INTERNATIONAL
ENDODONTIC JOURNAL

doi:10.1111/iej.12362

Apical extrusion of debris from root canals using reciprocating files associated with two irrigation systems

F. Xavier, G. Nevares, M. K. Romeiro, K. Gonçalves, L. Gominho & D. Albuquerque
Dental College of Pernambuco, University of Pernambuco, Camaragibe, Brazil

Abstract

Xavier F, Nevares G, Romeiro MK, Gonçalves K, Gominho L, Albuquerque D. Apical extrusion of debris from root canals using reciprocating files associated with two irrigation systems. *International Endodontic Journal*, **48**, 661–665, 2015.

Aim To compare apical extrusion of debris in canals prepared with two reciprocating file systems and two different irrigation systems.

Methodology Forty single straight root canals in human mandibular pre-molars were prepared using Reciproc R40 (REC) and WaveOne Large (WO) instruments. Before preparation, the dimensions of a size 40 instrument from each system were measured under scanning electron microscopy (SEM) at 80X. The teeth were randomly divided into four different groups of 10: REC and VPro EndoSafe (REC/VPro); WO/VPro; REC and conventional irrigation (REC/CI); and WO/CI Eppendorf tubes containing a single tooth were weighed on an analytical balance to the nearest 0.1 mg before instrumentation. Irrigation was performed with a total volume of 8 mL of 2.5% sodium hypochlorite. After instrumentation, the teeth were removed from the Eppendorf tube and incubated at 37 °C for 15 days to evaporate the liquid. The tubes were weighed again, and the difference between the initial and final debris weights was calculated and statistically evaluated using analysis of variance (two-way ANOVA) with a significance level of 0.05.

Results No significant difference was observed between the VPro and CI irrigation systems ($P > 0.05$). Apical extrusion of debris was confirmed in all samples, and extrusion was greater in the REC groups than in the WO groups ($P < 0.05$). The WO file had a 20% smaller diameter at the tip (D_0) than the measurement provided by the manufacturer.

Conclusions All systems were associated with apical extrusion of debris. The WO system was associated with less extrusion than the REC system. The amount of extruded debris was independent of the irrigation system used and was related to the instrumentation technique. Morphological analysis of instruments using SEM revealed no correlation between the diameter provided by the manufacturer and the measured diameter for the WO Large file.

Keywords: apical extrusion, endodontics, Reciproc, root canal irrigation, VPro EndoSafe, WaveOne.

Received 26 May 2014; accepted 31 July 2014

Introduction

A consequence of mechanical instrumentation, regardless of the system used, is the production of dentine shavings as a result of cutting the dentinal walls of root canals. Such debris must be removed using irrigation and canal aspiration procedures or via the flutes of endodontic instruments (Tanalp *et al.* 2006). However, some debris and irrigating fluid can be extruded through the foramen to the periapical tissue, and this extrusion has been associated with pain and/or edema on inflammatory response (Seltzer & Naidorf 1985, Siqueira 2003, Nair 2006). Mechanized instrumentation can minimize extrusion compared with manual

Correspondence: Felipe Xavier, Avenida Gal Newton Cavalcanti, 1650, Tabatinga, ZIP: 54753-901, Camaragibe, PE, Brazil (Tel.: +55 081 8832-1303; Fax: +55 081 3458-1476; e-mail: felipefatah@hotmail.com).

instrumentation (De-Deus *et al.* 2010, Ghivari *et al.* 2011). In addition to having a key role in antimicrobial activity, irrigation of the root canal aids in the removal of debris and is able to reach areas of the root canal untouched by endodontic instruments (Zehnder 2006). The VPro™Endosafe™ system (Vista Dental Products, Racine, WI, USA) was developed to optimize irrigation. According to the manufacturer, the system is a negative pressure system in which irrigation and aspiration are performed concurrently. The main advantages of the system include promoting a steady stream of irrigating solution from the apical to the coronal portion that avoids the risk of clogging the irrigation cannula and the fact that it is disposable. To date, the effectiveness of the VPro™ EndoSafe™ system in minimizing the apical extrusion of debris has not been tested.

This study aimed to compare the performance of the Reciproc® (VDW, Munich, Germany) and WaveOne® (Dentsply Maillefer, Ballaigues, Switzerland) instruments associated with the VPro™Endosafe™ irrigation system or conventional irrigation with respect to the apical extrusion of debris produced during the preparation of root canals. The null hypotheses tested were that there would be no difference in the amount of apically extruded debris between: (i) instrumentation and (ii) irrigation.

Materials and methods

Sample selection

The study was reviewed and approved by the Research Ethics Committee of the University of Pernambuco (Pernambuco, Brazil). Samples were selected according to the following parameters: mandibular pre-molars with intact roots, complete root formation and intact pulp chamber. The teeth were radiographed in the buccolingual and mesiodistal directions for the selection of single and straight canals (<10°), measured according to method of Schneider (1971). The Image J program (U.S. National Institutes of Health, Bethesda, MD, USA) was used to obtain canal curvature angles. The teeth were disinfected in a solution of 0.1% thymol for 24 h and stored in saline until use. After endodontic access, the teeth were explored with a size 10 file until its tip could be observed in the apical foramen with the help of Dental Operating Microscopy (DF Vasconcelos S/A, São Paulo, SP, Brazil) at 8X to determine the working length (WL). The crowns were reduced in height until the teeth reached 17 mm in length. The WL of all teeth was established at 1 mm short of the apical foramen. A size 20 file was inserted until the WL was reached. Teeth in which the file was loose when inserted or did not passively reach the WL were excluded. A total of 40 teeth met the criteria. The laboratory procedures were performed by a single operator. The 40 samples were numbered and randomly selected by computer (http://www.random.org) for distribution into four groups.

Initial weighing of the Eppendorf tubes

The experimental model used to evaluate debris extrusion was similar to that described by Myers & Montgomery (1991). An Eppendorf tube (Eppendorf AG, Hamburg, Germany) was numbered for each tooth, and a hole was created in the tube cap with a hot instrument. The Eppendorf tubes were individually weighed on an analytical balance to the nearest 0.1 mg (AUW220D, Shimadzu Analytical Balance, Tokyo, Japan). Five consecutive weightings were conducted for each tube, and the highest and lowest values were discarded. The arithmetic mean of three weights obtained was regarded as the initial weight of the Eppendorf tube. Thereafter, each root was embedded into the tube cap and affixed on the lateral side with cyanoacrylate and covered with a rubber dam to prevent accidental leakage of irrigating solutions during the experiment. The Eppendorf tube was placed in an opaque bottle to prevent the operator from being able to see the root canal during instrumentation. A 27-G needle was inserted into the Eppendorf cap to equalize internal and external pressure.

Scanning electron microscopy analysis (SEM)

Before instrumentation of the root canal, an instrument from each system was selected for SEM morphological analysis (FEI Quanta 200 FEG, Hillsboro, OR, USA). The Reciproc R40 and WaveOne Large instruments were photomicrographed with a Canon EOS 20D digital camera (Canon Inc., Tokyo, Japan) at 80X to analyse the D_0 diameters and presence of radial lands. Each image obtained was measured using the Image J program. The diameter was established by measuring the largest distance between the ends of the instrument perpendicular to its long axis. Instruments from the same batch were subsequently used in instrumentation.

Root canal preparation

The groups were distributed according to the instrumentation and irrigation systems used:

Reciproc and VPro ™ Endosafe™ Group (REC/VPro)
The pulp chamber and the canal were initially flooded with 2 mL of 2.5% sodium hypochlorite (NaOCl). The Reciproc® R40 size 40, .06 taper file was coupled to a VDW Silver (VDW) motor in the Reciproc programming. The file was used in smooth back and forth movements, and after three passes, the file it was cleaned with gauze, and the canal was irrigated with 2 mL of 2.5% NaOCl. Next, a size 10 file was used to maintain patency. These procedures were repeated three times until the file reached the WL. Irrigation was performed with the VPro™Endosafe™ system, according to manufacturer's guidelines. Needle penetration was standardized at 2 mm short of the WL, and the total volume of irrigant was standardized at 8 mL for each root.

WaveOne and VPro™Endosafe™ Group (WO/VPro)
The WaveOne® Large file size 40, .08 taper was coupled to a VDW Silver motor in the WaveOne programming. Instrumentation and irrigation were performed in the same manner as for the REC/VPro group.

Reciproc and conventional irrigation group (REC/CI)
Instrumentation was performed in the same way as for the REC/VPro group. Irrigation was performed with syringe and an open-end 30-G needle (NaviTip; Ultradent Products, South Jordan, UT, USA) in back and forth movements and positioned 2 mm short of the WL.

WaveOne and conventional irrigation group (WO/CI)
Instrumentation was performed in the same manner as for the WO/VPro group, and irrigation was performed as in the REC/CI group.

Final weighing of the Eppendorf tubes

The teeth were removed from the Eppendorf tubes, and their roots washed with 1 mL of NaOCl to collect the debris that had adhered to their outer side. All tubes were incubated at 37 °C for 15 days to allow the evaporation of the remaining irrigant from the tubes. After the incubation period, a final weighing was performed in the same manner as the initial weighing. The difference between the mean weights was calculated and statistically evaluated using the *F*-test (ANOVA) with two factors. Verification of the hypothesis of equality of variances was performed using Levene's *F*-test. The margin of error used in the statistical tests was 5.0%.

Results

Measurement of the SEM micrographs revealed that the D_0 of the Reciproc® system was compatible with that the reported by the manufacturer (0.40 mm). The WaveOne® system had a D_0 of 0.32 mm, 20% lower than that reported by the manufacturer (0.40 mm).

All instrumentation and irrigation systems caused apical extrusion of debris (Table 1). Significant differences were found between the instruments with respect to the apical extrusion of debris, with the Reciproc group exhibiting the greatest extrusion ($P = 0.048$). No significant difference was observed between the irrigation systems ($P = 0.503$). There was no interaction between the instruments and irrigation systems employed ($P = 0.333$).

Discussion

The results of this study demonstrated that the Reciproc® system extruded significantly more debris than the WaveOne® system ($P < 0.05$); therefore, the null hypothesis (i) was rejected. The results of a study by Bürklein & Schäfer (2012) were similar to those of the present study. Previous studies have indicated that greater apical extrusion may be related to the following: preparation technique, instrument design and differences in instrument taper (Bürklein & Schäfer 2012, Bürklein *et al.* 2014). The preparation technique recommended by the manufacturers of both systems is similar, despite the fact that the reciprocating movements are performed at different angles. The Reciproc® file is used with rotation angles of 150° counterclockwise and 30° clockwise, whereas the WaveOne® file is used at 130° and 50°, respectively.

Table 1 Amount of debris extruded apically after using the instruments and irrigation systems (grams)

Groups	Mean	SD	Max.	Min.	*n*
REC/VPro	0.10364	0.01078	0.12891	0.09411	10
WO/VPro	0.09785	0.00415	0.10379	0.09106	10
REC/CI	0.11267	0.03224	0.18287	0.09038	10
WO/CI	0.09619	0.00352	0.10065	0.09106	10

The Reciproc® system has a cross-sectional shape in the form of an S along the entire length of the working part, sharp cutting edges and no radial lands (Fig. 1), whereas the WaveOne® system has a different cross-sectional design along its entire active part, the tip has a triangular cross section modified with radial lands (Fig. 1), and there is a change to a neutral rake angle with a convex triangular transverse cross section in the middle and neck portions of the working part of the instrument (Bürklein *et al.* 2012). Thus, the WaveOne® system may have less cutting power and would produce less debris. As a consequence, decreased apical extrusion of debris is suggested, as was found in the results of this study. The Reciproc® R40 file (size 40, .06 taper) has a constant taper in the first 3 mm of the working part that decreases to D16, whereas the WaveOne® Large file (size 40, .08 taper) has decreasing taper along its entire length (Bürklein *et al.* 2012). It can be speculated that the greater taper at the tip of the WaveOne® file promotes greater debris extrusion than the Reciproc® due to the greater preparation of the dentinal walls. However, the Large file analysed by SEM in this study had a D_0 20% lower than that reported by the manufacturer, whereas for the R40 file, the D_0 was compatible with the measurements published by the manufacturer. This finding suggests that according to the taper established by the manufacturer, at D_1, the Large file is 0.40 mm and the R40 is 0.46 mm. This lower diameter of the Large file may be one reason for the reduced debris extrusion of WaveOne® observed in this study.

The results revealed no significant difference in the irrigation systems used ($P > 0.05$). Therefore, the null hypothesis (ii) was accepted. The manufacturer reports that the VPro™Endosafe™ system generates negative apical pressure through simultaneous irrigation and aspiration. Tambe *et al.* (2013) demonstrated that a negative pressure system (Endovac; SybronEndo Specialties, Orange, CA, USA) promoted decreased apical extrusion of debris than conventional irrigation. However, Khan *et al.* (2013) observed that the VPro™Endosafe™ system, unlike Endovac, cannot be considered a negative pressure system because it generates greater positive apical pressure than conventional irrigation.

In the present study, single-rooted mandibular premolars with mature apices and straight root canals were selected. All teeth were measured and decoronated at same length to assure standardization. In terms of the acquisition and analysis of debris extruded apically, this study was based on methodology of the Myers & Montgomery (1991) (Koçak *et al.* 2013, Tanalp & Güngör 2013, Yeter *et al.* 2013, De-Deus *et al.* 2014). The debris collection apparatus, proposed previously, was slightly modified using an Eppendorf supported on an opaque vial to allow the operator blinded view during procedures, minimizing possible bias. No attempt to simulate periapical tissue was made. Clinically, periapical tissue promotes a physical barrier, minimizing the apical extrusion of debris (Bonaccorso *et al.* 2009). This fact limits extrapolation of the results to the clinical environment, which is considered a weak point in most

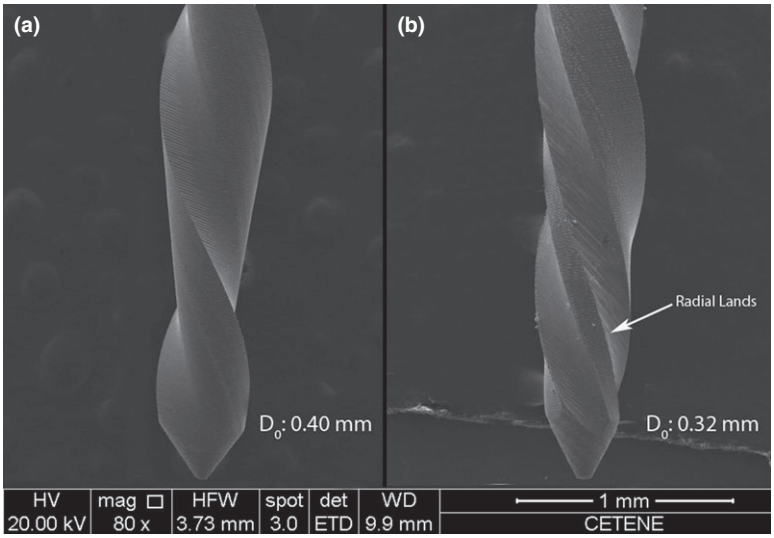

Figure 1 SEM images of the apical portion of the R40 (a) and WO Large (b) files (x80).

extrusion studies (Bürklein & Schäfer 2012, Tanalp & Güngör 2013, De-Deus *et al.* 2014).

Conclusion

Morphological analysis of files using SEM revealed no correlation between the diameter reported by the manufacturer and that measured in the WaveOne Large file. Although both systems caused the apical extrusion of debris, the WaveOne® system was associated with less extrusion than the Reciproc® system. The amount of extruded debris was independent of the irrigation system used and was related to instrumentation technique and size.

Acknowledgement

Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES) and Centro de Tecnologias Estratégicas do Nordeste (CETENE).

References

Bonaccorso A, Cantatore G, Condorelli GG, Schäfer E, Tripi TR (2009) Shaping ability of four nickel-titanium rotary instruments in simulated S-shaped canals. *Journal of Endodontics* **35**, 883–6.

Bürklein S, Schäfer E (2012) Apically extruded debris with reciprocating single-file and full-sequence rotary instrumentation systems. *Journal of Endodontics* **38**, 850–2.

Bürklein S, Hinschitza K, Dammaschke T, Schäfer E (2012) Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals of extracted teeth: Reciproc and WaveOne versus Mtwo and ProTaper. *International Endodontic Journal* **45**, 449–61.

Bürklein S, Benten S, Schäfer E (2014) Quantitative evaluation of apically extruded debris with different single-file systems: Reciproc, F360 and OneShape versus Mtwo. *International Endodontic Journal* **47**, 405–9.

De-Deus G, Brandão MC, Barino B, Di Giorgi K, Fidel RA, Luna AS (2010) Assessment of apically extruded debris produced by the single-file ProTaper F2 technique under reciprocating movement. *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics* **110**, 390–4.

De-Deus GA, Nogueira Leal Silva EJ, Moreira EJ, de Almeida Neves A, Belladonna FG, Tameirão M (2014) Assessment of apically extruded debris produced by the self-adjusting file system. *Journal of Endodontics* **40**, 526–9.

Ghivari SB, Kubasad GC, Chandak MG *et al.* (2011) Apical extrusion of debris and irrigant using hand and rotary systems: a comparative study. *Journal of Conservative Dentistry* **14**, 187–90.

Khan S, Niu L, Eid AA *et al.* (2013) Periapical pressures developed by nonbinding irrigation needles at various delivery rates. *Journal of Endodontics* **39**, 529–33.

Koçak S, Koçak MM, Saglam BC *et al.* (2013) Apical extrusion of debris using self-adjusting file, reciprocating single-file, and 2 rotary instrumentation systems. *Journal of Endodontics* **39**, 1278–80.

Myers GL, Montgomery S (1991) A comparison of weights of debris extruded apically by conventional filing and Canal Master techniques. *Journal of Endodontics* **17**, 275–9.

Nair PN (2006) On the causes of persistent apical periodontitis: a review. *International Endodontic Journal* **39**, 249–81.

Schneider SW (1971) A comparison of canal preparations in straight and curved root canals. *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics* **2**, 271–5.

Seltzer S, Naidorf IJ (1985) Flare-ups in endodontics: I. Etiological factors. *Journal of Endodontics* **11**, 472–8.

Siqueira JF (2003) Microbial causes of endodontic flare-ups. *International Endodontic Journal* **36**, 453–63.

Tambe VH, Nagmode PS, Vishwas JR, P SK, Angadi P, Ali FM (2013) Evaluation of the Amount of Debris extruded apically by using Conventional Syringe, Endovac and Ultrasonic Irrigation Technique: an In Vitro Study. *Journal of International Oral Health* **5**, 63–6.

Tanalp J, Güngör T (2013) Apical extrusion of debris: a literature review of an inherent occurrence during root canal treatment. *International Endodontic Journal* **47**, 211–21.

Tanalp J, Kaptan F, Sert S *et al.* (2006) Quantitative evaluation of the amount of apically extruded debris using 3 different rotary instrumentation systems. *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics* **101**, 250–7.

Yeter KY, Evcil MS, Ayranci LB *et al.* (2013) Weight of apically extruded debris following use of two canal instrumentation techniques and two designs of irrigation needles. *International Endodontic Journal* **46**, 795–9.

Zehnder M (2006) Root canal irrigants. *Journal of Endodontics* **32**, 389–98.