Investigation of the Efficacy of Passive Ultrasonic Irrigation Versus Irrigation with Reciprocating Activation: An Environmental Scanning Electron Microscopic Study

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Abstract

Introduction: The objective of this *ex vivo* study was to compare the efficacy of passive ultrasonic irrigation (PUI) versus a new activation system using reciprocating motion (EasyClean [EC]; Easy Equipamentos Odontológicos, Belo Horizonte, Brazil) to remove debris from the root canal walls at 6 predetermined apical levels using environmental scanning electron microscopy. **Methods:** Mesiobuccal root canals of 10 mandibular molars were prepared with a 30/.05 final instrument. The specimens were embedded in flasks containing heavy body silicone, cleaved longitudinally, and 6 round indentations were made into the apical region of the buccal half at 1-mm intervals. The same specimens were used to prepare a blank control group (no debris), a negative control group (completely covered by debris), and 2 experimental groups: PUI and irrigation with reciprocating activation. Standardized images of the indentations were obtained under environmental scanning electron microscopy and assessed by 2 examiners. The amount of debris was then classified using a 4-category scoring system. The kappa test was applied to determine interexaminer agreement, whereas the Kruskal-Wallis, Dunn, and Friedman tests were used to compare scores. **Results:** The EC group had results statistically similar to those of the blank control group for all 6 root levels examined. The PUI group had results statistically similar to those of the negative control group for the 3 most apical levels and similar to those of the blank control group for the 3 most cervical levels. **Conclusions:** Activating the irrigant with a reciprocating system (EC) promoted more effective debris removal from the more apical regions of the root canal when compared with PUI. *(J Endod 2016;42:659–663)*

Key Words

Debris, endodontic irrigation, environmental scanning electron microscopy, reciprocating motion, ultrasonics

The presence of debris adhered to root canal walls after endodontic instrumentation, particularly in the apical third, can be detrimental to subsequent steps of the endodontic treatment, leading to microleakage through the filling materials (1, 2) and failure of the disinfection process (3). Debris removal increases dentinal permeability, improving the effectiveness of the disinfection process (4).

Irrigation with activation using ultrasonic tips is a widely cited technique in the current literature. This technique is based on the premise that energy released by the instrument enhances the properties of the irrigation solution (5, 6) by cavitation and acoustic streaming (7–9). However, the effective occurrence of these phenomena is highly dependent on the power intensity of the device, the free space within the canal, and the total absence of interference on the tip (10). Because of the anatomic characteristics of the root canal, ultrasonic activation is less effective in the apical region than in the cervical region (11–16).

The introduction of mechanical agitation of the irrigant using electric motor-driven instruments with reciprocating motion provided a new option for debris removal in the root canal system, particularly in the apical third. Adopting the same principles of optimizing the action of chemical agents using instruments unaffected by contact with canal walls, by the space in which they operate or by the dispersion of forces within the canal, an acrylonitrile butadiene styrene (ABS) plastic instrument called EasyClean [EC] was developed (Easy Equipamentos Odontológicos, Belo Horizonte, Brazil [US patent pending 61/849,608]). The instrument has a size of 25/.04 and an "aircraft wing"–shaped cross section and operates with a reciprocating motion (ie, a 180° clockwise turn followed by a 90° counterclockwise turn).

Therefore, the objective of this *ex vivo* study was to compare the efficacy of passive ultrasonic irrigation (PUI) versus irrigation with reciprocating activation (EC) in the removal of debris from root canal walls at 6 predetermined apical levels during final irrigation of the canals determined by environmental scanning electron microscopy. The null hypothesis was that there would be no significant differences between the irrigation techniques tested.

Materials and Methods

The study protocol (no. 694.151) was approved by the Research Ethics Committee of the São Leopoldo Mandic Center for Dental Research, Campinas, São Paulo, Brazil.

Ten human mandibular molars with completely formed roots and distinct mesial canal ends and without any vertical fracture or root resorption (whether internal or external) were selected from the Tooth Bank of the São Leopoldo Mandic School of Dentistry, Campinas, São Paulo, Brazil. The selected teeth were stored in a 0.1% thymol solution until use in the experiment. Based on the 4 study groups involved, the

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minimally required sample size was 8 (17). Therefore, the 10 specimens used in each group were deemed sufficient.

After coronal access, a #10 Flex-R file (Miltex Inc, York, PA) was introduced into the canal using an oscillating motion until its tip became visible at the apical foramen. Buccolingual and mesiodistal radiographs were taken to determine the extent of the canal's curvature according to Pruett et al (18). Canals with a curvature between 15° and 20° were selected.

After establishing canal curvature, the real length of the specimen was determined with the aid of an endodontic ruler and rubber stop. The crowns were abraded from the occlusal surface down using a diamond disk (Horico Dental Hopf, Ringleb & Co GmbH & Cie, Berlin, Germany) until the rubber stop met the occlusal edge at 19.0 mm, thus standardizing the length of each specimen. One millimeter was then subtracted from this measurement to obtain a working length of 18.0 mm for all of the specimens. The mesiobuccal canal of each tooth was instrumented using the ProDesign Logic rotary system (Easy Equipamentos Odontológicos). The #10 Flex-R file was inserted up to the apical foramen followed by a 25/.01 file to achieve patency. A 30/.05 file was then introduced using an "in-and-out" motion up to the working length (18.0 mm). At each instrument change during the procedure, a #10 Flex-R file was used to confirm patency, and the canals were irrigated with 3 mL distilled water using a syringe and a 30-G NaviTip needle (Ultradent Products Inc, South Jordan, UT) positioned at the working length. The distal root was removed after instrumentation.

After preparation, a fine-medium gutta-percha cone (Odos de Deus, Belo Horizonte, Brazil) adjusted to a 0.30 tip diameter using a gutta-percha gauge ruler (Dentsply Maillefer, Ballaigues, Switzerland) was inserted into the mesiobuccal canal up to the working length. Two longitudinal grooves running the whole length of the mesiobuccal canal were cut into the mesial and distal walls using a 0.08 diamond disc (Horico Dental Hopf, Ringleb & Co GmbH & Cie) under a dental operating microscope (DF Vasconcelos, São Paulo, Brazil) at 8× magnification. The resultant grooves reached a depth close to the root canal yet without communicating with the main canal. After grooving, the roots were washed in running water to remove debris.

Using a diamond disc under constant irrigation, the dentinal walls were abraded to make the roots thinner, thereby reducing specimen moisture and its consequent interference in the process of obtaining images on environmental scanning electron microscopy. Roots were then embedded in heavy body silicone (Optosil Comfort Putty; Heraeus Kulzer GmbH, Hanau, Germany) up to the level of the cementoenamel junction. After the silicone set, a vertical force was applied using a #24 spatula (SSWhite Duflex, Rio de Janeiro, Brazil) to cleave the specimen into 2 halves. The buccal part of the mesiobuccal canal was then removed using hemostatic forceps. Using a #15 K-type file (KEndo CC Cord; VDW GmbH, Munich, Germany) with an oscillating motion, round indentations approximately 0.15 mm in diameter by 0.05 mm in depth were created by exerting manual pressure perpendicularly to the buccal wall of the canal at 1-mm intervals starting from the apex to give a total of 6 round indentations at predefined levels: L1, L2, L3, L4, L5, and L6 (Fig. 1). The specimens were washed under running water for 1 minute to remove detritus.

By using this flask system with elastic material, it was possible to reassemble the 2 halves of the cleaved specimens and prevent the extrusion of the irrigant, thus simulating a closed system of irrigation and aspiration. By doing so, it was further possible to reuse the same 10 specimens in the different experimental groups of the study as follows.

Blank Control Group

The specimens were immersed in an ultrasonic bath containing 5.25% sodium hypochlorite (NaOCl) solution for 3 minutes and then in 17% EDTA for 3 minutes. Specimens were then washed with distilled water for 1 minute and oven dried at 80°C for 3 minutes; the areas containing the indentations were analyzed under an environmental scanning electron microscope (Phenom-World BV, Eindhoven, Netherlands) at 1750× magnification. The entire surface of the indentations was completely free of debris. After obtaining the blank control images, the same specimens were prepared for the negative control group as follows.

Figure 1. Round indentations created on the apical third at 1-mm intervals.

Negative Control Group

Using a low-speed round bur, the root of an additional tooth (not from the study groups) was abraded, and the removed dentin debris were collected and placed in a plastic container with 2.5% NaOCl solution. The dentin material collected was smeared over and into the grooves using a SingleTim brush (Voco, Cuxhaven, Germany). The specimens were dried, and environmental scanning electron microscopic images were obtained using the same procedure used in the previous step.

Preparation of Experimental Groups

For the 2 experimental groups, the specimens were smeared with the dentin debris in the same manner as that used for the negative control group and placed back into their respective niches in the flask. The corresponding halves of the specimens were checked for a perfect fit by introducing a gutta-percha cone and taking a digital radiograph in both the buccolingual and mesiodistal directions.

PUI Group

The irrigating needle was placed at the working length, and 2.5% NaOCl solution was dispensed until complete filling of the root canal was attained. PUI was then performed as previously described by van der Sluis et al (19). An Irrisonic E1 (20/.01) tip (Helse Indústria e Comércio, Santa Rosa de Viterbo, Brazil) (Fig. 2*A*) fitted to an ENAC ultrasonic handpiece (Osada Electric Co, Aichi, Japan) set to power 3 was placed 1.0 mm short of the working length and first activated with 5 mL 2.5% NaOCl followed by 5 mL 17% EDTA and lastly with 5 mL 2.5% NaOCl solution. All solutions were renewed and activated by 3 cycles