

Original Research Article

Verification of remaining filling materials in flattened/oval-shaped root canals after use of several endodontic retreatment protocols

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Abstract

Introduction and Objective: This study verified of remaining filling materials in flattened/oval-shaped root canals after use of several endodontic retreatment protocols. **Material and methods:** Seventy human mandibular incisors were selected. Sixty specimens received crown-apex preparation performed by ProTaper Next[®] system and were filled with hybrid Tagger technique with gutta-percha and AH Plus[®]. Ten specimens were left unprepared (Control Group). The specimens were randomly distributed in six groups, according the different retreatment protocols: G1 – Clearsonic[®] + ProTaper Universal Retreatment[®] + Reciproc[®]; G2 – Reciproc[®]; G3 – Clearsonic[®] + ProTaper Universal Retreatment[®]; G4 – Clearsonic[®] + Reciproc[®]; G5 – Oscillatory EndoEze[®] + Manual files; G6 – ProTaper Universal Retreatment[®]. Presence of root canal filling material residual were evaluated using Scanning Electron Microscopy. The relative differences of remaining filling materials between the groups and root thirds were determined by Kolmogorov-Smirnov and Levene tests followed by Tukey post hoc test. The level of significance was set at $\alpha = 5\%$. **Results:** Regarding the presence residual, G1 (Clearsonic[®] +

ProTaper Universal Retreatment® + Reciproc®, G2 (Reciproc®), G3 (Clearsonic® + ProTaper Universal Retreatment®) and G6 (ProTaper Universal Retreatment®) protocols presented a lower amount ($p < 0.05$). The highest values ($p < 0.05$) of remaining filling materials were presented in the G5 (Oscillatory EndoEze® + Manual files) protocol. Intermediate values ($p < 0.05$) were presented by G4 (Clearsonic® + Reciproc®) protocol. **Conclusion:** The endodontic retreatment protocols no showed effectiveness for complete removal of remaining sealing material from flattened/oval-shaped root canals.

Introduction

Root canal treatment (RCT) include to remove organic remains and bacteria by using chemical-mechanical preparation, maintaining the original shape of the curvature and apical foramen spatial position, followed by root canal filling [6, 14]. Despite the advances made with the development of new instrumentation techniques and materials [19], failures in RCT may occur [6, 7, 20].

Different local factors have associated with a possible doubtful prognosis in cases of root canal retreatment (or that impede use of the correct endodontic technique), such as anatomic-pathological factors (modifications of the internal anatomy; excessive dilacerations; pulp cavity calcifications); current factors of endodontic accidents (working length loss - step; root perforation; endodontic instrument fracture); endodontic failures (presence of widespread posts; filling only with cements; sealer and gutta-percha; sealer and silver cone etc.). On the other hand, one can also consider factors relative to the patient, such as the characteristics of systemic diseases [6]. The complex internal anatomy of root canals, its ramifications and isthmus areas may not permit the appropriate contact to the instruments and irrigating solutions during root canal preparation [14, 19]. These conditions allow that debris and bacteria and may lead to RCT failure [7, 20]. Consequently, complementary treatment may be necessary, and usually include as initial option, the orthograde way retreatment [7, 20].

Root canal retreatment constitute a complex process that requires special care, being responsible by a new opportunity to control root infection which persist on first RCT [6, 7, 20], with elimination of periapical infection and consequent healing process repair [8]. Therefore, to the complete elimination of the previous root canal filling on the root canal walls is essential the use of strategies of emptying

and shaping [6]. Thus, it can be achieved by using instruments of stainless steel, nickel-titanium rotary instruments, ultrasonic tips or other recourses [1, 3, 4, 19, 23].

The complete removal of root canal filling material is an often challenge found in root canal retreatment. Thus, given the need to establish an effective protocol for removal of filling material in cases of retreatment, this study assessed the effectiveness protocols with a contemporary instruments system to remove remaining sealing material from flattened/oval-shaped root canals. The null hypotheses were that there would be no significant differences between the contemporary instruments with respect to remaining sealing material in flattened/oval-shaped root canals.

Material and methods

Tooth selection

Seventy human single-rooted mandibular central incisors with fully formed apices and straight root canals from dental service of School of Dentistry, University of Cuiabá, Brazil were used in this study. Digital radiographs from both buccolingual and mesiodistal directions were taken for each tooth for sample selection. The length of the teeth was standardized between 19- and 22-mm. Sixty teeth were distributed in experimental groups. Ten specimens were left untreated as a control group. This study was approved by the Research Ethics Committee of the University of Cuiaba, Brazil (CAAE 04012718.7.0000.5165).

Sample preparation

Standard access was performed with round diamond burs (#1011, #1012; KG Sorensen, Barueri, Brazil). Root canal exploration was accomplished

using K-File # 15 (Dentsply Sirona, York, USA) until the visualization of the endodontic instrument through the apical foramen. From this length, one millimeter was retracted to obtain the actual working length. Cervical preflaring was performed, and then root canal preparation (RCP) was performed with ProTaper Next[®] (Dentsply Sirona, York, USA) in a sequence X1 to X4 at the working length. Each instrument was used to prepare only one root canal. The instruments were driven by the VDW Silver Reciproc[®] motor (VDW, Munich, Germany) with standards determined by the manufacturer. The root canals were irrigated with 2.5% NaOCl delivered by Navitip[®] 31ga (Ultradent Products Inc., South Jordan, USA) disposables syringes. Between the use of each instrument, the root canal was irrigated with 2 ml of 2.5% NaOCl. Subsequently the RCP, an irrigation protocol was adopted with 2 ml of 2.5% NaOCl stimulated with ultrasonic activation driven by EMS PM200 (Electro Medical Systems, Nyon, Switzerland) equipped with E1 Irrisonic tip (Helse, Santa Rosa do Viterbo, Brazil) with power level 3, for three times for 20 s each. Subsequently, the root canals were irrigated with 17% EDTA (Biodinâmica, Londrina, Brazil) and activated with E1 Irrisonic tip for 60 s. Another irrigation with 2 ml of 2.5% NaOCl using E1 Irrisonic tip was performed three times for 20 s and finished with saline irrigation and drying with paper point #40 (Dentsply Sirona, York, USA).

The root canal filling was performed after RCP in all specimens by the hybrid technique of Tagger (11) with #40 gutta-percha main point and AH Plus[®] (Dentsply Sirona, York, USA) sealer, according to the manufacturer's instructions. The specimens were then sealed with temporary material (Coltosol Vigodent, Rio de Janeiro, Brazil) and kept at 37°C, in a humidifier for a period of 14 days. After that, teeth were divided randomly into six groups (n=10) and retreated with the following protocol:

- Group 1. ULTRORE: R1 Clearsonic[®] (Helse, Santa Rosa do Viterbo, Brazil) at 30 kHz, 3 cycles of 20 s + ProTaper Retreatment[®] (Dentsply Sirona, York, USA) - Sequence of D1 to D3 + Reciproc[®] (VDW, Munich, Germany) - R25 and R40 instruments at working length.
- Group 2. RE: Reciproc[®] R25 and R40 instruments at working length.
- Group 3. ULTRO: R1 Clearsonic[®] at 30 kHz, 3 cycles of 20 s + ProTaper Retreatment[®] - Sequence of D1 to D3 + ProTaper Next[®] X4 at working length.
- Group 4. ULTRE: Clearsonic[®] (30 kHz, cycles of 20 s) + Reciproc[®] R25 and R40.
- Group 5. MAOS: Oscillatory kinematic #15 to #40 K-File (Dentsply Sirona, York, USA) and Manual #40 Hedström file (Dentsply Sirona, York, USA) at working length.
- Group 6. RO: ProTaper Retreatment[®] - Sequence of D1 to D3 + ProTaper Next[®] X4 at working length.

All retreatment protocols were performed according to the manufacturer's instructions. Clearsonic[®] tips were activated by EMS PM200 scaler. ProTaper Retreatment[®], ProTaper Next[®] and Reciproc[®] instruments were all driven by VDW Silver Reciproc[®] motor. K-files instruments were driven by oscillatory kinematic using a TEP SUPER-NSK reduction contra-angle (Nakanishi, Tochigi-ken, Japan) coupled to an Intramatic 181DBN (Kavo, Joinville, Brazil) motor. At each instrument change the root canal was irrigated with 2 ml of 2.5% NaOCl. No aid solvents were used during endodontic retreatment.

Root canal sectioning and Scanning Electron Microscopy

After the retreatment stage, the experimental and positive control groups were prepared for Scanning Electron Microscopy (SEM). For the cleavage of the specimens, an orientation groove with flexible diamond disk (KG- Sorensen, São Paulo, Brazil) was created in the buccolingual direction under refrigeration. Then on this groove was printed force using a chisel (Duflex SS White, Rio de Janeiro, Brazil) to promote the section. The fragments were fixed in buffered formalin solution for one week. Then, 50, 70, 95 and 100% ethanol solution dehydration were performed with three 10-min changes in each solution. The fragments were fixed with the aid of carbon tape and subjected to the metallographic preparation covered with gold as conductive material. Then, the acquisition of high vacuum SEM images (JED, JSM, 6360LV, Tokyo, Japan) with magnification 100 and 150 times was taken. The images were analyzed by two evaluators, through the computer screen, with a digital ruler demarcating the cervical, middle and apical third from the apex, to verify the pattern of remaining of filling material.

The area of residuals on root canal surfaces (total area) and in each root canal third (cervical, middle, and apical) was measured from the SEM images. The images were reassigned to image analysis software (Autocad 2004; Microsoft, Redmond, Washington, USA). The percentage of residuals in the root canal walls (A) was calculated

using the following equation: $A = (\text{area of residuals} \times 100) / \text{area of the root canal}$ (12).

Statistical analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 15.0 for Windows (SPSS Inc., Chicago, USA). Comparisons between means were realized by analysis of variance, using Kolmogorov-Smirnov and Levene tests followed by Tukey post hoc test at a significance level of $P < .05$.

Results

Regarding the presence residual after root canal retreatment (table I), group 1 ULTRORE, group 2 RE, group 3 ULTRO and group 6 RO presented lower root canal filling material residuals ($p < 0.05$). The higher values ($p < 0.05$) were presented in the group 5 MAOS. Intermediate values ($p < 0.05$) were presented in group 4 ULTRE. The apical third

presented a higher frequency of root canal filling material residuals. Considering the root canal third (table II), Apical > Middle > Cervical thirds ($p < 0.05$) presented higher presence of residual after root canal retreatment. Considering each protocol and root canal third (table III), it was observed that group 5 MAOS, presented the highest values ($p < 0.05$) in the apical third. The lowest values ($p < 0.05$) found in the group 1 ULTRORE and group 3 ULTRO were observed in the cervical and middle thirds, respectively, without significant differences between them ($p > 0.05$). In group 1 ULTRORE, group 3 ULTRO, group 4 ULTRE and group 5 MAOS, a higher ($p < 0.05$) presence of residual was observed in the apical third. Assessing the third of the root canal, the cervical third presented lower values of residuals by means of group 1 ULTRORE. In the middle third, group 1 ULTRORE, group 3 ULTRO and group 6 RO presented the lowest values ($p < 0.05$). In the apical third, the lowest values ($p < 0.05$) were found group 2 RE and group 6 RO.

Table I - Presence of residual according to the retreatment protocol

Group 1 ULTRORE	Group 2 RE	Group 3 ULTRO	Group 4 ULTRE	Group 5 MAOS	Group 6 RO
12 (40%) ^{a*}	14 (46.6%) ^a	11 (36.6%) ^a	17 (53.3%) ^b	22 (73.3%) ^c	14 (46.6%) ^a

* Different letters indicate statistically significant differences ($p < 0.05$)

Table II - Presence of residual according to the root canal third

Root canal third	Cervical	Middle	Apical
Total	19 (20.8%) ^{a*}	30 (32.9%) ^b	42 (46.1%) ^c

* Different letters indicate statistically significant differences ($p < 0.05$)

Table III - Presence of residual according to the retreatment protocol and root canal third

Third/Protocol	Cervical	Middle	Apical
Group 1 ULTRORE	01 ^{A*.a**}	03 ^{A.a}	08 ^{B.a}
Group 2 RE	03 ^{A.b}	06 ^{B.b}	05 ^{B.b}
Group 3 ULTRO	03 ^{A.b}	01 ^{B.a}	07 ^{C.a}
Group 4 ULTRE	04 ^{A.b}	07 ^{B.b}	07 ^{B.a}
Group 5 MAOS	04 ^{A.b}	09 ^{B.c}	09 ^{B.a}
Group 6 RO	04 ^{A.b}	04 ^{A.a}	06 ^{B.b}

* within the lines, different capital letters indicate statistically significant differences ($p < 0.05$)

** within the columns different lowercase letters indicate statistically significant differences ($p < 0.05$)

Discussion

There are significant differences between the endodontic retreatment protocols to remove filling materials in flattened/oval-shaped root canals. The null hypothesis was rejected.

Endodontic retreatment involves filling material removal and cleaning of the root canal in order to neutralize the irritating factors that may have led to failure of the initial treatment [6, 7, 22]. Different studies have demonstrated that it is not possible to completely remove filling material during retreatment, regardless the system used [2, 13, 15, 24], corroborating with the findings of this present study. Another finding observed was that the use of ultrasonic instrumentation did not eliminate completely the amount of residual in endodontic retreatment. Rivera-Peña *et al.* [17] evaluated the influence of ultrasonic instrumentation as an auxiliary method for removing filling material from flattened/oval-shaped canals evidencing a higher presence of residuals in the group that did not use ultrasonic instrumentation. In contrast, Kaloustian *et al.* [10] showed that the percentage of residual material was not significantly different among the groups regarding use of ultrasonic tips.

Therefore, there is no evidence that ultrasonic instrumentation can be responsible for the complete removal of filling material in endodontic retreatment, suggesting new studies in this subject. Concerning rotatory and reciprocating instrumentation, this study observed lower residuals after endodontic retreatment compared to the use of manual and oscillatory instrumentation, in accordance with the results of Patil *et al.* [12]. Regarding root canal thirds, Rivera-Peña *et al.* [17] showed lower residual in the cervical third when ultrasonic instrumentation was used, the same was not seen in the middle and apical thirds.

In this present study, there were statistical differences regarding the presence of root canal residual in root canal thirds. The cervical third presented less presence of residual, which could be explained by the fact that the apical third has more difficult access in relation to the cervical third. However, the presence of debris in all thirds has already shown a failure in the gutta-percha removal process. The positive control group permitted validated the integrity of the sample and the applied methodology.

Study methods to determination of operative procedure errors, such as presence of residual in dentin include periapical radiography, stereomicroscope, scanning electron microscopy,

computerized microtomography as well as cone beam computed tomography (CBCT) [5, 9, 11, 16, 23]. Thus, studies on the dentin microstructure requires techniques that allow to observe details of its morphology. Scanning electron microscopy (SEM) allows assess with high magnifications. In order to evaluate the properties and the structure of the dentine in SEM it is necessary that there is a slight demineralization of its surface, which could interfere with the results. On the other hand, use of SEM allows the superficial topographic analysis. Therefore, SEM could be used for analysis in the removal of smear layer, verification of sealer penetration inside dentinal tubules as well as another related area [9]. The literature presents shortage of studies with SEM analysis involving filling material residuals, in topographic analysis. This fact deserves investigation in the interpretation of images and data, being useful in the analysis of the structures. Raj *et al.* [16] applied SEM to analyze the cervical, middle and apical thirds after retreatment with magnification of 1000x. The ProTaper Retreatment® had less residual in the middle third compared to manual files, higher residuals were found in the apical third. Similar results were found in the present study.

It should be considered that the complex anatomy of the dental group used in the present study may have influenced the effectiveness of endodontic retreatment protocol, as it is known of the difficulty of action of endodontic instruments in flattened/oval-shaped root canals. Crozeta *et al.* [5] evaluated filling material removal from distal oval-shaped canals of mandibular molars with rotary, reciprocating, and adaptive motion systems by using micro-computed tomography. Twenty-one teeth were prepared up to a size 40 file, root filled, according to the filling material removal technique: group PTUR, ProTaper Universal Retreatment combined with ProTaper Universal F2, F3, F4, and F5 files; group RP, Reciproc R50 file; and group TFA: TF Adaptive 50.04 files. The specimens were scanned preoperatively and postoperatively to assess filling material removal by using micro-computed tomography imaging, and the percent volume of residual filling material was calculated. The use of the adaptive motion increased the amount of root filling removed in the middle and apical thirds compared with the reciprocating motion. However, no technique was able to completely remove the filling material from the canals.

The prospects for the continued search for strategies of retreatment for the removal of filling material in clinical cases requiring new non-surgical

endodontic interventions should continue, especially with the use of new obturator materials.

Conclusion

The endodontic retreatment protocols tested no showed effectiveness for complete removal of remaining sealing material from flattened/oval-shaped root canals.

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