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ORIGINAL ARTICLE

Cleaning Ability of Irrigants and Orange Oil Solvent Combination in the Removal of Root Canal Filling Materials

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ABSTRACT

Objective: This study investigated the influence of different irrigants and the use of orange oil solvent in the removal of filling materials during root canal retreatment.

Methods: Forty maxillary premolars were shaped using the ProTaper System up to file F3 (size 30, 0.09 taper) and filled by Tagger's hybrid technique using the AH Plus. Samples were randomly assigned to four groups (n=10) according to the irrigating protocol during endodontic retreatment with the ProTaper Universal Retreatment System: G1, 2% chlorhexidine (CHX) gel; G2, 2% CHX gel with an orange oil solvent; G3, 5% sodium hypochlorite (NaOCl); and G4, 5% NaOCl with an orange oil solvent. Afterwards, the samples were longitudinally split into two halves, and the root wall images were prepared by scanning electron microscopy. Two pre-calibrated evaluators analyzed the images using a filling materials remnants score system. Data were statistically analyzed using the Kruskal–Wallis and Dunn's tests ($p<0.05$).

Results: All samples had residual filling materials in the root canal walls after instrumentation. According to the presence of the filling material remnants in the total area of samples, the groups were ranked in the follow-ing order: G2=G4>G1=G3. No statistical differences were found when the CHX and NaOCl were used ($p>0.05$). Groups in which a solvent was used showed a less effective cleaning ability ($p<0.05$). The use of NaOCl with solvent presented the highest amounts of filling materials remnants in the critical apical area ($p<0.05$).

Conclusion: The use of orange oil with NaOCl or CHX does not improve the removal of residual root canal filling materials.

Keywords: Endodontics, root canals irrigants, root canal treatment, scanning electron microscopy

HIGHLIGHTS

- It seems to be virtually impossible to achieve a complete removal of the filling materials with the available techniques.
- Previous reports have demonstrated the advantageous viscosity and rheological action of the CHX gel that keeps the smear layer and debris in suspension, yielding cleaner dentinal wall surfaces when compared with NaOCl. In the present study, however, no statistical differences were found when NaOCl or CHX were used for the removal of filling materials during root canal retreatment.
- The use of orange oil with NaOCl or CHX does not improve the removal of residual root canal filling materials.

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INTRODUCTION

Root canal retreatment procedures involve reaccessing of the pulp cavity, removing the pre-existing endodontic filling material, and further chemomechanical reinstrumentation and refilling of the root canal space (1). Several techniques have been proposed for the removal of root filling materials, including the use of laser, ultrasonic activation, and manual, rotary or reciprocating instruments, associated or not associated with adjunct chemical solvents (1-4). Most of these techniques are effective in removing gutta-percha and sealers of the pulp space; however, obtaining a totally clean root canal wall, free of filling remnants, is still a challenge (4, 5). The rotary instruments from the ProTaper Universal Retreatment System (Dentsply Sirona, York, PA, USA) are widely used for this purpose as they have demonstrated to be effective in removing filling materials from root canals (2, 4, 5).

Choosing an appropriate root canal irrigation solutions during endodontic therapy is crucial to disinfection of root canals and an increase in the permeability of dentinal tubules, permitting a proper adaptation of filling materials to canal walls (6, 7). Among irrigating solutions, sodium hypochlorite (NaOCl) is the most widely used because it demonstrates a low surface tension, high antimicrobial activity, neutralization of toxic products, lubricant capacity, bleaching action, and organic dissolution properties (8). However, the use of chlorhexidine (CHX) has been highlighted in the root canal cleaning and shaping, and it has been recommended as an alternative, or as an adjunct, to NaOCl (9). CHX gel consists of CHX gluconate and a water-soluble gel base (1% natrosol) that permits cleaner root canal walls during endodontic treatment when compared to other irrigants (9, 10). Moreover, CHX shows an extended and wide-range antimicrobial activity, staying active in the root dentine for up to 12 weeks in a process known as substantivity (11).

The aim of this study was to investigate the influence of different irrigants and the use of a solvent during the removal of filling materials in endodontic retreatment. The null hypotheses tested were the following: There are no differences in the cleaning ability when using 2% CHX gel or 5% NaOCl during endodontic retreatment, and there are no differences in the cleaning ability when using or not using a solvent during endodontic retreatment.

MATERIALS AND METHODS

Samples selection and preparationThe sample size estimation was calculated using the G*Power v3.1. (Heinrich Heine University Düsseldorf). The alpha-type error of 0.05, beta power of 0.95, and N2/N1 ratio of 1 were also stipulated. The test calculated a total of eight samples for each group as the ideal size for noting significant differences. However, we used an additional 20% of the total samples to compensate for possible errors that might lead to sample loss. Therefore, 10 samples per group were used. A total of 40 human permanent maxillary premolars were selected from a random collection of extracted teeth obtained after receiving the respective patients' informed consent, under a protocol approved by the local Ethics Committee Review Board. Digital periapical radiographs were taken through the IDA system (intraoral sensor and software) (Dabi Atlante, Ribeirão Preto, São Paulo, Brazil) in the buccolingual and mesiodistal directions to only select teeth with complete radicular formation, no previous endodontic treatment, and presenting single straight, oval-shaped root canals, with a cross-section diameter ratio of ≥2.5, as measured 5 mm from the apex. A statistical analysis revealed that the ratio of buccolingual to mesiodistal dimensions was not significantly different (Tukey's multiple comparison test, $p>0.05$), confirming that the anatomy of teeth was similar for each group. For standardization, roots were sectioned at 16 mm from the anatomic apex. Then, a size 10 K-file (Dentsply Sirona, York, PA, USA) was used to verify the patency of the canals. Patency was confirmed when the file exceeded the apex. The working length was established 1 mm beneath the apical foramen.

Initial root canal treatment

Root canal instrumentation was performed with the ProTaper Universal Rotary System (Dentsply Sirona, York, PA, USA) up to the file F3 (size 30, 0.09 taper) according to manufacturer´s recommendation. The canals were irrigated with 3 ml of 5% NaOCl (Drogal, Piracicaba, SP, Brazil) after each file. After preparation, roots were filled with 3 ml of ethylenediaminetetraacetic acid (EDTA; Drogal, Piracicaba, SP, Brazil) for 3 minutes, which was followed by a final wash with saline solution. Then, canals were dried with absorbent paper points, and obturation was performed with gutta-percha and an AH Plus endodontic sealer (Dentsply Sirona, York, PA, USA) using Tagger's hybrid technique. The excess of gutta-percha in the most coronal aspect of the oval root canal and access cavity was removed using a heated plugger. Vertical compaction was performed with a n.1/2 plugger (Dentsply Sirona, York, PA, USA) at the level of the root canal orifice. After that, all teeth were stored at 37°C for 30 days.

Root canal filling materials removal

For endodontic retreatment, the samples were randomly assigned to four groups (n=10), according to the irrigation protocol, as described in Table 1. Root canal filling materials were removed with the ProTaper Universal Retreatment System (Dentsply Sirona, York, PA, USA) in all groups. The instruments were used as follows: D1 (size 20, 0.09 taper) for the coronal third; D2 (25/.08) for the middle third; and D3 (20/.07) and F4 (40/.06) for the apical third. The instruments were used with a VDW motor (VDW, Munich, Germany) at 600 rpm for ProTaper Universal Retreatment System instruments, and 300 rpm for the F4 instrument, with a torque setting of up to 2 N/cm, according to manufacturer's instructions.

Samples were irrigated with the corresponding irrigant between each file exchange. An orange oil solvent (Biodinâmica, Ibiporã, Paraná, Brazil) was inserted in the coronal third of samples from groups G2 and G4, remaining active during 1 min. Next, the D1 instrument was used at the coronal third, followed by a new insertion of the solvent during 1 min. After that, the D2 and D3 instruments and the corresponding irrigant were used as previously clarified without the orange oil solvent. A single operator prepared all samples. The removal of filling materials was deemed to be complete when no gutta-percha or sealer was seen on the final instrument.

TABLE 1. Irrigation Protocols Investigated

Groups (n=10)	Irrigation material	Intermediate irrigation	Smear layer removal	Final irrigation
G1–CHX without solvent	3 ml 2% CHX gel	5 ml SS	2 ml EDTA 17% (3 min)	5 ml SS
G2–CHX with solvent	1 ml Orange oil (1 min)+3 ml 2% CHX gel	5 ml SS	2 ml EDTA 17% (3 min)	5 ml SS
G3–NaOCl without solvent	3 ml 5% NaOCl	5 ml SS	2 ml EDTA 17% (3 min)	5 ml SS
G4–NaOCl with solvent	1 ml Orange oil (1 min)+3 ml 5% NaOCl	5 ml SS	2 ml EDTA 17% (3 min)	5 ml SS

* SS, saline solution

Scanning electron microscopy evaluation

Aiming to vertically split the root samples into two halves, two longitudinal grooves were prepared in each tooth with a diamond saw. Then, both root halves were dehydrated at 37°C for 7 days and sputter-coated with gold (Desk IV DentonVacuum, Moorestown, NJ, USA). The samples were equally divided so that each root third had 5 mm. After that, the most central part of each root third from both halves was chosen for analysis, obtaining two images per third of each sample. Therefore, six images were evaluated per root, totaling 60 images for each group and a total of 240 images for analysis. Images of root canal walls were randomly obtained by scanning electron microscopy (SEM) at 100 pA pressure conditions with voltages of 3 KV and 1.000x magnification.

Two previously calibrated examiners analyzed the images in a qualitative observation of the efficiency in cleaning and removing the amounts of filling materials through the existing measures of these remnants in root canal walls and dentinal tubules. This analysis was performed with a scoring system from 1 to 4, according to the percentage of root filling materials remnants per image area (Fig. 1):

- Score 1: Absence or low presence of filling materials remnants (0%–25%);
- Score 2: Low to moderate presence of filling materials remnants (25%–50%);
- Score 3: Moderate to great presence of filling materials rem-nants (50%–75%);
- Score 4: Great presence of filling materials remnants (75%–100%).

Examiners were calibrated by means of a previous analysis with the score system until reaching a consensus in 10 images, which were not used in the present study.

Statistical analysis

The kappa test was carried out to verify the interexaminer reliability. A statistical analysis was performed with the BioEstat software version 5.0. A preliminary analysis of the raw pooled data was unable to reveal a Gaussian distribution (D'Agostino and Person omnibus normality test). The non-parametric tests Kruskal–Wallis and Dunn were applied, at a 5% signif-icance level ($p<0.05$), to detect statistical difference among groups.

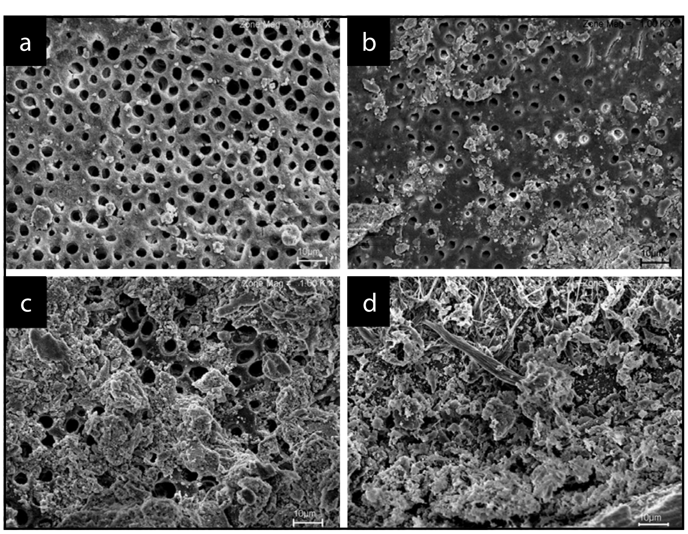

Figure 1. Photo micrographs of the scores system used to analyze the scanning electron microscopy images: (a) Score 1; (b) Score 2; (c) Score 3; (d) Score 4

RESULTS

There was an almost perfect agreement between examiners, confirmed by the kappa test (value of 0.92).

All teeth had some residual filling material present within the root canal walls. Table 2 shows the cleanliness scores results assigned to the SEM images of the root canal regions between groups. According to the presence of filling materials remnants in the total area of samples, the groups were ranked in the following order: G2 (CHX with solvent)=G4 (NaOCl with solven-t)>G1 (CHX without solvent)=G3 (NaOCl without solvent). No statistical differences were found when CHX and NaOCl were used ($p>0.05$). Groups that did not use solvent were associated with less retained materials than groups that received solvent during retreatment ($p<0.05$).

Scores values were similar between groups in the coronal third ($p<0.05$). In the middle third, the CHX groups provided a signif-icantly better dentinal cleaning than G3 group (NaOCl without solvent), followed by G4 group (NaOCl with solvent) ($p<0.05$). With regard to the apical region analysis, results were even more categorical, since G4 group (NaOCl with solvent) showed the greatest presence of filling materials remnants, whereas G1 (CHX without solvent), G2 (CHX with solvent), and G3 (NaOCl without solvent) groups demonstrated similar score values ($p<0.05$).

TABLE 2. Median and Standard Derivation (SD) of Root Filling Remnants Scores in Each Region of Groups and Thirds

Groups (n=10)	Region	Median±SD
G1–CHX without solvent	Total area	3 ± 1.20^{1}
	Coronal	3 ± 0.99^{a}
	Middle	3 ± 0.74^{a}
	Apical	2.5 ± 1.43^{a}
G2–CHX with solvent		
	Total area	4 ± 0.67^{2}
	Coronal	4 ± 0.70^{a}
	Middle	4 ± 0.85^{a}
	Apical	4 ± 0.97^{a}
G3–NaOCl without solvent		
	Total area	2 ± 1.36^{1}
	Coronal	2.5 ± 1.25^{a}
	Middle	2 ± 1.18^{b}
	Apical	2.5 ± 1.17^{a}
G4–NaOCl with solvent		
	Total area	4 ± 0.34^{2}
	Coronal	4 ± 0.85^{a}
	Middle	4 ± 0.32^{c}
	Apical	4 ± 0.42^{b}

*Different superscript numbers^{1,2} indicate a statistically significant difference ($p<0.05$) between groups in the total root canal area. Different superscript letters^{a,b,c} indicate a statistically significant difference ($p<0.05$) between groups in each anatomical third

DISCUSSION

Complete removal of filling materials is an important objective of root canal retreatment procedures. The achievement of a clean root canal walls and dentinal tubules favours endodontic therapy and increases the reduction of microorganisms (12). The aim of this study was to investigate the effect of different irrigants and the use of a solvent during the removal of filling materials in root canal retreatment.

In this study, all samples showed remnants of filling materials on the surface of the root canal walls, in accordance with literature (4, 5, 13). Although the main goal of nonsurgical endodontic retreatment is the complete removal of the filling material, it seems to be virtually impossible to achieve this purpose with the available techniques.

The use of CHX as an irrigation material shows some benefits, such as substantivity (residual antimicrobial action) and low cytotoxicity (9). Furthermore, the use of the CHX gel instead of a solution presents a significant benefit related to: the viscosity and rheological action of the gel (10). This physicomechanical property is capable of maintaining the debris in suspension, and it thus compensates the inability of the CHX solution to dissolve the pulp tissue (9, 10). As a result, CHX gel promotes a better mechanical cleansing of the root canal and a better removal of the dentin debris and remaining tissues when compared to other irrigants (9, 10).

Despite previous findings that CHX shows a superior cleaning capacity during root canal cleaning and shaping (10), no statistically significant difference was detected in the filling materials remnant scores between the NaOCl and CHX groups ($p<0.05$). This indicates that CHX gel shows no action on the residual root filling materials during endodontic retreatment. A possible explanation is that the residual filling materials present different physical characteristics in comparison with dentinal debris, as it is composed of synthetic components, and both residues present different densities. Therefore, the first null hypothesis that there are no differences in the cleaning ability when using 2% CHX gel or 5% NaOCl during root canal retreatment was accepted. This result corroborates with another study that compared the dentine cleaning ability of these irrigation materials during primary root canal instrumentation (14).

The clinical choice of an irrigant during endodontic retreatment goes beyond its dentine cleaning property. Although it is stated that both NaOCl and CHX gel showed similar results, other factors must be considered. When comparing the antimicrobial action of these two solutions, some studies observed similar results (10, 15, 16), while others claim that CHX gel or solution stands out the action of NaOCl (17) or the opposite (18). It has also been reported that the effectiveness of NaOCl and the CHX gel or solution are similar in identical concentrations (15). However, the increased concentration of NaOCl can cause adverse reactions, such as the irritation of periradicular tissues, in case of leakage of irrigant solution, and allergic reactions, due to its high toxicity (19). This consideration is important, since cases of endodontic retreatment are commonly associated with periradicular lesions. Above all, use of the CHX gel in root canal retreatment seems promising as it demonstrates great advantages due to its low toxicity and substantivity, in addition to effectively reducing bacteria and endotoxin contents in the post-treatment of apical periodontitis (9, 20).

In this study, G2 (CHX with solvent) and G4 (NaOCl with solvent) groups demonstrated the highest degree of filling material remnants in dentinal walls, with no statistically significant difference between them; thus, the second null hypothesis that there are no differences in the cleaning ability when using or not using a solvent during endodontic retreatment was rejected. Chemical solvents such as eucalyptol, orange oil, and chloroform are used during root canal retreatment to solubilize gutta-percha without damaging the tooth tissue (1). The use of orange oil has been recommended as it is more biocompatible than eucalyptol and chloroform (21). Moreover, this solvent demonstrated to be effective in removing gutta-percha or different types of sealers (22), and it leads to less canal transportation than chloroform (23). However, the current study showed that the use of orange oil solvent was associated with an increase in root canal filling remnants.

Literature shows that the use of stainless steel hand files results in a lesser amount of filling debris compared to nickel–titanium rotary instruments (24). Another study showed no difference between the use of nickel–titanium rotary instrument system with or without chloroform and stainless steel hand files (25). These contradicting findings might be attributed to differences in specimens' selection, instruments and materials selected for the study, and methodological procedures using for analysis.

The presence of solvents during endodontic retreatment forms a slurry layer of filling materials that penetrates into dentine tubules, thus obscuring proper cleaning of the root canal walls (14, 26). It is worth noting that the use of solvents reduces the time for desobturation due to softening of gutta-percha, which facilitates the penetration of the instruments and the removal of filling materials (27).

The comparative analysis of root thirds between groups only detected significant differences at the middle and apical thirds. The score values in the coronal third were similar between groups ($p<0.05$). This is attributed to the anatomy of this third that favours a better access of both suction cannulas and irrigation tips, as well as the facility of instruments to touch its walls. Therefore, the removal of filling material in the coronal region was considered adequate, even though it has larger amounts of filling materials (13). In the middle and apical thirds, G4 group (NaOCl with solvent) presented the worst results ($p<0.05$). The use of NaOCl associated with a solvent seems to be the irrigation protocol with the highest amount of filling materials remnants during the removal of root filling materials. This is because the apical region is the critical area for cleaning and shaping.

Under the conditions of the present study, 2% CHX gel and 5% NaOCl have demonstrated a similar cleaning capability during the removal of filling materials. Groups in which a gutta-percha solvent was used showed a less effective cleaning ability, as the application of orange oil increased the root filling remnants scores. It can be assumed that the use of a solvent during the process of desobturation brings disadvantages in the root canal cleaning. The use of NaOCl with a solvent presented the highest amounts of filling material remnants in the critical apical area. However, it cannot be assumed that solvents are not recommended during the root canal retreatment procedures. In some instances, solvents must be attempted when other retreatment procedures fail to remove the root canal filling material. Nevertheless, solvents can be toxic and should be used with caution (28).

It is important to point out that this study had some limitations. The qualitative score-based SEM analysis can be subjective, and the selection and evaluation of images could vary among different examiners. Furthermore, as this is an in vitro study, it does not reflect exactly the clinical situation of root canal retreatment procedures.

CONCLUSION

The use of orange oil with NaOCl or CHX does not improve the removal of residual root canal filling materials.

Disclosures

Conflict of interest: The authors deny any conflict of interest.

Ethics Committee Approval: Ethics Comittee (Protocol Number: 1154233).

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