Article published online: 2021-11-01

Original Article

Evaluation of Apical Debris Extrusion during Endodontic Retreatment by Different Systems

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Abstract

Aim: This study sought to evaluate the amount of apical debris extrusion during the removal of filling material (RFM) performed by the ProTaper-Retreatment (ProTaper-R), Mtwo-Retreatment (Mtwo-R), Reciproc, and hand files. **Materials and Methods:** Sixty lower premolars were prepared using the ProTaper Universal system and filled with thermoplastic technique. Subsequently, the samples were randomly divided into four groups ($n = 15$) according to the system used for the removal of the filling material: Mtwo-R (R25/.05); ProTaper-R (D1, D2, and D3); Reciproc (R25); and hand file (type K and Hedstroem stainless steel files). The apical debris extrusion was evaluated before and after the RFM from the root canal by weighing Eppendorf tubes on a high-precision balance. Statistical analysis was performed using the ANOVA test followed by the Tukey's test ($P < 0.05$). **Results:** All of the systems produced apical debris extrusion; however, the Mtwo-R group demonstrated significantly more extrusion as compared with the ProTaper-R and Reciproc groups ($P < 0.05$). There was no statistically significant difference between the Reciproc, ProTaper-R, and hand file groups ($P > 0.05$). **Conclusions:** The Mtwo-R group produced significantly more extrusion than did the ProTaper-R and Reciproc groups. There was no difference between the Reciproc, ProTaper-R, and hand file groups.

Keywords: Endodontic, filling materials, retreatment, root canal

Introduction

Endodontic retreatment aims to ensure complete removal of filling material (RFM) and to eliminate necrotic debris and remaining microorganisms to reestablish the health and normal conditions of the periapical tissues.[1-3] Retreatment is indicated when failure of primary endodontic treatment occurs, which can be due to technical failures, complexity of the root anatomy, and/or persistence of infection in the apical portion of the root canal.[4,5]

Different techniques have been proposed for performing the RFM during retreatment, including the use of continuous motion rotary instruments such as the ProTaper Universal Retreatment (ProTaper-R) (Dentsply Maillefer, Ballaigues, Switzerland), Mtwo Retreatment (Mtwo-R) (VDW, Munich, Germany), D-RaCe (FKG Dentaire, La Chaux-de-Fonds, Switzerland), and R-Endo (Micro-Mega, Besançon, France), and those with reciprocating movement including Reciproc (VDW, Munich, Germany), Reciproc Blue (VDW, Munich, Germany), and WaveOne Gold (Dentsply Maillefer, Ballaigues, Switzerland). Such instruments are generally employed because of the decrease in working time associated with their use versus that of hand files.[6-9] However, there is no consensus to date on the effectiveness of rotary instruments as compared with hand files in RFM.[6-10]

During RFM, the extrusion of the filling material, necrotic pulp tissue, microorganisms, and irrigators to the periapical[11] can occur causing irritation in the periapical tissues, postoperative pain, and difficulty in repairing the periapical tissue.[12,13] In general, apical debris extrusion occurs in RFM regardless of the technique, motion, and type of instrument used.[14-24]

There is no consensus regarding the apical debris extrusion caused by hand and rotary techniques. Chandrasekar

Access this article online

Quick Response Code:

Website: www.ejgd.org

DOI: 10.4103/ejgd.ejgd_114_19

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How to cite this article: Dadalti MT, Almeida NE, Ormiga F, Risso PA. Evaluation of apical debris extrusion during endodontic retreatment by different systems. Eur J Gen Dent 2020;9:69-72.

Submitted: 02-Aug-2019 **Accepted:** 07-Jan-2020
Published: 29-Apr-2020

et al.[17] verified that the hand files caused less debris extrusion compared to the rotary. However, other authors observed that the hand files caused more debris extrusion compared to the rotary.[14,16] There is also a divergence of findings of apical debris extrusion caused by the employment of different kinematics systems.[15,18,25] Dincer *et al*.[18] and Silva *et al*.[15] observed that reciprocating instruments extruded less than continuous rotations, whereas Çanakçi *et al*.[25] reported the opposite. Thus, the aim of the present study was to evaluate apical debris extrusion during RFM performed by the ProTaper-R, Mtwo-R, Reciproc, and hand files.

Materials and Methods

This study was approved by the Local Ethics Committee (protocol No. 44100015700005257). Sixty human premolars with a single canal, fully formed apex, and curve up to 25°[26] were selected. Teeth with incomplete root formation, resorption, calcification, or previous endodontic treatment were excluded. Thereafter, X-rays in the buccolingual and mesiodistal directions were carried out.

The access cavity was prepared using diamond drills under constant irrigation. A size 10 K-file (VDW, Munich, Germany) was then introduced passively into the canal until the tip was flush with the root surface. The working length (WL) was determined 1 mm shorter than that measurement.

All canals were prepared with ProTaper Universal (Dentsply-Maillefer, Ballaigues, Switzerland) nickel–titanium rotary files according to the manufacturer's recommendations, through the use of the X-Smart Plus (Dentsply-Maillefer, Ballaigues, Switzerland) endodontic motor. Irrigation with 2 mL of 5.25% sodium hypochlorite was performed after each instrument. The F3 instrument was the last used in the WL. At the end of the instrumentation, the canal was irrigated with 2 mL of 17% ethylenediaminetetraacetic acid for 3 min; subsequently, the canal was irrigated with 5 mL of 5.25% sodium hypochlorite, and a final irrigation with 5 ml distilled water was performed. The root canals were dried with paper points and an association of the Continuous Wave Compaction technique and the hybrid Tagger technique was used to fill the canals with gutta-percha F3 cones of the ProTaper system and AH Plus root canal Sealer (Dentsply-Maillefer, Ballaigues, Switzerland).

The filling compaction was confirmed by orthogonal and 90° angled X-ray. The teeth with bubbles and voids in the filling material were discarded. Following the temporary restoration of access cavities with a zinc-oxide-based shutter, the teeth were stored in an incubator at 37°C with 100% humidity for 7 weeks to allow for complete setting of the sealer.

Retreatment

At the end of the storage period, the dental crown was removed from the samples and the roots standardized to 13 mm of total length. All steps were performed by a single operator. Before the use of the files, the filling material was removed from the initial 3 mm of the canal with Gates Glidden drills (Dentsply-Maillefer, Ballaigues, Switzerland), in order to facilitate the penetration of instruments.

During the retreatment phase, no solvent was used; instead, only 2 mL of 5.25% sodium hypochlorite solution was used as the irrigating solution after each instrument. Instruments were used only in three canals and then discarded. There was a criteria used to indicate that an instance of RFM with one instrument was finished and that the next instrument should be started. The criteria were as follows: Active part of the instrument seen without debris after its removal from the canal; free penetration of instruments to patency without interference; and absence of gutta-percha in the walls of the canal observed by an optical microscope (D. Vasconcelos, São Paulo, SP, Brazil) with ×25 magnifying.

The instruments were used in an X-Smart Plus endodontic motor (Dentsply-Maillefer, Ballaigues, Switzerland). The Mtwo-R and ProTaper-R systems were used with individual torque and speed according to the manufacturer's recommendations, whereas Reciproc was used with reciprocating motion. The RFM sequences were as follows:

- Mtwo-R group: Instrument R25/.05 was used in the middle and cervical thirds with brushing motion on the walls of the canal, after the same instrument was used with a gentle in-and-out motion to reach the WL
- ProTaper-R group: The D1 instrument was used in the cervical third, in the first 4 mm passively, whereas the D2 instrument was used with brushing motion to the middle third and the D3 applied gentle pressure to the WL
- Reciproc group: The R25 instrument was used to penetrate the filling material with an in-and-out motion to the WL
- Hand file group: Type K and Hedstroem hand files were used in a "crown-down" sequence for gutta-percha removal to 3 mm short of the WL. After a size 15 K-file (Dentsply-Maillefer) was employed to open the space until the proximity of the WL, sizes 20, 25, and 30 K-files were used sequentially and were intercalated with H-files of a similar diameter to seize the gutta-percha and remove it.

Evaluation of debris extrusion

The extruded debris were collected in a preweighed Eppendorf tube attached to the lower edge of an individual silicone plug prepared for each tooth according the method described by Myers and Montgomery.[27] After removing the dental crown, the root apex was suspended by the cervical within the receptor tube. A second tube was used to hold the device during instrumentation. A disposable 27-gauge needle was inserted into the silicone plug, simulating a cannula, to balance the internal and external pressures. The Eppendorf tubes were sealed so that the operator could not observe the contents inside. In all groups, after RFM, the root was removed from the Eppendorf tube and the debris adhered to the outside of the root was collected by washing the root with 1 mL of distilled water inside the tube. The tubes were then placed in a dry heat oven at 37°C for 7 days to stimulate the evaporation of the irrigation solution.

A high-precision analytical balance (model FA-2104N; Bioprecisa, Brazil) with an accuracy of 10^{-4} g was used to evaluate the tubes before and after the instrumentation. The initial weighing of the Eppendorf tube was done before the tooth root was inserted and attached to the Eppendorf tube. The final weighing was completed after instrumentation, root removal from the Eppendorf tube, irrigation of the outside of the root, and drying. Three weighing sessions were performed and a mean was obtained for the initial and final weights. A single independent operator performed the weighing. The apical extrusion of debris was determined by the difference of the final dry weight average and the mean initial weight of each sample.

Statistical analysis

Data analysis was performed using the Statistical Package for the Social Sciences version 2.0 program (IBM Corp., Armonk, NY, USA). The data were analyzed by a blind and independent evaluator. The mean apical debris extrusion in grams was calculated for each group. The difference between the groups was analyzed statistically by the ANOVA variance test with Tukey's test ($P < 0.05$).

Results

In the Mtwo-R group, two samples were discarded due to instrument fracture during RFM of the middle third. The occurrence of perforations was not observed in any of the tested groups. Apical debris extrusion occurred in all groups [Table 1]. The Mtwo-R group produced significantly more extrusion than did the ProTaper-R and Reciproc groups ($P < 0.05$); however, there was no significant difference between the Reciproc, ProTaper-R and hand file groups ($P > 0.05$).

Discussion

During RFM, endodontic maneuvers should be performed to minimize apical debris extrusion and thus avoid flare-up.[13] In light of this, the present study aimed to evaluate the apical debris extrusion during RFM performed by different systems. It was verified that all four systems evaluated caused apical debris extrusion during RFM. However, the Mtwo-R group produced significantly more extrusion in comparison with the ProTaper-R and Reciproc groups.

The method used here for the evaluation of debris extrusion was proposed by Myers and Montgomery.[27] Although this method presents limitations due to the lack of inverse pressure, which would simulate the periodontal ligament, it is still widely used for such an evaluation.[14,15,19,25,28] Studies used distilled water as an irrigating substance because sodium hypochlorite forms crystals of sodium that can be added to the weight of the extruded debris apically.[18,28] However, as well as other studies,[14,25] we have chosen to use it to simulate more faithfully the clinical situation, because sodium hypochlorite is a widely used irrigating substance.

For standardization of the samples, we used mandibular premolars with a single straight canal and performed preinstrumentation of all samples with the ProTaper Universal system, ending with the F3 file. In addition, the removal of the dental crown and establishment of equal root lengths for all groups was completed.

The results of the present study revealed that all of the systems caused apical debris extrusion, which corroborated with previous findings.[14-24] When comparing the groups to one another, this study showed that Mtwo-R instruments caused a significantly greater amount of apical debris extrusion than the Reciproc and ProTaper-R instruments. A similar study also observed that the Mtwo-R group showed more extrusion as compared with the Reciproc group; however, unlike in the case of our findings, no difference was found between the Mtwo, ProTaper-R, and hand files in this previous study.[18] We believe that this discrepancy with our results is related to the final instrumentation performed after RFM used by Dincer *et al*.[18] In the present study, we evaluated only the apical debris extrusion caused by RFM.

Contrary to the results obtained here, Lu *et al*.[14] determined that Reciproc extruded significantly more than Mtwo-R. According to the authors, the reciprocating motion allows the instrument to advance continuously forward and such an action may push debris toward the apex. Separately, Çiçek *et al*.[21] observed no difference in the characteristics of debris extrusion between the ProTaper-R and Mtwo-R systems. These discrepancies as compared with our findings may be related to a difference in the filling technique performed before RFM, the irrigating substance used, and/or the choice of the instruments size used in RFM in relation to the canal diameter.

It was verified in the present study that there was no significant difference between the Reciproc, ProTaper-R, and hand file groups. Thus, although some studies suggest that the use of hand files causes greater apical debris extrusion when compared with rotary use[14,16,29] or the inverse,[17] we cannot in good faith suggest this based on our results. Similarly, we cannot confirm the hypothesis that the kinematics of the movement may influence the apical debris extrusion,[14,30] because the ProTaper-R system, a continuous rotary system,

Table 1: Amount of apical debris extrusion (g)

Apical debris extrusion	Mtwo-R	ProTaper-R	Reciproc	Hand file
Mean±SD	0.1112±0.1255	0.0605±0.0053	0.0038±0.0045	0.0432±0.0795
Minimum	0.0041	0.0003	0.0002	0.0015
Maximum	0.3624	0.0216	0.0170	0.2461

Mtwo-R – Mtwo retreatment, ProTaper-R – ProTaper Universal Retreatment, SD – Standard deviation

did not lead to a significant difference when compared with a reciprocating system. We agree with another study that reported that instrument design plays an important role in the amount of debris extruded apically.[29]

The tip of the last instruments used during RFM of Mtwo-R, ProTaper-R, Reciproc, and hand file groups had nominal diameters of 0.25 mm, 0.20 mm, 0.25 mm, and 0.30 mm, respectively. Although the tip diameter difference between the instruments used in the four groups varied in size between 0.05 mm and 0.1 mm, no difference was found between the ProTaper-R, Reciproc, and hand file groups. The Mtwo-R group extruded more than the other groups independently of having a similar sized tip diameter or not. In addition, we used instruments with such diameters because the ProTaper-R provides only one instrument to clear the apical third and among the instruments available from the Mtwo-R and Reciproc lines, the ones used were compatible with the tip diameter of the instrument F3 used in the instrumentation that preceded the canal filling. Thus, they are compatible with the apical diameter of the canal.

Conclusions

All four systems caused apical debris extrusion during RFM. The Mtwo-R group produced significantly more debris extrusion than did the ProTaper-R and Reciproc groups. There were no differences among the Reciproc, Protaper-R, and hand file groups.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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