Evaluation of the amount of remained sealer in the dentinal tubules following re-treatment with and without solvent

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Abstract

Background: The effect of solvent and sealer type (BioRoot RCS [BRRCS], mineral trioxide aggregate [MTA] Fillapex, and AH26) on the root canal residues was evaluated by confocal laser scanning microscopy (CLSM).

Materials and Methods: Distal root canals of 60 mandibular molars prepared up to ProTaper-F4 were filled using one of the sealers labeled with 0.1% rhodamine-B (n = 20 per sealer). Samples were divided into two according to reprocessing methods as follows: ProTaper Universal Reprocessing System (PTUR) or solvent plus PTUR. Samples were sectioned at 2–5 and 8 mm from the apex and the samples were observed under CLSM. Penetration depth, percent penetration depth, and percent penetration into canal walls were evaluated. Statistical analysis was performed using the repeated measures of the two-way ANOVA and Bonferroni post hoc test at P = 0.05.

Results: The highest penetration depth was measured in BRRCS in all root canal thirds with or without chloroform addition. Percentage of penetration depth values of MTA Fillapex and BRRCS was statistically similar and higher than AH26 in all sections, except the apical section re-treated with the addition of chloroform.

Conclusion: None of the sealers were completely removed. The type of sealant and the use of chloroform changed the amount of sealant remaining in the root canal system.

Keywords: Chloroform; extrusion; penetration; rhodamine b

INTRODUCTION

Removal of all root canal filling material during root canal re-treatment is an important step that can affect the success of re-treatment procedures. It has been reported that remaining filling material may include debris and infected dentin, thus jeopardizing re-treatment procedures and outcome. In addition, Kok et al. reported that endodontic sealers cannot penetrate into dentinal tubules after endodontic re-treatment. Various solvents different nickel–titanium (NiTi) rotary systems, and manually used instruments have been used efficiently to remove the filling materials. Solvents can exhibit antimicrobial properties. However, there are controversial results regarding the contribution of solvents to the retreatability of root canal filling materials.

The different characteristics of the newly produced root canal sealers are compared to well-known sealers such as AH 26 and AH Plus, which are considered gold standards. The advantages of mineral trioxide aggregate (MTA) such as calcium release ability and bioactivity have increased the popularity of tricalcium silicate-based sealers. MTA Fillapex (MTAFA, Angelus, Londrina, Brazil) was the first commercial tricalcium silicate-based sealer. However,
it is classified as a two-component resin-based sealer, mainly because it consists of salicylate resin instead of MTA. Unlike MTAFA, BioRoot RCS (BRRCS, Septodont, Saint-Maur-des-Fosses, France), which releases calcium hydroxide after setting, is a water-based sealer consisting of tricalcium silicate and zirconium oxide. The ideal root canal filling material should be easily removed from the root canal if necessary, and it is important to evaluate the solubility of newly produced sealants in solvents and the effectiveness of removal from the root canal with the techniques mentioned above. Therefore, the purpose of this study is to evaluate the effect of solvent (chloroform) on the remaining root canal sealers (BRRCS, MTAFA, AH26) in dentinal tubules with confocal laser scanning microscopy (CLSM). The null hypothesis of this study was that the removal efficiency of the solvent was not dependent on the sealer.

MATERIALS AND METHODS

Following ethics committee approval (GO 17/302), 60 mandibular molars with one distal root and canal, mature apex, and <10° canal curvature were selected. With the help of periapical radiographs taken in buccolingual and mesiodistal directions, distal roots with oval-shaped root canals with a long: short cross-sectional diameter ratio of >2.5 at a point 5 mm from the apex were selected as previously reported. The working length was determined to be 1 mm shorter than the length determined by the 15-K file with the tip visible at the major apical foramen. All teeth were instrumented with ProTaper Universal Rotary System (Dentsply Maillefer, Ballaigues, Switzerland) up to F4 according to the manufacturer’s recommendation. During the instrumentation procedure, 1 mL of 2.5% sodium hypochlorite (NaOCl) was used for irrigation between each file. For the final irrigation, 5 mL 2.5% NaOCl, 5 mL 17% ethylenediaminetetraacetic acid for 2 min, and 10 mL distilled water were applied. All irrigation procedures were performed with a 30 G side-vented irrigation needle. The root canals were then dried with paper points and randomly divided into three experimental groups (n = 20) as follows:

- Group AH26/S, MTAFA/S, and BRRCS/S: Size 2 and 3 Gates-Glidden drills were used to remove the 3 mm coronal part of the root canal fillings. 0.01 mL of chloroform was then added for 2 min. ProTaper Universal Re-treatment files (Dentsply Maillefer) were used, as stated in the previous group. After removing each 4 mm of root canal filling, 0.01 mL of solvent was placed in the root canal for 2 min. The total amount of solvent used for each sample was 0.04 mL.

All root canals were reprepared using the F5 file of the ProTaper Universal System and a #50 H file. For each specimen, a total of 20 mL of distilled water was used for irrigation between files during the re-treatment and final preparation procedure.

Evaluation of remaining sealer

The distal roots of the samples were embedded in acrylic resin blocks and sectioned transversely from the apex at 2, 5, and 8 mm with a cutting machine (IsoMet 1000; Buehler, Lake Forest, IL, USA), under water cooling. The sections were mounted on glass slides and photographed under a confocal laser scanning microscope (CLSM; LSM 510, Carl Zeiss, Oberkochen, Germany). Images were analyzed in the CLSM Image Browser (Carl Zeiss, Germany) to measure the longest penetration depth of the remaining sealer, the percentage of penetration depth of the remaining sealer, and the percentage of sealers penetrating the dentinal tubules [Figure 1a and b].

Statistical analysis

Measurements in the coronal, middle, and apical thirds were compared with repeated measures of the two-way ANOVA and Bonferroni post hoc test (P < 0.05). SPSS (SPSS Version 23, IBM, Armonk, NY, USA) software was used for the statistical analysis.

RESULTS

Table 1 shows the results of this study. Figure 2 shows representative stereomicroscope [Figure 2a, c and e] and CLSM [Figure 2b, d and f] images of sections.

Penetration depth

The use of chloroform significantly reduced the penetration depth of remaining AH26 in coronal third (P < 0.05), but the penetration depth of AH26 was inversely increased in the middle (P > 0.05) and apical thirds (P < 0.05). The highest
penetration depth, in all sections with or without the use of chloroform, was measured by BRCCS. Penetration depth length was significantly shortened from coronal to apical direction in all groups when the solvent was not used and in BRCCS and MTAFA groups when the solvent was used ($P < 0.05$). On the other hand, the penetration depth of AH26 was statistically similar in all sections when the solvent was used ($P > 0.05$).

**Percentage of penetration depth**
The use of chloroform statistically increased the penetration depth percentage of AH26 compared to mechanical removal in apical third ($P < 0.05$). When the solvent was not used, there were statistically significant differences among root sections when considering the penetration depth percentage of AH26 ($P < 0.05$).

**Penetration percentage into the dentinal tubules**
The penetration percentage values of BRCCS were higher in both re-treatment procedures and were statistically different from AH26 in all sections and MTAFA in the apical section ($P < 0.05$). Solvent use caused a significant increase in penetration percentage of AH26 ($P < 0.05$) and a significant decrease in the penetration percentage of MTAFA in the apical third compared to the solvent-free group ($P < 0.05$).

**DISCUSSION**
Root canal shape has an impact on the bond strength of filling materials[17] and amount of remaining filling material following re-treatment.[18] Filling of oval canals could
be more challenging compared to round canals\cite{18} and this might affect the success of the initial treatment and therefore the need for re-treatment. Considering these parameters; distal roots with oval-shaped root canals were used in the current study.

Various methods have been used to evaluate the effectiveness of re-treatment methods, such as splitting the roots and observing under a microscope,\cite{5,8} taking radiographs,\cite{10} scanning electron microscopy,\cite{6,7} confocal microscopy,\cite{3,9} and using cone-beam/microcomputed tomography.\cite{19} Differences in the results of previous studies might also be due to different evaluation methods. CLSM has been used several times in previous studies.\cite{3,9} CLSM has several advantages over conventional wide-field optical microscopy and scanning electron microscopy.\cite{20} Ability to control field depth, the elimination or reduction of background information away from the focal plane, and the capability to collect serial optical sections even from thick specimens are some of these advantages. Therefore, this method was preferred in this study.

Sealer penetration into inaccessible areas such as accessory canals, isthmus, apical delta, and dentinal tubules is very important because the antibacterial activity and blocking effect of the sealer can be considered beneficial to prevent reinfection.\cite{21} Arias-Moliz and Camilleri\cite{22} compared the antibacterial activity of BRRCS, MTAFA, and AH Plus; as a result, they concluded that BRRCS exhibited the highest antimicrobial activity, followed by MTAFA through penetration into bacteria-infected dentin. On the other hand, if there are residues of the former sealer after re-treatment, it could inhibit the penetration\cite{3} as well as antibacterial activity of the latter used sealer. According to results of this study, the addition of chloroform caused differences in the amount of remaining sealer in the dentinal tubules due to the sealer. Sealer penetration depth and percentage decreased when the solvent was added during re-treatment of samples filled with BRRCS and MTAFA; on the other hand, they increased in the middle and especially in the apical sections of the samples filled with AH26. Thermal manipulation of the AH26 to adjust its flow capacity is suggested by the manufacturer, which implies that the application of heat can increase the flow of AH26 as well as micromechanical retention of sealer to the root canal dentin. The combination of heat release and chloroform may increase flow capacity during re-treatment, resulting in increased penetration in the apical third. Çanakçı et al.\cite{4} recommended the use of a sealer-specific solvent to reduce the amount of extruded debris during re-treatment, which can also be advantageous to improve cleaning efficiency. In addition, a recent study\cite{23} reported that the use of solvents not traditionally used in dentistry proved to be excellent alternatives to chloroform or xylene solvents. Further studies need to evaluate this aspect. It has been reported that the retreatability of BRRCS\cite{7,8} and MTAFA\cite{8,19} with different NiTi rotary files was better than AH Plus/AH26. In the present study, the maximum values regarding penetration characteristics were observed with hydrophilic BRRCS, even after re-treatment procedures. The solvent activity of chloroform may be limited for BRRCS, depending on its composition. However, chloroform was reported to be an effective solvent for AH26\cite{12} and MTAFA\cite{11,12} and they showed similar dissolution rates in chloroform.\cite{12}

According to the results of the present study, the dentinal tubule penetration depth of the sealers was deeper in the coronal sections of the root canals compared to the middle and apical sections and in the middle than apical sections as in previous studies.\cite{3,8,9} In addition to previous studies, the penetration depth percentage was also calculated by dividing the longest penetration depth by the entire length up to the outer surface of the section. Considering the tapered root canal anatomy, this measurement was made and it was revealed that there was no significant difference between the percentages of the penetration depth values of the compared sections and that there were significant differences between the penetration depth values of these sections. In the literature, a decrease in the penetration in
apical tubule density has been attributed to sclerotic dentin,[24] less tubule density in apical dentin than those found in coronal dentin or occluded tubules.[25] As noted in previous studies, dentinal tubule diameter and number may have a significant effect on penetration depth,[13,18] while it may also be important to consider taper of root anatomy in comparing results. The longer the distance from root canal space to the external perimeter, the longer the depth of penetration of the sealer. Therefore, the penetration depth percentage may be a more accurate way of evaluating penetration depth.

CONCLUSION

Under the limitations of this study, the null hypothesis was rejected. Considering oval-shaped root canals and tapered root canal anatomy, it can be concluded that the use of chloroform modified the amount of remaining sealer in the root canal depending on the sealer type. Sealer-specific solvents have to be produced for newly introduced tri-calcium silicate sealers, and further studies need to be done to find more effective solvents when removing these sealers.

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Conflicts of interest

There are no conflicts of interest.

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