Micro–Computed Tomography Study of Filling Material Removal from Oval-shaped Canals by Using Rotary, Reciprocating, and Adaptive Motion Systems

Bruno Monguilhott Crozeta, DDS, MSc, Yara Teresinha Correa Silva-Sousa, DDS, MSc, PhD,† Graziela Bianchi Leoni, DDS, MSc,* Jardel Francisco Mazzi-Chaves, DDS, MSc,* Thais Fantinato, DDS, MSc,† Flares Baratto-Filho, DDS, MSc, PhD,‡ and Manoel Damião Sousa-Neto, DDS, MSc, PhD**

Abstract

Introduction: This study evaluated filling material removal from distal oval-shaped canals of mandibular molars with rotary, reciprocating, and adaptive motion systems by using micro–computed tomography. **Methods:** After cone-beam computed tomography scanning, 21 teeth were selected, prepared up to a size 40 file, root filled, and divided into 3 groups (n = 7) according to the filling material removal technique: group PTUR, ProTaper Universal Retreatment combined with ProTaper Universal F2, F3, F4, and F5 files; group RP, Reciproc R50 file; and group TFA: TF Adaptive 50.04 files. The specimens were scanned preoperatively and postoperatively to assess filling material removal by using micro–computed tomography imaging, and the percent volume of residual filling material was calculated. **Results:** The statistical analysis showed the lowest percent volume of residual filling material at the coronal third in all groups ($P < .05$). There was no significant difference among the systems in the coronal third ($P > .05$). In the middle third, group TFA (31.2 ± 10.1) showed lower volume of residual filling material than group RP (52.4 ± 14.1) ($P < .05$). In the apical third, groups TFA (44.8 ± 20.6) and PTUR (48.6 ± 16.8) presented a lower percent volume of filling material than group RP (70.6 ± 7.2) ($P < .05$), as confirmed by the qualitative analysis. **Conclusions:** The use of the adaptive motion increased the amount of root filling removed in the middle and apical thirds compared with the reciprocating motion. However, no technique was able to completely remove the filling material from the canals. *(J Endod 2016;42:793–797)*

Key Words

Computed microtomography, reciprocating motion, Retreatment, TFA adaptive

Failure in root canal treatment is usually related to the presence of residual bacteria (persistent infection) or reinfection of an endodontically treated tooth (secondary infection) because of inadequate cleaning, disinfecting, shaping, and filling of the root canal system, leaving endodontic retreatment as the first therapeutic alternative (1). The primary goal of root canal retreatment is to treat the infectious process by removing the filling material and eliminating debris and microorganisms associated with apical periodontitis (2–4).

With the advent of mechanized instrumentation, different techniques have been proposed for endodontic retreatment by using nickel-titanium rotary systems (3, 5–7) and reciprocating systems (8–12). However, none of the various techniques and file systems tested in the numerous studies were able to completely remove the filling material from inside the canals (3, 5, 7–9, 11–15).

The TF Adaptive system (SybronEndo, Orange, CA), which has an innovative kinematics that automatically adapts to instrumentation stress, was recently launched in the market. This system is designed to permit switching from a continuous clockwise motion, when the instrument is not subjected to stress within the canal, to an interrupted reciprocation motion, when undue tensions are generated by dentin during instrumentation. The adaptive motion varies from 600° clockwise/0° counterclockwise up to 370° clockwise/50° counterclockwise, depending on the intracanal stresses produced on the instrument (16, 17).

Recent studies have shown that the combination of rotary and reciprocating motion (adaptive motion) permits greater centralization of the instrument inside the canal (16, 18, 19) and reduces dentinal crack formation during instrumentation (20, 21) when compared with rotatory and reciprocating systems. Capar et al (17) evaluated the effectiveness of rotary instruments used with rotational or adaptive motion in the removal of root canal filling material from mandibular molars and found better results with the adaptive motion. However, there are few studies evaluating the use of this kinematics in endodontic retreatment (17). Thus, the aim of this study was to evaluate the removal of filling material from distal oval-shaped canals of mandibular molars with

From the *Department of Restorative Dentistry, School of Dentistry of Ribeirão Preto, University of São Paulo, São Paulo, Brazil; †University of Ribeirão Preto, Ribeirão Preto, São Paulo, Brazil; and ‡Positivo University, Curitiba, Paraná, Brazil

Address requests for reprints to Prof Dr Manoel Damião Sousa-Neto, Rua Célia de Oliveira Meirelles 350, 14024-070 Ribeirão Preto, SP, Brasil. E-mail address: sousanet@unaerp.br

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rotary, reciprocating, and adaptive (alternated rotational and reciprocating motion) motion systems by using micro–computed tomography (micro-CT).

Materials and Methods

Selection of Teeth

After Ethics Committee approval (Protocol no. 2012/146.661), 60 extracted human mandibular molars with a patent and single canal in the distal root, fully formed apex, no internal calcifications, and no previous endodontic treatment were selected on the basis of clinical and radiographic examinations from a pool of extracted teeth. The teeth were stored in individual plastic vials containing 0.1% thymol solution and were washed in running water for 24 hours before use. For standardization purposes, all teeth were scanned with a cone-beam computed tomography device (I-Cat; Kavo-Imaging Science, Hatfield, PA) to identify distal roots with a single, straight, oval canal. Oval-shaped canals were considered when the buccolingual diameter was 2 times larger than the mesiodistal diameter at 5 mm from the root apex (22–24). According to these inclusion and exclusion criteria, 21 mandibular molars were selected for the study.

SigmaPlot 11.0 statistical software (Systat Software Inc, San Jose, CA) was used for sample size calculation that was based on the following pre-established parameters from a pilot study: minimum detectable difference between means equal to 0.40 and coefficient of variation equal to 0.20. An alpha-type error of 0.05, power beta of 0.8, and number of groups (within subjects) of 2 were considered. With these results, the estimated minimum sample was found to be 6 specimens per group. The statistical power analysis before the experiments resulted in a value of 0.742.

Preparation of Specimens

The crowns were removed and ground coronally to establish a uniform 14-mm root length for all teeth. To eliminate interoperator variability and biases, a single experienced operator performed all procedures.

Subsequently, coronal third enlargement was performed with Gates-Glidden drills sizes 1, 2, and 3 (Dentsply Maillefer, Ballaigues, Switzerland), and apical patency was determined by inserting a size 10 K-file (Dentsply Maillefer) into the root canal until its tip was visible at the apical foramen, and the working length (WL) was set 1.0 mm short of this measurement. The root canal was prepared by the crown-down technique to the WL at a speed of 350 rpm with the use of a torque control endodontic motor (VDW Silver; VDW GmbH, Munich, Germany) by using the K3 (SybronEndo) sequence as follows: #25/.08, #25/.06, and #25/.04. All files were used passively, and apical enlargement was performed by using #25.06, #30.04, #35.02, and #40.02 files. At each instrument change, the root canal was irrigated with 2 mL 2.5% NaOCl. A final rinse was performed with 2 mL 17% EDTA for 5 minutes followed by 2 mL distilled water for 1 minute, and the canals were dried with paper points (Dentsply Maillefer).

Canal Filling

The root canals were filled with gutta-percha (main cone size 40) and an epoxy resin-based sealer (AH Plus; Dentsply DeTrey GmbH, Konstanz, Germany) by using the Tagger hybrid technique. The roots were radiographed in ortho-radial and mesiodistal directions to ensure consistency of the root filling procedure and absence of voids in the filling mass. The canal access was sealed with a temporary restorative material (Coltosol; Vigodent, Ulm, Baden Wuerttemberg, Germany), and the specimens were stored in 100% humidity at 37°C for 2 weeks. To simulate the thermal changes occurring in the mouth, the specimens were subjected to thermocycling (1000 cycles) between 5°C and 55°C with 30-second dwell time.

Retreatment Procedures

The specimens were matched on the basis of initial volume of the filling material and randomly assigned to 3 groups (n = 7) by using a computer algorithm program (http://www.random.org) according to the filling removal technique: group PTUR (ProTaper Universal Retreatment D1, D2, and D3 files combined with ProTaper Universal F2, F3, F4, and F5 files; Dentsply Maillefer, Tulsa, OK), group RP (Single file Reciproc 50.05; VDW GmbH), and group TFA (Single file TF Adaptive 50.04; SybronEndo).

Group PTUR: Rotary Motion

The instruments were used in continuous clockwise rotation by using a gentle in-and-out pecking motion with 500 rpm speed and 2 N/cm torque (VDW Silver; VDW GmbH). Instrument D1 (size 30, taper 0.09) was used for filling removal in the coronal third, followed by instrument D2 (size 25, taper 0.08) in the middle third, and instrument D3 (size 20, taper 0.07) at the WL. Filling removal was completed with ProTaper instruments F2 (size 25, taper 0.08), F3 (size 30, taper 0.09), F4 (size 40, taper 0.06), and F5 (size 50, taper 0.05) used sequentially.

Group RP: Reciprocating Motion

The Reciproc 50.05 file was introduced into the canal until resistance of the filling material was felt and then activated in reciprocating motion generated by a 6:1 contra-angle handpiece (Sirona, Bensheim, Germany) powered by an electric motor (VDW Silver). The file was moved in the apical direction by using an in-and-out pecking motion with approximately 3-mm amplitude by using light apical pressure combined with brushing action against the lateral canal walls. After 3 pecking motions, the instrument was removed from the canal and carefully cleaned. This protocol was repeated until the instrument reached WL.

Group TFA: Adaptive Motion

The TFA 50.04 file was introduced into the canal until resistance of the filling material was felt and then activated in the adaptive motion generated by the M4 handpiece (Axxis; SybronEndo) powered by an electric motor (Elements Motor; SybronEndo, Copel, TX), with the torque and speed determined by the manufacturer. The file was moved by using an in-and-out pecking motion with light apical pressure combined with brushing action against the lateral canal walls. After 3 pecking motions, the instrument was removed from the canal and carefully cleaned. This protocol was repeated until the instrument reached WL.

For all groups, each instrument was discarded after use in 2 canals. Between each preparation step, irrigation was performed with disposable syringes and 30-gauge NaviTip needles (Ultradent, South Jordan, UT) introduced up to 2 mm short of the WL by using 2 mL 2.5% NaOCl. In all groups, no solvent was used, and filling material removal was considered complete when there was no evident filling material on the instrument.

Micro-CT Scanning and Evaluation

The specimens were scanned preoperatively and postoperatively to assess filling material removal from the root canals by using a micro-CT device (SkyScan 1174v2; Bruker-microCT, Kontich, Belgium) with the following parameters: 50 kV, 800 mA, isotropic resolution of 16.7 μm, and 360° rotation. The images were reconstructed by using NRecon v.1.6.3 software (Bruker-microCT), and CTAn v.1.15.4 software (Bruker-microCT) was used for determining the preoperative