Accumulated Hard Tissue Debris Produced during Reciprocating and Rotary Nickel-Titanium Canal Preparation

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Abstract

Introduction: This study compared the amount of hard tissue debris produced after different apical enlargement with single-file reciprocating systems (WaveOne [Dentsply Maillefer, Baillaigues, Switzerland] and Reciproc [VDW, Munich, Germany]) and a conventional multifile rotary system (BioRaCe [FKG Dentaire, La-Chaux-de-Fonds, Switzerland]) using micro–computed tomographic imaging. **Methods:** Thirty moderately curved mesial roots of mandibular molars presenting 2 independent root canals were selected and scanned at an isotropic resolution of 14.16 μm. The sample was assigned to 3 groups (n = 10) with respect to the root length and degree of curvature of the mesial root according to the system used for the root canal preparation: Reciproc, WaveOne, and BioRaCe. Second and third scans were taken after the root canals were prepared up to ISO sizes 25 and 40, respectively. The matched images of the mesial canals, before and after preparation, were examined from the furcation level to the apex to evaluate the amount of hard tissue debris (%). Data were statistically compared using a general linear model for repeated-measures with a significance level set at 5%. **Results:** Instrumentation systems per se did not influence the amount of hard tissue accumulation ($P > .05$), whereas a significant reduction in the percentage of hard tissue debris was observed after sequential enlargement in all groups ($P < .05$). **Conclusions:** None of the systems yielded root canals completely free from packed hard tissue debris. The increased final apical size resulted in significantly less debris accumulation for both reciprocating and rotary systems. *(J Endod 2015;41:676–681)*

Key Words

Hard tissue debris, micro–computed tomographic imaging, nickel-titanium, reciprocating motion, root canal preparation, rotary system

In 2011, Paqué et al (1) reopened the discussion about the substantial amount of debris packed in the fins, isthmuses, irregularities, and ramifications of the root canal system after preparation using an innovative approach based on micro–computed tomographic (micro-CT) imaging. Micro-CT imaging allows monitoring the accumulation and removal of radiopaque structures in the main space of the root canal and its recesses and isthmuses during and after instrumentation (2–4) while preserving the sample integrity (5).

Hard tissue debris accumulation has been considered an undesirable side effect of the shaping procedures and may be considered more clinically relevant than the smear layer per se because it could easily harbor bacterial contents away from the disinfection procedures (1). It has been shown that the currently used irrigation systems and solutions are unable to render root canals completely free from packed hard tissue debris (1–4, 6–8), which raises the need for preparation protocols that reduce debris buildup (3).

The introduction of new preparation systems based on the use of only 1 instrument through a reciprocating motion has raised new perspectives for the mechanical preparation of the root canal space (5). The reciprocating working motion consists on a forward counterclockwise rotation to cut dentin and a shorter clockwise rotation to relieve the instrument (9). Overall, research findings on reciprocating systems report a decrease in preparation time (9), increased cyclic fatigue life (10), and similar shaping ability compared with multiple-file systems (5, 11, 12). In the literature, it remains controversial whether the use of reciprocating movement per se is able to influence the final amount of packed hard tissues debris in the root canal (3, 9). Likewise, the impact of further apical enlargement on the accumulation of hard tissue debris is still unknown.

Within this background, the current study was designed to compare the volume of hard tissue debris accumulated in mesial root canals of mandibular molars prepared by single-file reciprocating systems (WaveOne [Dentsply Maillefer, Baillaigues,

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Switzerland] and Reciproc [VDW, Munich, Germany]) and a conventional multifile rotary system (BioRaCe [FKG Dentaire, La-Chaux-de-Fonds, Switzerland]) at 2 different apical sizes using micro-CT technology. The following hypotheses were tested:

1. Single-file reciprocating systems produce less hard tissue debris accumulation than a conventional multifile system.
2. Single-file reciprocating systems produce similar hard tissue accumulation.
3. Larger apical preparation is an effective antidebris strategy.

Materials and Methods

Sample Size Estimation

A repeated measures analysis of variance, within-between interaction was selected from the F tests family in G*Power 3.1.7 software for Windows (Heinrich Heine, Universität Düsseldorf). Because of the lack of previous studies evaluating hard tissue debris accumulation after canal preparation with reciprocating instruments at different apical enlargements, the effect size for this study was established from the medium convention (0.2526, derived from $n^2 = 0.06$). An alpha-type error of 0.05, power beta of 0.95, correlation among repeated measures of 0.7, nonsphericity correction of 1, number of groups (within subjects) of 2, and number of measurements (between subjects) of 3 were also specified. Twenty-six teeth were indicated as the total sample size required to observe significant differences.

Specimen Selection

From a pool of 300 mandibular first molar teeth, moderately curved mesial roots (10°–20°) were selected applying Schneider's method (13) in digitized buccolingual radiographs using AxioVision4.5 software (Carl Zeiss Vision GmbH, Hallbergmoos, Germany). In addition, the inclusion criteria comprised only mandibular molars presenting 2 independent root canals in the mesial root (Vertucci type II configuration system) in which the final apical gauging allowed for an ISO size 10 hand K-file (Dentsply Maillefer) to be placed to the working length (WL). Based on these criteria, 44 mesial molar roots were selected. After resection of the distal root at the furcation level, 14 teeth were discarded, and 30 mesial roots were disinfected in 0.5% chloramine T, stored in distilled water at 4°C, and used within 6 months after extraction.

The specimens were randomly assigned (http://www.random.org) into 3 experimental groups ($n = 10$) according to the system used for the chemomechanical preparation: Reciproc, WaveOne, and BioRaCe. After checking for normality assumption ($P > .05$, Shapiro-Wilk test), the degree of homogeneity of the groups, with respect to the root length and degree of curvature of the mesial root, was statistically confirmed ($P > .05$, 2-way analysis of variance). For the experimental procedures, the apex of the mesial roots was sealed with hot glue, and the roots were embedded into a thin film of polyvinyl siloxane.

Root Canal Preparation

Root canals were accessed and patency confirmed by inserting a size 10 hand K-file through the apical foramen before and after completion of root canal preparation. For all groups, a glide path was created by scouting a stainless steel size 15 K-file (Dentsply Maillefer) up to the WL, which was established by deducting 1 mm from the canal length. In each group, instruments were driven with the VDW Silver motor (VDW GmbH) according to each manufacturer's instructions, and a single experienced operator performed all preparations.

Group 1: Reciproc System

Reciproc R25 (25/0.08) (VDW GmbH) was introduced into the canal until resistance was felt and then activated in reciprocating motion. The instrument was moved in an apical direction using an in-and-out pecking motion of about 3 mm in amplitude with a light apical pressure. After 3 pecking motions, the instrument was removed from the canal, and its flutes were cleaned off. This procedure was performed until the instrument reached the WL. Afterward, the Reciproc R40 instrument (40/0.06) (VDW GmbH) was used with the same protocol.

Group 2: WaveOne System

WaveOne Primary (25/0.08) and Large (40/0.08) instruments (Dentsply Maillefer) were used to the WL following the same protocol described for group 1.

Group 3: BioRaCe System

BioRaCe instruments (FKG Dentaire) were used in a crown-down manner according to the manufacturer's instructions using the following sequence: BR0 (25/0.08), BR1 (15/0.05), BR2 (25/0.04), BR3 (25/0.06), BR4 (35/0.04), and BR5 (40/0.04) instruments. The motor was adjusted to 500–600 rpm and 1 N/cm^2. After 4 gentle in-and-out motion strokes, the instrument was removed from the canal and cleaned until the WL was reached.

After the glide path and each nickel-titanium file, root canals were irrigated with 2 mL 5.25% NaOCl for 1 minute delivered by a VATEA peristaltic pump (ReDent-Nova, Ra'anana, Israel) at a 2-mL/min rate connected to a 30-G Endo-Eze Tip (Ultradent Products Inc, South Jordan, UT) inserted up to 2 mm from the apical foramen. Aspiration was performed with a SurgiTip (Ultradent Products Inc) attached to a high-speed suction pump. After canal preparation to size 40, an additional rinse with either 18 mL/9 min (for the rotary group) or 24 mL/12 min (for the reciprocating groups) NaOCl was performed to equalize the amount and time of irrigant used within the groups. A final rinse with 5 mL 17% EDTA (pH = 7.7) delivered at a 1-mL/min rate for 5 minutes followed by a 5-minute 5-mL rinse with bidistilled water was performed for both groups. Hence, a total volume of 40 mL irrigant was used per canal in a total time of 25 minutes. Then, canals were dried with absorbent paper points (Dentsply Maillefer).

Micro-CT Scanning

Three high-resolution scans were accomplished per tooth:

1. Before treatment
2. After root canal preparation up to ISO size 25
3. After root canal preparation up to ISO size 40

Teeth were placed inside a custom-made epoxy resin holder (Ø = 18 mm) and adapted into a sample holder of a micro-CT device (Sky-Scan 1173; Bruker-microCT, Kontich, Belgium). Scanning procedures were performed at an isotropic resolution of 14.16 μm, 70 kV, 114 μA, 360° rotation around the vertical axis, rotation step of 0.5°, and camera exposure time of 250 milliseconds. Acquired projection images were reconstructed into cross-sectional slices (NRecon v.1.6.9; Bruker-microCT) using standardized parameters for beam hardening (40%) and ring artifact correction of 10 as well as similar contrast limits. The volume of interest was selected extending from the furcation level to the apex of the root, resulting in the acquisition of 700 to 900 transverse cross sections per tooth.

Quantitative Tridimensional Image Analysis

Evaluation procedures have been described elsewhere in details (4). Image stacks, before and after canal preparation, were registered