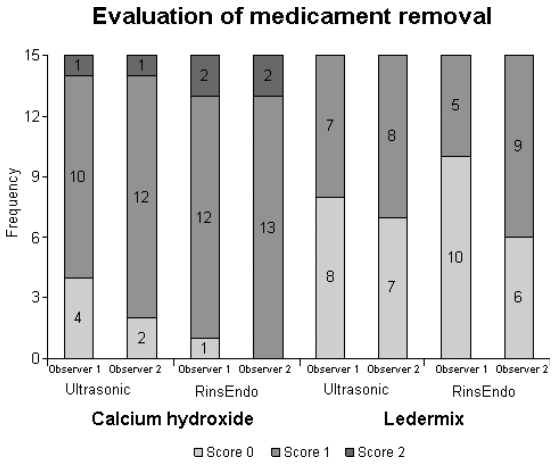

Figure 3 Distribution of scores for the removal of intracanal medicament according to experimental groups and observers.

The scoring system used in this study has been described by van der Sluis *et al.* (2007). Following thorough calibration, interindividual agreement of 90% and intraindividual reproducibility of 94% and 92%, respectively, could be shown. Statistical analysis revealed a significant influence of the observer ($P = 0.0291$), despite calibration with observer 2 scoring more strictly than observer 1 (Fig. 3). However, inter- and intraindividual differences in scoring never exceeded one score, and the interactions between observer and irrigation technique and between observer and intracanal dressings were statistically not significant ($P > 0.58$).

Irrigation time was set at 3 min, but standardization of irrigant volume was not possible. Therefore, the

amount of irrigation solution for each specimen was measured to calculate the mean irrigant volume. Although different volumes of irrigant were delivered with RinsEndo and ultrasonics, no significant differences in the cleaning efficacy of these devices were observed. This finding may be due to the fact that the effectiveness of root canal irrigation depends on several factors, e.g. apical preparation size (Falk & Sedgley 2005, Hsieh *et al.* 2007), taper (Lumley 2000), penetration depth of the irrigation needle (Hsieh *et al.* 2007, Bronnec *et al.* 2010), irrigant volume (Sedgley *et al.* 2004), flow rate (Boutsioukis *et al.* 2009) and the chemical ability of the irrigant to dissolve tissue (Çalt & Serper 1999) or intracanal medicaments (Rödig *et al.* 2010b).

Because large final preparation sizes for single-rooted teeth of size 50–90 have been suggested (Kerekes & Tronstad 1977, Hecker *et al.* 2010), in this study, apical preparation was performed to size 60, 0.02 taper to simulate an average size of chemomechanical instrumentation before placement of the interappointment dressing. Several studies have demonstrated that larger sized apical preparations have a positive impact on the mechanical efficacy of root canal irrigation (Ram 1977, Abou-Rass & Piccinino 1982, Huang *et al.* 2008) and improved irrigant replacement (Boutsioukis *et al.* 2010). Therefore, it could be hypothesized that root canal preparation to a smaller apical size may influence hydrodynamics and decrease the effectiveness of irrigation, resulting in larger amounts of medicament remaining.

Several studies examined the efficacy of RinsEndo in comparison with manual and ultrasonic irrigation (Hauser *et al.* 2007, McGill *et al.* 2008, Caron *et al.* 2010, Rödig *et al.* 2010a, Vivan *et al.* 2010). Hauser *et al.* (2007) showed that irrigation with RinsEndo resulted in a significantly higher penetration depth of a dye marker into root canal dentine in comparison with syringe irrigation demonstrating the efficacy of the oscillation in distribution of the irrigant. In addition, RinsEndo was found to be significantly more effective in removing a bio-molecular collagen film than static syringe irrigation *in vitro* (McGill *et al.* 2008). However, the same authors found that RinsEndo was significantly less effective than dynamic manual irrigation. Caron *et al.* (2010) examined the effect of different irrigant activation protocols on smear layer removal in curved root canals. They compared manual-static and manual-dynamic techniques, a sonic device (EndoActivator; Advanced Endodontics, Santa Barbara, CA, USA) and RinsEndo. For the middle and apical third, smear layer removal was significantly more effective in the activation groups in comparison with manual irrigation without activation. In the apical third, manual-dynamic activation and the EndoActivator showed significantly better smear layer removal than static manual irrigation and RinsEndo. In a recent study with a similar experimental set-up, 30 mL NaOCl (1%) was used to compare ultrasonic irrigation, RinsEndo and syringe irrigation for debris removal in different sized root canals (Rödig *et al.* 2010a). The percentages of complete debris removal (Score 0) were 66.7% for ultrasonic irrigation, 45.8% for RinsEndo and 0% for manual irrigation. Ultrasonic irrigation performed significantly better than RinsEndo and manual irrigation. In addition, irrigation with RinsEndo was significantly more effective than manual irrigation (Rödig *et al.* 2010a). In the present study, despite a higher volume of irrigant in the ultrasonic group (57.5 mL) compared with RinsEndo (21.5 mL), no significant difference was found between both irrigation techniques, and the first null hypothesis had to be accepted.

Furthermore, the percentages of complete clean grooves (Score 0) were lower in comparison with the aforementioned investigation (Rödig *et al.* 2010a). In the present study, medication was completely removed after ultrasonic irrigation in 35.0% of the specimens and after irrigation with RinsEndo in 28.3% of the specimens. Therefore, it can be considered that the cleaning efficacy of an irrigation technique depends not only on mechanical agitation and volume of the irrigation solution but also on the chemical activity of the irrigant (Lee *et al.* 2004). Whereas sodium hypochlorite is efficient in dissolving the organic compounds of dentine debris (Baumgartner & Mader 1987), it has limited ability to dissolve inorganic substances such as calcium (Salgado *et al.* 2009). As chelators are significantly more effective than NaOCl for the removal of calcium hydroxide (Salgado *et al.* 2009, Rödig *et al.* 2010b), the use of EDTA may have improved root canal cleanliness. The percentages of complete removal of medication (Score 0) were 11.7% for calcium hydroxide and 51.7% for Ledermix paste. Therefore, the second null hypothesis has to be rejected because the removal of Ledermix paste was significantly more effective than calcium hydroxide removal. The enhanced removability of Ledermix paste may be due to its water-soluble base and the oxidization and degradation of its compounds by sodium hypochlorite.

In this study, calcium hydroxide remnants were found in 88.3% of the specimens. This finding is in

agreement with previous studies that found considerable amounts of calcium hydroxide remnants on the root canal walls although several different removal techniques were investigated (Lambrianidis *et al.* 1999, Kenee *et al.* 2006, Nandini *et al.* 2006, van der Sluis *et al.* 2007, Wiseman *et al.* 2011). No comparable data are available for the removal of Ledermix paste.

Because many of the samples showed remnants of calcium hydroxide and Ledermix paste, further research is necessary to optimize irrigation protocols for the removal of intracanal medicaments.

Conclusion

Within the limitations of the study, neither ultrasonic irrigation nor RinsEndo was able to remove the intracanal medications from the apical part of the root canal effectively. Irrespective of the irrigation technique, significantly less Ledermix paste was detected compared with calcium hydroxide.

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