Comparative Analysis of Dentinal Erosion after Passive Ultrasonic Irrigation versus Irrigation with Reciprocating Activation: An Environmental Scanning Electron Study

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Abstract

Introduction: The aim of this study was to assess *ex vivo* the erosive effects of passive ultrasonic irrigation versus irrigation with reciprocating activation on the dentinal surface of the root canal at 3 predetermined levels using environmental scanning electron microscopy. **Methods:** Ten roots of mandibular premolars were prepared using the ProTaper Universal system (Dentsply Maillefer, Ballaigues, Switzerland). The specimens were embedded in flasks cleaved longitudinally, and indentations were made 3.0, 6.0, and 9.0 mm from the apex. The specimens in the control group (n = 10) were cleaned in an ultrasonic bath containing 2.5% sodium hypochlorite and 17% EDTA and then dried. Then, environmental scanning electron microscopic images were obtained at magnification × 800. The specimens were then reassembled in their flasks, and the NaOCl and EDTA solutions were activated according to the conditions established for the experimental groups (ie, the passive ultrasonic irrigation group [n = 5] and the EasyClean (Easy Equipamentos Odontológicos, Belo Horizonte, MG, Brazil) group, irrigation with reciprocating activation with the EasyClean instrument [n = 5]). The specimens of both experimental groups were analyzed in the same manner as in the control group. Analysis of the dentinal surface topography was conducted using the 3D Roughness Reconstruction program (Phenom-World BV, Eindhoven, the Netherlands) as a means for assessing erosion. The data were evaluated by means of the Kruskal-Wallis, Student-Newman-Keuls, and Mann-Whitney tests. **Results:** In the EasyClean group, the degree of dentinal erosion at 3.0 mm was significantly higher than at 9.0 mm. In the other comparisons, there was no statistically significant difference ($P < .05$). **Conclusions:** The final irrigation techniques tested were equivalent in relation to the degree of erosion caused to the dentinal surface. *(J Endod 2017;43:141–146)*

Key Words

Endodontic irrigation, environmental scanning electron microscopy, erosion, final irrigation, passive ultrasonic irrigation, reciprocating motion

Significance

PUI and the EasyClean irrigation system proved equal in terms of dentinal erosion. However, the EC instrument can be maintained at the working length for greater contact of the irrigant with the canal walls in their entire length.

Root canal instrumentation produces a smear layer that can negatively influence the prognosis of the endodontic treatment (1–4). Therefore, its removal is recommended (5). The 2 main substances indicated to remove the smear layer are sodium hypochlorite (NaOCl), used to dissolve the organic portion, and EDTA, used to remove the inorganic portion (6–8). Passive ultrasonic irrigation (PUI) is widely used to enhance the cleaning process. The energy released by inserts during PUI produces cavitation and acoustic streaming, resulting in the formation of microbubbles and hydrodynamic waves that promote agitation of the liquid and, consequently, enhanced cleaning (9, 10).

A new irrigation system (EasyClean; Easy Equipamentos Odontológicos, Belo Horizonte, MG, Brazil) using reciprocating motion to mechanically activate the irrigant has recently been launched in the market. The EasyClean instrument is made of acrylonitrile butadiene styrene plastic with a 25/.04 tip size and an "aircraft wing"–shaped cross section. It is driven by an electric motor producing reciprocating motion and operates at the working length, thus providing better cleaning of the apical third compared with the ultrasonic method (11).

Together with promoting the cleaning of canal walls, alternation of the irrigant agents and the agitation process may also produce dentinal erosion, negatively influencing the endodontic treatment (12). The erosion caused to the surface wall of the root canal is an indication of the alteration of some dentin properties, such as modulus

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0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2016.09.016

of elasticity, microhardness, mineral content, and roughness (6). Erosion produces a chemical change in the dentin with a resulting physical change (ie, a change in the dentin topography). Because the roughness of the dentin is one of the parameters for determining erosion, topographical analysis is a method that allows a longitudinal observation of the erosion on the root canal walls.

Unlike scanning electron microscopy, environmental scanning electron microscopy (ESEM) is a nondestructive method because it does not involve the specimen dehydration and metallization steps. Thus, ESEM allows direct pre- and postexperiment observation of the structure of the same specimen in high resolution, allowing standardization of the region to be analyzed (8, 11). The 3D Roughness Reconstruction program (Phenom-World BV, Eindhoven, the Netherlands) was developed to analyze surface roughness on the images obtained by ESEM. It is a specific program of the Phenom ProX system (Phenom-World BV) used to obtain topographic measurements by means of lines drawn on the image, providing numeric data on the surface.

The objective of the present study was to compare *ex vivo* the topographic change resulting from erosion caused to the dentinal surface of the root canal after PUI with that resulting from irrigation with reciprocating activation (EasyClean) in the final irrigation stage. The null hypothesis was that there would be no significant differences between the irrigation techniques tested in relation to the topographic change caused to the dentinal surface at 3 different levels of the root canal wall.

Materials and Methods

This study was approved by the institutional research ethics committee (protocol no. 1.130.343), and the teeth were donated by the Human Tooth Bank of the São Leopoldo Mandic School of Dentistry, Campinas, SP, Brazil.

Ten human mandibular premolar roots with single canals were used. The teeth had root curvatures between 0° and 15° (13), and the initial anatomic diameter of the canal foramen corresponded to a #15 K file (Dentsply Maillefer).

The analysis of variance test was used for sample size calculation in the pilot test (power of 0.80 with alpha of 0.01) and resulted in a minimum number of 5 repetitions per group. Thus, the number of 10 roots used in the study was considered sufficient.

The teeth were stored in a 0.1% thymol solution until use in the experiment. The surface was cleaned with periodontal curettes. After accessing the pulp chamber and locating the canal orifice, a #10 K file was inserted in the root canal until its tip became visible at the apical foramen using a dental operating microscope (Alliance Comércio Ltda, São Carlos, SP, Brazil) under magnification × 16. A rubber stop was then adjusted to the occlusal edge to establish the length of the root. The occlusal surface was abraded with a diamond disk (Horico Dental Hopf, Ringleb & Co GmbH & Cie, Berlin, Germany) to obtain a standardized canal length of 12 mm. One millimeter was subtracted from this measurement to obtain a working length of 11 mm.

The root canals were instrumented using the ProTaper Universal rotary system (Dentsply Maillefer) following the sequence recommended by the manufacturer up to instrument F3, and the apical preparation was complemented with #30 and #35 K files. The canals were irrigated with 2 mL 2.5% NaOCl with a Navitip 30-G needle (Ultradent Products Inc, South Jordan, UT) placed 1 mm short of the working length at each instrument change during the procedure, totaling 34 mL of irrigant solution. Apical patency was maintained during the entire process with a #10 K file.

After complete instrumentation of the root canal, 2 longitudinal grooves were made with a 0.15-mm Horico H355F220 diamond disc (Horico Dental Hopf, Ringleb & Co GmbH & Cie), 1 on the buccal wall and the other on the lingual wall, without allowing communication with the root canal. The specimens were washed in running water for 1 minute to remove debris. The apical foramen was sealed with utility wax (Artigos Odontológicos Clássico Ltda, São Paulo, SP, Brazil), and the specimens were embedded in heavy-body silicone (Optosil and Activator; Heraeus Kulzer GmbH, Hanau, Germany) in a 1.5-mL Eppendorf tube. This set served as both a flask and a closed irrigation and aspiration system.

After the material hardened, the specimens were cleaved with a Lecron spatula (Duflex SS White; Artigos Dentários Ltda, Rio de Janeiro, RJ, Brazil). The root portion with the most well-preserved canal walls after the cleavage procedure was separated for use in the experiment. Two round indentations of approximately 0.16 mm in diameter, 0.05 in depth, and 0.3 mm apart were made 3.0, 6.0, and 9.0 mm from the apex with the tip of a #15 K file positioned perpendicular to the wall using manual pressure. This step standardized the evaluation area considered for the erosion analysis (Fig. 1*A* and *B*).

After creating the indentations, the specimens were washed in an ultrasonic bath (Ultrasonic Cleaner 1440DA; Odontobras Ind Com Equip Médicos Odontológicos Ltda, São Paulo, SP, Brazil) with 3.5% NaOCl for 3 minutes, washed in running water for 1 minute, and submitted to another ultrasonic bath with 17% EDTA (Fórmula & Ação Labor Farm Ltda, São Paulo, SP, Brazil) for 2 minutes and another wash in running water for an additional 1 minute, obtaining walls completely free of debris. The specimens were dried with absorbent paper and stored in a plastic container with silica gel for 4 days. At the end of this period, the specimens were mounted on a charge reduction sample holder and submitted to ESEM (Phenom ProX) to obtain images of the area between the 2 preprepared indentations under magnification × 800 (Fig. 1*B*). These initial images comprised the control group (n = 10, Fig. 2*A* and *C*).

After acquisition of the control group images, the specimens were remounted in the flask and divided into 2 test groups according to the final irrigation system to be used following the methodology proposed by van der Sluis et al (9). 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. It was further possible to reuse the same 10 specimens in the different experimental groups of the study as explained later (Fig. 3).

In the PUI group (n = 5), for each activation cycle, 1 mL 2.5% NaOCl solution was dispensed at the working length with a Navitip 30-G irrigation cannula and a 5-mL Luer Slip syringe (BD Ind Cir, Curitiba, Brazil), filling the entire canal length. Activation of the irrigant was performed with a 20/.01 E1-Irrisonic insert (Helse Indústria e Comércio Ltda, Santa Rosa de Viterbo, SP, Brazil; Fig. 1*C*) driven by a Varios 560 Multi-Functional Scaler (NSK Nakanishi Inc, Tochigi, Japan) at power setting 1 and positioned 2.0 mm short of the working length. The insert was activated in 3 cycles of 20 seconds for a total of 6 mL 2.5% NaOCl, 6 mL 17% EDTA, and, finally, 6 mL 2.5% NaOCl. The experimental procedure was finalized with irrigation using 20 mL distilled water.

In the EasyClean group (reciprocating activation using the EasyClean system, n = 5), the irrigant solutions were activated using the reciprocating EasyClean instrument (25/.04, Fig. 1*D*) positioned at the working length and driven by the X-Smart Plus electric motor of the WaveOne set (Dentsply Maillefer). The time, volume, and sequence of irrigation were the same as those used for the PUI group.

After conducting the experimental procedures, the specimens were removed from their flasks, and the procedures of drying and