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Original Article

Analysis of the presence of filling material in oval root canals using computed microtomography after endodontic retreatment performed by different techniques

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Aim: The aim of this study was to evaluate the presence of filling material in oval root canals after endodontic retreatment performed by different techniques, considering the area (mm^2), location and root third using computed microtomography (µ-CT). **Methods:** Thirty human lower central incisor underwent biomechanical preparation, root filling and filling removal using two techniques (n=15): MN- manual retreatment technique (Gates Glidden burs and stainless steel manual files); and RT- rotary retreatment technique (ProTaper Universal and ProTaper Retreatment Systems). Cross-sectional images of the teeth were made using µ-CT to identify the presence of remaining filling in all root thirds of the canal walls. The remaining material detected in 150 µ-CT sections was identified and its area quantified (mm^2) for each root third individually. **Results:** Data analysis showed no difference in the remaining area of filling material (p=0.8611) for the both techniques. Higher frequency of remaining material was verified in the lingual wall of the root canals. Regardless of the retreatment technique, the apical third showed lager areas of remaining filling material. More areas of remaining material were detected in the cervical third of the RT group, whereas for the MN group, most areas were observed in the middle and apical thirds. **Conclusion:** According to our results, no significant differences were verified between the efficiency of the rotary and manual techniques for removing filling material due to the interferences caused by the root canal anatomy.

Keywords: Retreatment. Micro-Computed Tomography. Root Canal Preparation

Introduction

The removal of obturation materials from the root canal system is a primary objective in root canal retreatment procedures, to eliminate or at least reduce the amount of microorganisms in the root canals. In addition to the complete removal of the material filling, it is essencial the cleaning and shaping of root canal system and other obturation for a favorable prognosis[1].

There are several techniques that can be used to remove filling materials of root canal during endodontic retreatments, such as, hand files, reciprocating systems, ultrasonic instruments, rotary files, solvents, lasers and combinations of these methods[1-11]. Several studies have demonstrated that the complete removal of the root filling from the canal walls is not always possible[1-5,7-12]. The remaining filling material after retreatment has been described by its presence[8,9], area[3,5,7,10,12] and volume[11,13], through different analytical techniques using microscopy[9], radiographies[3,8,10], photographies[5,12], and computed tomography[4,6,11,13]. However, the studies do not report in which canal walls filling material remained in larger amounts[5]. This specific information would allow for better understanding of the limitations involving different retreatment techniques and instruments.

Thus, the aim of this study was to evaluate the presence of filling material in oval root canal after endodontic retreatment performed by different techniques, considering the area (mm^2) and location (root aspect and third) of the remaining material using micro-computed tomography (µ-CT). The null-hypothesis tested was that no differences would be detected between the efficiency of the manual and rotary instrumentation techniques in the removal of filling material from oval root canals.

Material and methods

Thirty human lower central incisors with single root canal were selected (following informed consent approved by the Committee for Ethics in Research of the Federal University of Uberlândia #887.517). The selected teeth had no previous endodontic treatment, intraradicular post, fractures or extensive damage in crowns. Teeth showing apical curvature, incomplete root formation, calcification or more than one root canal were excluded, using periapical radiograph.

Coronal opening was performed using round diamond burs #1016 (KGSoresen, Barueri, Brazil) and tapered carbide burs with non-cutting tip, Endo-Z (Dentsply-Maillefer, Ballaigues, Switzerland). The root canal was located and explored with #10 K-file (Dentsply-Maillefer) and the working length determined subtracting 1 mm from the length measured when the tip of the file was first observed emerging from the apical foramen. Teeth were instrumented with a step-down technique, using K-files (Dentsply-Maillefer) up to #30 memory file. Irrigation was performed with 1.0 mL of 1% sodium hypochlorite after each instrument and 5.0 mL of physiological saline for final rinse. Canals were dried with paper points and filled with gutta-percha and mineral trioxide aggregate-based sealer, MTA Fillapex (Ângelus, Londrina, Brazil), by the lateral condensation technique. Coronal access was provisionally restored with zinc-oxide temporary cement (Biodinâmica, Ibiporã, Brazil). The specimens were then stored (100% humidity at 37ºC) for 3 weeks to allow for complete setting of the sealer.

The teeth were randomly assigned into two experimental groups (n=15): MN- manual retreatment technique; and RT- rotary retreatment technique. For MN group, #2 and 3 Gates-Glidden burs (Dentsply-Maillefer) were used to initially remove the filling material from the cervical and middle root thirds. Then, eucalyptol-based solvent (Biodinâmica) was inserted in the filling with #15 and #20 K-files (Dentsply-Maillefer) using oscillatory movements and the material was laterally removed with Hedströem files (Dentsply-Maillefer). Canal repreparation was performed with K-files up to #30 file, in order to obtain 0.30 mm final apical diameter. For RT group, D1-D3 ProTaper Universal Retreatment (Dentsply-Maillefer), were used to prepare the cervical, middle and apical thirds, respectively. The finishing of the canal repreparation was done with F1-F3 ProTaper Universal (Dentsply-Maillefer) to obtain a final apical diameter compatible to that produced by the #30 K-file, since the last file from the retreatment system (D3) correspond only to the diameter of a #20 K-file. The instrument was used in electric motor X-Smart (Dentsply – Maillefer) five times each.

The removal procedure was interrupted when filling material was no longer detected in the instruments[5,7,8,10]. Canal irrigation and drying was performed as described before. One experienced operator conducted all endodontic procedures. Afterwards, teeth were mounted on a custom attachment base and scanned with the µ-CT scanner (SkyScan 1174v2; SkyScan, Kontich, Belgium) at an isotropic pixel size of 19.6 µm, 90 kV, 112 µA, resulting in the acquisition of 800-1.000 transverse cross sections per tooth. The scanning procedure was carried out by 360º rotation around the vertical axis; camera exposure time of 2.600 ms, rotation step of 0.6°, frame averaging of 2 and medium filtering of the data were applied. X-rays were filtered with aluminum (500 µm) and copper (38 µm) filters and a flat field correction were performed prior to scanning to correct for variations in the pixel sensitivity of the camera.

A thousand µ-CT cross-sections were individually analyzed for each specimen, seeking for the presence of remaining filling material and identification of its location in the canal walls. The sections were then divided according to the root thirds (cervical, middle, and apical) for each specimen (Fig. 1). After, 150 sections were selected for each specimen, with 50 sections per each third. The criterion for selection was defined by picking the sections following the first 100 sections of each root third. The selected sections were then employed for quantifying the remaining filling material area in the root thirds using the ImageJ software (National Institutes of Health, EUA) (Fig. 2).

The normality test was not applied during data processing because of the large sampling (n=2250), thus the estimators approached a normal distribution by the central limit theorem[14]. The t test for two independent samples was applied for comparisons between the techniques, and one-way Analysis of Variance (ANOVA) was used for comparisons among thirds. A multiple comparison test (Tukey test) was applied to check the differences among thirds. All tests were conducted using 5% significance level in the SPSS Statistics software for Windows, Version 20.0 (IBM Copr. Releases in 2011, Armonk, NY, USA).

Results

Remaining filling material was found after retreatment in 1.918 sections for the RT group (85.24%) and in 1.462 sections for the MN group (64.98%). Higher frequency of remaining filling material was observed in the buccal wall of the root canal for the both groups (Table 1).

Table 1. Frequency distribution (%) of remaining filling material presence after retreatment in the root canal walls according to the experimental groups

Group/Wall	Distal (%)	Mesial (%)	Buccal (%)	Lingual (%)	p value
RT	14.81^{d}	19.56^{c}	45.25^{a}	20.39^{b}	< 0.001
MN	18.10^{b}	9.99^{d}	13.17^{c}	58.74^{a}	< 0.001
p value	0.005	< 0.001	< 0.001	< 0.001	

Lowercase letters indicate differences between columns (between groups).

No significant differences (p=0.861) were detected on the total area of remaining filling material between the both experimental groups (Table 2). However, significant differences were verified between the groups when comparing the remaining filling in the root thirds (Table 3). More areas of remaining filling material were observed in the apical third of specimens from RT group, whereas for MN group, remaining filling was detected most in the middle and apical thirds. The apical third showed the largest amount of remaining filling material for both groups.

Table 2. Mean (±SD), minimum and maximum area (mm²) of remaining filling material in the sections according to the experimental groups

Group	Mean (mm²)	Minimum (mm²)	Maximum (mm²)
RT	0.08+0.06	0.00	0.31
MN	0.08+0.08	0.00	0.50

Table 3. Mean (±SD) area (mm^{2}) of remaining filling material in the root thirds according to the experimental groups

Root third	RT (mm²)	MN (mm²)	p value
Cervical	0.06+0.06^{Aa}	0.02+0.04^{Ba}	0.0001
Middle	0.07+0.06^{Bb}	0.08+0,07^{Ab}	0.0040
Apical	0.10+0.06^{Bc}	0.12+0.07^{Ac}	0.0001
p value	0.0001	0.0001	

Uppercase letters indicate statistical difference between lines (within root thirds) and lowercase letters indicate differences between columns (between groups). Tukey test (p< 0.05).

Discussion

The hypothesis tested was accepted since no significant differences were observed between the efficiency of the manual and rotary instrumentation techniques in the removal of filling material from oval root canals. Although no significant differences were observed between the both experimental groups, the rotary technique would be expected to remove more filling material since these instruments are designed to remove filling towards the apex-crown direction[1,5] and because the frictional heat generated by the files can soften the gutta-percha, allowing to reach the working length more easily[5].

Adding the two analyzed groups the remaining filling material was observed in 75% of all the µ-CT sections analyzed in this study. According to our results, none of the retreatment techniques tested was able to completely remove filling material from the root

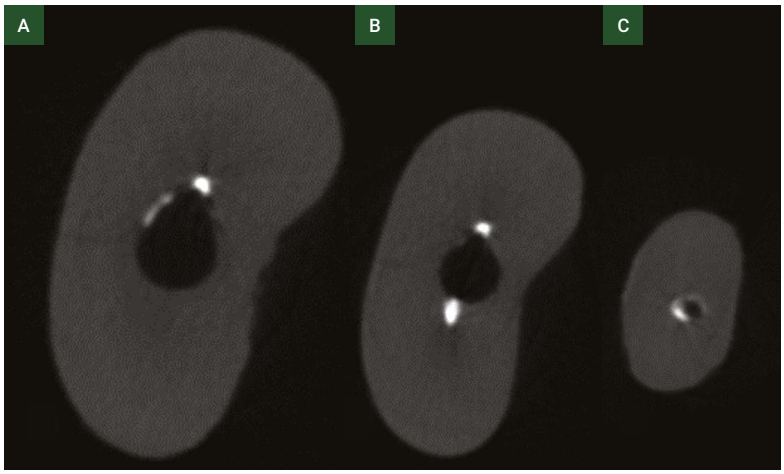

Figure 1. Sections of a RT specimen before removal of the filling material: cervical (A), middle (B) and apical (C) thirds.

canals. Some endodontic treatment failures are related to the permanence of microorganisms in the root canals, so it is very important to assure complete removal of root filling material during endodontic retreatment in order to allow proper canal cleaning[11].

The possible cause for the permanence of remaining filling material in the root canals after the use of both retreatment techniques may be credited to the failure of instruments to completely reach all canals walls due to anatomic interferences[5,7]. The interference of anatomical complexities in the capacity of instrumenting root canals was evidenced by a previous study that analyzed human mandibular incisors before and after biomechanical preparation using digital radiographs taken in the buccolingual and mesiodistal direction and micro-computed tomography sections[15]. This study has reported that after instrumentation, the canal remained without action of files in a region described as critical instrumentation area[15].

In some cases, these unprepared areas represented 64.2% of the root canal area, being located in the lingual and buccal walls of the root canal. The critical instrumentation area previously described corresponds to the same regions that presented the

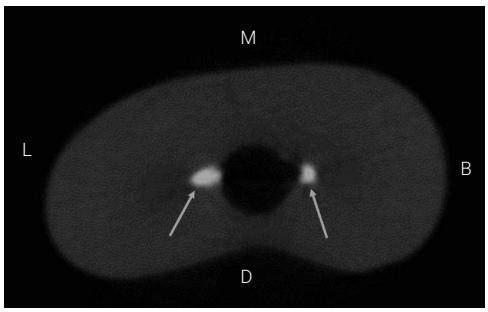

Figure 2. Section of the middle third MN specimen after removal of the filling material, showing remaining material (yellow arrows) in the root canal walls (M-mesial, D-distal, B- buccal and L-lingual aspects).

greatest amount of remaining filling material in the present study. It was clearly possible to observe that the filling remained in the areas where the canal has not been instrumented during the retreatment procedure (Figures 3A and 3B). This fact probably occurred when trying to remove the filling material during retreatment, which was probably, pressed to these areas which are inaccessible to files or where the instruments had limited action[15].

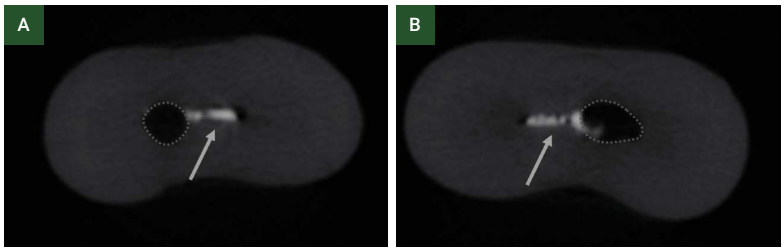

Figure 3. Post–instrumentation sections of the middle third showing: area file action (blue line), and remaining filling material (yellow arrows) in the RT (A) and MN (B) groups.

The critical instrumentation area of human mandibular incisors occurs on the buccal and lingual walls because the root canal is not conical as observed in conventional buccolingual radiographs, but it presents irregular shape when analyzed in the mesiodistal view by X-ray or tomography exams[15]. The classical periapical X-Ray gives poor information about root canal morphology. In this study the micro-computed tomography was chosen because provides detailed three-dimensional reconstructions of root canal, and accurate images of the endodontic space. Micro-CT can also be used to evaluate the ability of endodontic instruments to clean the root canal system[16].

Endodontic hand and rotary files are commonly designed to work in canals with conical shape[6], what affects the action of files in regions presenting irregular configurations. A previous study, observed that the files could be deviated from the original canal path to the buccal aspect when instrumenting lower incisors with oval canals[17]. Consequently, non-instrumented areas may remain on the lingual wall of the root canal. The non-instrumented regions reported in the previous study[18], correspond to the critical instrumentation area formerly described[15], and to the zones presenting remaining filling material found in our study. These anatomical interferences are not present only in mandibular incisors, but in all teeth with roots presenting oval shaped canals, as the distal root of mandibular molars[11].

Additionally, it was found that irrespective of the retreatment technique, the apical third showed the largest areas of remaining filling material. Other studies have also presented similar results[8,9,19], as the apical third is a critical area and requires enlargement for proper cleaning and shaping of canals[17]. The canal enlargement in this region may lead to apical deviations, which can play an important role in the retention of filling material during canal retreatment[18,19]. Thus, in order to reduce the limitations imposed by anatomical interferences of teeth with oval root canals, it is suggested to

perform an enlargement of the canal entrance during retreatments, allowing to direct the files to the buccal and lingual walls. Additionally, active ultrasonic irrigation with a straight edge tip should be used, since ultrasound devices are effective in areas difficult to be accessed[20], due to its great irrigation capacity through oscillation in canal limits, thereby eliminating pulp tissue, filling material and dentin debris[21].

According to the results of the present study, no significant differences were observed between the efficiency of filling material removal for the manual and rotary retreatment techniques evaluated, probably due to the interferences caused by the root canal anatomy. In addition, clinicians should take into account that large amounts of filling material may remain on the buccal and lingual walls when performing retreatment in teeth presenting oval canals. Efforts should be focused on removing the filling material of these areas through the association of techniques and instruments.

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