Micro–Computed Tomographic Evaluation of Hard Tissue Debris Removal after Different Irrigation Methods and Its Influence on the Filling of Curved Canals

Laila Gonzales Freire, DDS, MS, PhD, Elaine Faga Iglecias, DDS, MS, PhD,* Rodrigo Sanches Cunha, DDS, MS, PhD,† Marcelo dos Santos, DDS, MS, PhD,‡ and Giulio Gavini, DDS, MS, PhD‡*

Abstract

Introduction: The aim of this study was to compare the efficacy of passive ultrasonic irrigation (PUI) and the EndoVac (EV) System (Discus Dental, Culver City, CA) in hard tissue debris removal and its influence on the quality of the root canal filling with the aid of micro–computed tomographic scanner. **Methods:** Twenty-four mandibular molars were subjected to 4 microtomographic scannings (ie, before and after instrumentation, after final irrigation, and after obturation) using the SkyScan 1176 X-ray microtomograph (Bruker microCT, Kontich, Belgium) at a resolution of 17.42 μm. Mesial canals were prepared using R25 Reciproc instruments (VDW GmbH, Munich, Germany) and divided into 2 groups according to the final irrigation method: the PUI group (n = 12) and the EV group (n = 12). All specimens were filled with the continuous wave of condensation technique. CTAn and CTvol software (Bruker microCT) were used for volumetric analysis and 3-dimensional model reconstruction of the root canals, hard tissue debris, and the filling material. Data were statistically analyzed using the Student t test. **Results:** Analysis of the micro–computed tomographic scans revealed debris accumulated inside the root canals, occupying an average of 3.4% of the canal's volume. Irrigation with PUI and the EV system reduced the volume of hard tissue debris in 55.55% and 53.65%, respectively, with no statistical difference between them ($P > .05$). Also, there was no difference among the groups with regard to the volume of filling material and voids ($P > .05$). **Conclusions:** PUI and the EV system were equally efficient in the removal of hard tissue debris and the quality of root canal filling was similar in both groups, with no influence from the irrigation method. *(J Endod 2015;41:1660–1666)*

Key Words

Debris, irrigation, micro–computed tomography, root canal filling

The goal of endodontic therapy is to remove vital or necrotic pulp tissue, microorganisms, and microbial by-products from the root canal system through procedures that maintain the health of the periradicular tissue. This task is frequently challenging because of the complex anatomy of the root canal system, which may favor the accumulation of the smear layer and hard tissue debris that, in turn, may prevent compact filling of the root canal space (1, 2).

Recent studies using micro–computed tomographic (micro-CT) imaging have expanded the knowledge on the limitations of endodontic instruments, reporting that the canal surfaces often remain untouched (3) and that the current irrigation methods provide poor cleaning of the root canal system (4).

In a 3-dimensional (3D) study using high-resolution micro-CT imaging, Paqué et al (5) observed that some areas of the original canals were filled with a radiopaque material after rotary instrumentation, confirming that hard tissue debris is deposited inside the canal in the form of small dentin chips.

Over the past decade, technological advances have resulted in several methods for irrigant agitation, mainly for the final rinse before filling (6). The currently available techniques include passive ultrasonic irrigation (PUI), which has shown better effectiveness in cleaning the root canal compared with conventional irrigation (7), and the EndoVac (EV) system (Discus Dental, Culver City, CA), which generates negative pressure through a microcannula inserted within the vicinity of the working length (WL) and facilitates apical flow of the irrigant with minimal extrusion (8).

The need to obtain a 3D root canal filling is recognized, with a demand for techniques that provide improved coating of the gutta-percha and sealer to the root canal walls and, consequently, decreased void formation.

Numerous experimental models have been used to assess the effectiveness of irrigation and filling techniques; however, most of the models involve 2-dimensional sections of the roots, therefore providing a limited view (9, 10). Moreover, changes in the location of debris and displacement of the filling material may invariably occur during specimen handling (11, 12).

To overcome these drawbacks, micro-CT imaging is considered a more reliable and less invasive screening method that can distinguish filling materials, voids, and dental structures (13). This technology also allows for quantitative and qualitative lon-

From the *Division of Endodontics, Department of Restorative Dentistry, School of Dentistry, University of São Paulo, São Paulo, São Paulo, Brazil; †Endodontology, Restorative Dentistry, College of Dentistry, University of Manitoba, Winnipeg, Canada; and ‡Division of Endodontics, Restorative Dentistry, School of Dentistry, University of São Paulo, São Paulo, São Paulo, Brazil.

Address requests for reprints to Dr Giulio Gavini, Division of Endodontics, Department of Restorative Dentistry, School of Dentistry, University of São Paulo, Av Prof Lineu Prestes, 2227, 05508-000 São Paulo, SP, Brazil. E-mail address: ggavini@usp.br
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gitudinal assessments of dentin debris with high accuracy (5). However, studies assessing the impact of different irrigation techniques on the quality of root canal fillings using micro-CT imaging are scarce, and no data are available to date.

Therefore, it is necessary to investigate whether the removal of a larger amount of dentinal debris from root canals, including their isthmus and irregularities, improves the quality of the root canal filling.

This study aimed to use a micro-CT scanner to evaluate and quantify the presence of dentinal debris in the mesial canals of mandibular molars after cleaning and shaping and compare the effectiveness of PUI and the EV system in the removal of this debris. The influence of the final irrigation was also assessed in regard to the quality of the root canal filling with the continuous wave of condensation technique by measuring the volume of filling material and voids.

Materials and Methods

Selection of Teeth

The present study was approved by the research ethics committee (number 15598). A total of 24 first and second human mandibular molars that showed an intact pulp chamber, mesial roots with a fully formed apex, and a curvature of 25°–35° according to Schneider (14) on buccolingual and mesiodistal radiographs were selected from the Permanent Human Teeth Bank.

The size of the teeth was standardized at 17 mm. After access opening, the mesial canals were located and explored using a #10 K-file (Maillefer, Ballaigues, Switzerland). When the tip of the instrument could be seen through the apical foramen under 8× magnification, it was withdrawn 1 mm, and the WL was determined.

Micro-CT Imaging

Each specimen was subjected to a micro-CT scanner (SkyScan 1176; Bruker microCT, Kontich, Belgium) before and after instrumentation, after final irrigation, and after obturation. To improve repositioning of the samples during image acquisition, the teeth were individually embedded in high-precision impression material (Speedex; Coltène, Cuyahoga Falls, OH) with the access cavities facing down. Subsequently, groups of 7 teeth were positioned in a sample holder and were brought to the carbon fiber bed of the micro-CT scanner. The specimens were scanned at 90 kV, 278 μA, 360° rotation, and a 0.5° rotation step, resulting in an image with a 17.42-μm voxel size. The filter used was made of copper and aluminum. The average scan duration was 24 minutes 40 seconds.

Thereafter, the images were reconstructed with NRecon v.1.6.9 software (Bruker microCT) using the modified Feldkamp cone-beam reconstruction algorithm, which resulted in 800–900 cross sections per specimen. Reconstruction parameters were adjusted in order to suppress noises using the fine-tuning function as follows: Gaussian filter (smoothing, kernel = 2), beam hardening correction of 40%, postalignment of 0.50 to compensate possible misalignment during acquisition, and ring artifact correction of 10.

Cleaning and Shaping

For cleaning and shaping, the roots of the teeth were covered with 2 layers of nail varnish and then embedded in polyvinyl siloxane (Coltène) to reproduce the periodontal ligament and prevent passive irrigant extrusion (15). After establishing the glide path with a #15 K-file (Maillefer), a clinically experienced operator instrumented both mesial canals using Reciproc R25 instruments (VDW GmbH, Munich, Germany) driven with an electric motor (VDW.SILVER, VDW GmbH) in a reciprocating motion according to the manufacturer's instructions (ie, slow insertion of the instrument in an in-and-out pecking motion about 3 mm in amplitude, with light apical pressure up to the WL). A new R25 (VDW GmbH) instrument was used for each specimen.

At each withdrawal of the instrument, the canals were rinsed with 2 mL 1% sodium hypochlorite (NaOCl) by using a 30-G NaviTip needle (Ultradent Products Inc, South Jordan, UT) positioned as apical as possible without binding to the walls of the canal. In-and-out movements were used to irrigate each canal with a total of 8 mL NaOCl. The patency of the canals was maintained throughout the experimental procedure by using a #10 K-file (Maillefer).

Final Irrigation

After preparation, the canals were irrigated with 5 mL 1% NaOCl followed by 5 mL 17% EDTA and a further 5 mL 1% NaOCl. The canals were subsequently aspirated with a Capillary Tip suction cannula (Ultradent Products Inc) and dried with Reciproc R25 sterile absorbent paper points (VDW GmbH). The condensation silicone was removed, and the teeth were repositioned in the carrier port for postpreparation scanning.

The 24 samples were then randomly divided into 2 groups (n = 12) based on the irrigation method used: the PUI group or the EV group. Subsequently, the roots were again covered with condensation silicone.

In the PUI group, each canal was irrigated with 2 mL 1% NaOCl followed by activation of the irrigant for 30 seconds with a #20/0.00 ultrasonic tip (Irrisafe Satelec Acteon, VDW) coupled with an ultrasound device marked at power 5 (Suprasson P5; Satelec Acteongroup, Merignac, France). The ultrasonic tip was manipulated by using in-and-out movements up to the most apical extent where it could vibrate freely, respecting the maximum distance of 2 mm from the WL. This procedure was repeated 2 more times, once with 2 mL 17% EDTA and once with 2 mL 1% NaOCl.

In the EV group, 3 cycles were implemented with the microcannula. Each cycle included positioning of the microcannula 1 mm from the WL for 6 seconds followed by withdrawal to 2 mm from the WL for 6 seconds. These movements were repeated for 30 seconds, maintaining the irrigant within the pulp chamber through continuous delivery by the master delivery tip. The first cycle was performed with 2 mL 1% NaOCl, the second cycle with 2 mL 17% EDTA, and the third cycle with 2 mL 1% NaOCl.

Finally, the canals were aspirated with a Capillary Tip suction cannula and were dried with Reciproc R25 sterile absorbent paper points. The condensation silicone was removed, and the teeth were repositioned in the sample holder for postirrigation scanning.

Obturation

All canals were obturated with Reciproc R25 gutta-percha cones (VDW GmbH) and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) mixed according to the manufacturer's instructions. The thermoplastic continuous wave of condensation technique was used for obturation using the Elements Obturation Unit (SybronEndo, Orange, CA) as described previously (10).

After filling was completed, the pulp chamber was cleaned with a cotton pellet soaked in 70% alcohol, and the canal openings were filled with temporary restorative material (Coltosol, Coltène). The teeth were stored at 37°C under 100% humidity for 72 hours and were repositioned in the sample holder for postobturation scanning.

Evaluation Methodology

The resulting images from the 4 scans were geometrically aligned by using the 3D registration function of the DataViewer v.1.5.1 software (Bruker microCT). The recorded images were processed with the CTAn