ORIGINAL RESEARCH

Assessment of Apical Extrusion using Rotary and Reciprocating Systems during Root Canal Retreatment

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Abstract

Aim: The objective of this study was to assess apical extrusion after filling material removal using two systems, one rotary and one reciprocating.

Materials and methods: A total of 34 extracted mandibular premolars with single roots were selected and, posteriorly, prepared and filled. Following material aging for 60 days, teeth were divided into two groups, according to the method used to remove root filling material: group I, ProTaper® Universal Retreatment instruments plus refining with the Hero 642® sequence and group II, WaveOne® instruments. The teeth were fixed in an apparatus designed to collect the extruded material during removal procedure. Data on the amount of debris extruded (mg/weight) were analyzed using the Student's *t* test with a significance level of 5%.

Results: No significant differences were found between the groups with regard to the amount of material extruded during root canal retreatment.

Conclusion: The present findings suggest that the extrusion of debris during apical root canal retreatment does not depend on the instrument design or the protocol employed.

Clinical significance: Regardless of root canal clearance techniques, debris extrusion eventually occurs during endodontic retreatment and may be related to postoperative pain.

Keywords: Apical extrusion, Reciprocating system, Rotary system, Root canal retreatment.

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Introduction

Root canal retreatment procedures are performed when failure of the original treatment is clinically and radiographically confirmed.[1] Among the treatment options available, nonsurgical root canal retreatment is the first choice.[2] It includes filling material removal, reinstrumentation, and new obturation of the root canal system with the aim of creating a favorable environment for the recovery of periapical tissues.[3,4]

Among the several techniques described in the literature for the removal of filling material, the use of nickel–titanium (NiTi) rotary systems, especially the ProTaper® Universal Retreatment System (Dentsply Maillefer, Ballaigues, Switzerland), stands out.[2,5–7] These instruments were especially designed to remove filling material from root canals,[8] and their effectiveness, cleaning ability, and safety have been demonstrated.[9–11]

More recently, reciprocating instruments have been released, with important advantages in root canal instrumentation.[12,13] These instruments have also been used for root canal retreatment, following the same original technique, i.e., brushing movements against the lateral walls of the root canal so as to remove residual filling material.[3,11–13]

During the chemical–mechanical preparation of root canals, dentin debris, remaining pulp tissue, irrigating solutions, microorganisms, and their byproducts are frequently extruded from the apical foramen into periapical tissues.[14] This may have serious consequences and cause delays in the healing process.[4,15,16] In this sense, using an instrumentation technique that can reduce the amount of apically extruded debris would be extremely advantageous.[17]

The objective of this *in vitro* study was to assess apical extrusion after filling material removal in root canals of mandibular premolars using the ProTaper Universal Retreatment rotary system plus refining with the Hero 642® system (Micro-Mega®, Besançon, France), compared with the single-file WaveOne Large® reciprocating system (Dentsply Maillefer).

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Materials and Methods

This study was approved by the Research Ethics Committee of Faculdade Meridional IMED, Passo Fundo, Southern Brazil (protocol no. 1096000). Sample size was calculated considering a power of 90% and the ability to detect correlations at 0.05%. The sample comprised 34 human teeth obtained at the Tooth Bank of Universidade do Oeste de Santa Catarina, in Joaçaba, Southern Brazil.

Mandibular premolar teeth showing fully developed, intact roots and full or partial crowns were included. Exclusion criteria were presence of a second canal, calcified roots, severe

curvature, restorations with posts, resorptions, diffuse or localized calcifications, root fractures, and canal atresia. Digital radiographs were obtained to confirm inclusion in the study. The selection of this dental group was due to the lower anatomical variation of the root canals with lower curvature indices, facilitating the length standardization.

Radiographs were used to assess the feasibility of removing filling material in the two groups assessed.

Teeth were cleaned, and remnants of periodontal ligament were removed by scraping. Then, teeth were washed in running water and immersed in thymol solution 0.2%, changed weekly. Prior to instrumentation, teeth were immersed in water for 24 hours to eliminate any traces of thymol and then allowed to air dry at room temperature.

Surgical access was gained using a #1012 HL spherical diamond bur (KG Sorensen®, Barueri, Brazil) at high-speed rotation under water-spray refrigeration (KAVO, Joinville, Brazil). Canals were located with the aid of a straight exploratory probe and then irrigated with saline solution (BASA®, Caxias do Sul, Brazil), delivered using a 5-mL disposable plastic syringe (Descarpack, São Paulo, Brazil). Chlorhexidine gel 2% with Natrosol (Natufarma® Farmácia, Passo Fundo, Brazil) was used as an auxiliary chemical substance, replacing sodium hypochlorite, delivered using a 3-mL syringe (Descarpack). Both syringes (5-mL and 3-mL) were used with 20 × 5.5/2 (5-mm) needles (BD, Curitiba, Brazil). Before tooth measuring, root canals were explored throughout their length using a #10 K-file (Dentsply Maillefer) to confirm apical patency.

Root length was determined by leveling the active tip of a #15 K-file (Dentsply Maillefer) with the apical foramen (zero point), thus establishing the actual working length. The apical foramen was standardized via instrumentation with a #15 K-file. Root canals were subjected to biomechanical preparation (hybrid technique), first using the reciprocating WaveOne Small #21/.06 file (Dentsply Maillefer) to working length, followed by Hero 642 rotary instruments, in the following sequence: 25/.02, 25:04, and 30/.02. All instruments were used to point zero, with irrigation and aspiration at each instrument change. Rotary and reciprocating instruments were coupled with an X-Smart Plus motor (Dentsply Maillefer) operated at 350 rpm and with 2.8 N of torque for the rotary system.

Once instrumentation was completed, a #15 K-file was once again introduced to the apical foramen to confirm patency. Root canals were irrigated with ethylenediaminetetraacetic acid 17%, pH 7.5 (Natufarma® Farmácia), for 3 minutes, followed by a final flush with saline solution.

Before obturation, teeth were dried by aspiration (disposable cannula), followed by the use of absorbent paper points (Dentsply Maillefer) compatible with the memory instrument and according to the actual working length. Then, an Odous FM gutta-percha cone (Odous FM Extra Long; Odous de Deus, Belo Horizonte, Brazil) was calibrated and adjusted according to the size of the memory instrument, ensuring that it was locked at 2 mm short of the actual working length.

The teeth were sealed using individual cones and AH Plus® cement (Dentsply Maillefer) with the hydraulic condensation technique. New digital radiographs were obtained at this point to assess the quality of obturation.

Teeth were stored in a bacteriological incubator at 37°C and 100% humidity, for 60 days, to allow the filling material to age. Then, specimens were randomly assigned to one of the two groups (n = 14), according to the method used to remove root filling material: group I, ProTaper Universal Retreatment Rotary System to working length, plus refining with the Hero 642 sequence (last instrument: #45/.02), and group II, WaveOne single-file reciprocating system (Large 40/.08). Obturated teeth were wrapped in gauze and fixed to a vise. Coronal sealer was removed using a #1012 diamond bur (KG Sorensen®) at high-speed rotation and observing a depth equivalent to the active tip of the bur.

Following coronal sealer removal, teeth were fixed to the apical extrusion collection system. Apical extrusion debris were collected and analyzed using a collection system with paper filters weighed before and after instrumentation, dried in an incubator for 24 hours, and then weighed again for analysis. A cylinder was fabricated from medium-density fiberboard with a hole in the center for attachment of an Eppendorf microtube (microcentrifuge tube, 1.5 mL; Kasvi, China). On the microtube lid, another hole was made to allow attachment of the tooth, and the end of the tube, left suspended, was cut open to allow extrusion of debris into a size 100 paper filter (Melitta® do Brasil, São Paulo, Brazil). The filter was supported by a plastic cone (Original 100; Melitta® do Brasil) placed on top of a collecting cup (Melitta® do Brasil) to collect the extinct shutter material (Fig. 1).

One drop of eucalyptol (Biodinâmica®, Ibiporã, Brazil) was placed at the root canal entrance and left to act for 1 minute. This was used for the purpose of softening the gutta-percha facilitating the entry of the instruments.

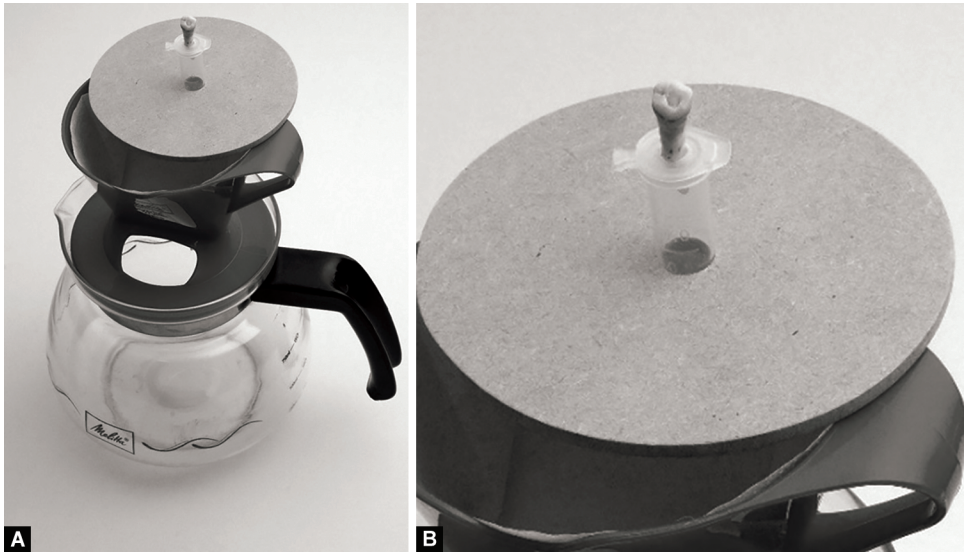
Rotary and reciprocating instruments were used three times and then discarded or earlier when any sign of fatigue/distortion was observed. All procedures were conducted by one single endodontist.

During filling material removal, the irrigants, auxiliary chemical substances, and syringes employed were the same as mentioned earlier. Chlorhexidine gel 2% was placed at the root canal entrance, and saline solution was vigorously injected into the canal using a 5-mL syringe and then aspirated using a disposable cannula, both after instrumentation and at each instrument change. Instrumentation was performed to 1 mm beyond the actual working length.

Group I: ProTaper Universal Retreatment Plus Hero 642

Filling material was removed using ProTaper Universal Retreatment rotary instruments D1, D2, and D3 (#30/.09, #25/.08, and #20/.07, with lengths 16, 18, and 22 mm, respectively). In all specimens, D1 was used to 4 mm (coronal third), with smooth penetration movements and traction, across the long axis of the root, in apical direction, with a maximum amplitude of 3 mm, on all walls. The second instrument (D2) was used to the middle third of the root, and the third (D3) in the apical third, to working length. All instruments followed the same kinematics, coupled with the X-Smart Plus motor, operated at 500 rpm and torque ranging from 1.5 N cm to 2.0 N cm.

Subsequently, root canals were refined using Hero 642 instruments, in the following sequence: 25/.02, 30/.02, 35/.02, 40/.02, and 45/.02. Instruments were coupled with the X-Smart Plus motor at 350 rpm and torque of 2.8 N, always to 1 mm beyond the working length (foramen cleaning). Smooth brushing movements were made on the canal walls until the instrument was loose inside the canal.



Figs 1A and B: (A) Apical extrusion collection system developed by the authors; (B) Detail showing the supporting structure for the attachment of the microtube

Group II: WaveOne Large

Filling material was removed using the WaveOne mechanized single-file reciprocating system with the large file (#40/.08). The instrument was introduced into the root canal, then three smooth, small angled engaging/disengaging cutting cycles were made, and the instrument was removed and cleaned. Canals were irrigated with both saline solution and the auxiliary chemical substance and then the file was reintroduced into the canal and a new cycle was started, and so on, until reaching 1 mm beyond the foramen. In this group, the X-Smart Plus motor was set to the specific reciprocating program, according to the manufacturer's instructions.

Following instrumentation, any debris adhered to the end of the root were scraped using the inferior edge of the microtube, and the root apex was rinsed with 3 mL of saline solution to wash out any remaining debris. Subsequently, filters were stored in individual plastic envelopes, placed in an incubator at 37°C for 12 hours to dry and then kept at room temperature for 24 hours. Filters were handled cleaned every time with alcohol 70°.

Apical debris were weighed using a precision balance (Shimadzu AY220; Shimadzu do Brasil, São Paulo, Brazil) precise to 0.0001 g. At each weighing, the tare key was pressed to reset the balance; weighing started once the stable indicator was on. The balance was calibrated by weighing each specimen twice and recording the two values, to confirm that it remained constant. Data were recorded in a spreadsheet for the subsequent analysis.

Data on the amount of debris extruded (milligram/weight) were analyzed quantitatively using the Student's *t* test. Analyses were performed using the Statistical Package for the Social Sciences version 20.0 at a significance level of 5%.

Results

Mean values obtained for apical extrusion were 0.0187 ± 0.002466 g in group I and 0.01934 ± 0.004159 g in group II (Student's *t* test, $p = 0.623$). There was no statistically significant difference between the groups analyzed ($p > 0.05$).

Discussion

This *in vitro* study compared the amount of apical debris extruded after filling material removal using the rotary ProTaper Universal Retreatment system associated with refining with Hero 642 instruments vs the reciprocating WaveOne system. Filling material extrusion is a common finding and retreatment, and no technique has so far been able to eliminate this problem. Some studies have shown that the different techniques and systems available result in different amounts of debris extruded.[18–20]

The method traditionally used for collecting extruded materials is the Myers and Montgomery method.[21] Nevertheless, the amount of materials extruded using that method is usually extremely low; furthermore, contact with moist or greasy fingertips may affect the final weight of extruded debris.[14,22] Therefore, here, we proposed a new methodology to measure the amount of apically extruded debris. The method was simple, accessible, easily reproducible, and eliminated the possibility of fingertip contamination.

Another important methodological consideration is related to the selection of teeth for the present sample. Only single-rooted mandibular premolars, with a single root canal, were used. Despite anatomical variations, the teeth included were standardized in terms of their length (mean of 22 mm), and special care was taken so as to form two groups with similar anatomical characteristics.

In this study, the amount of extruded debris from the apical foramen of teeth during the removal procedure of root canals with different protocols did not show significant differences ($p > 0.05$). Bürklein and Schäfer,[16] in turn, found a significantly higher amount of materials apically extruded with WaveOne compared with Mtwo and ProTaper. They concluded that reciprocal motion seemed to increase transportation of debris toward the apex, whereas continuous rotation seemed to improve coronal transportation of dentin chips and debris by acting like a screw conveyor.

In group I, refining of the root canal preparation was necessary for two reasons: first, ProTaper Universal Retreatment instruments were not designed for root canal preparation but rather for filling material removal; second, the diameter of the D3 file (#20) of the ProTaper Universal Retreatment system does not allow optimal

cleaning and shaping of the apical portion of the root canal.[23] In this study, the Hero 642 sequence of rotary files was used for refining. In group II, WaveOne Large (40/.08) was used.

In both groups, the working length was set to 1 mm beyond the apical foramen to ensure apical preparation of teeth and thus promote preparation and cleaning of the apical foramen. However, practitioners should be careful and ensure the use of files with a lower taper and cross section, with high flexibility, and consequently with a lower tendency to produce dentin defects.[24]

Careful consideration is needed when extrapolating the results of this study to the clinical setting, as the *in vitro* methodology here employed allowed the apex of each specimen to be suspended in the air, without any physical back pressure; conversely, in an *in vivo* situation, granulomatous, periradicular tissues would be surrounding the tooth apex, possibly limiting apical extrusion.[14,25] Moreover, no attempt was made in this study to simulate the periodontal ligament, as the approaches used in the previous studies have been shown to absorb irrigating solution and debris, interfering with extrusion results.[26,27]

Regardless of the system used, both instrumentation techniques produced extrusion debris. Further studies should evaluate the behavior of the newly introduced NiTi systems during both treatment and retreatment of root canals.

Conclusion

Within the limitations of this study, no significant differences were observed between the rotary ProTaper Universal Retreatment system combined with Hero 642 and the reciprocating WaveOne Large system with regard to apical extrusion during the removal procedure of root canals.

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