Geometric Analysis of Root Canals Prepared by Four Rotary NiTi Shaping Systems

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Abstract

Introduction: A great number of nickel-titanium (NiTi) rotary systems with noncutting tips, different cross-sections, superior resistance to torsional fracture, varying tapers, and manufacturing method have been introduced to the market. The purpose of this study was to evaluate and compare the effect of 4 rotary NiTi preparation systems, Revo-S (RS; Micro-Mega, Besancon Cedex, France), Twisted file (TF; SybronEndo, Amersfoort, The Netherlands), ProFile GT Series X (GTX; Dentsply, Tulsa Dental Specialties, Tulsa, OK), and ProTaper (PT; Dentsply Maillefer, Ballaigues, Switzerland), on volumetric changes and transportation of curved root canals. **Methods:** Forty mesiobuccal canals of mandibular molars with an angle of curvature ranging from 25° to 40° were divided according to the instrument used in canal preparation into 4 groups of 10 samples each: group RS, group TF, group GTX, and group PT. Canals were scanned using an i-CAT CBCT scanner (Imaging Science International, Hatfield, PA) before and after preparation to evaluate the volumetric changes. Root canal transportation and centering ratio were evaluated at 1.3, 2.6, 5.2, and 7.8 mm from the apex. The significance level was set at $P \leq .05$. **Results:** The PT system removed a significantly higher amount of dentin than the other systems ($P = .025$). At the 1.3-mm level, there was no significant difference in canal transportation and centering ratio among the groups. However, at the other levels, TF maintained the original canal curvature recording significantly the least degree of canal transportation as well as the highest mean centering ratio. **Conclusions:** The TF system showed superior shaping ability in curved canals. Revo-S and GTX were better than ProTaper regarding both canal transportation and centering ability. *(J Endod 2012;38:996–1000)*

Key Words

Computed tomography, canal transportation, root canal volume, twisted file, Revo-S, GTX, ProTaper, nickel-titanium instruments

Canal shaping remains to be one of the critical aspects of endodontic treatment because a number of mishaps such as ledges, zips, perforations, and root canal transportation can occur, particularly when preparing curved canals (1). The introduction of nickel-titanium (NiTi) rotary instruments has represented a major breakthrough in root canal preparation by permitting easier and faster instrumentation while maintaining the original canal shape with considerably less iatrogenic errors (2–4). However, it has been shown that the design features and method of manufacturing might significantly affect the clinical performance of NiTi rotary instruments (5–7). Hence, a constant search for better performance in terms of the quantity of material removed from the root wall concurrent with faithful adherence to the original shape of the root canal is progressing through introducing new methods of manufacturing NiTi rotary instruments (2, 5).

Recently, new generations of NiTi rotary instruments with higher flexibility and greater cutting efficiency have been introduced (2). The Twisted File (TF; SybronEndo, Amersfoort, The Netherlands) represents one of the most advanced endodontic NiTi rotary files in the market. It has 3 unique design features: the R-phase heat treatment, twisting of the metal, and special surface conditioning. These features significantly increase the instrument's resistance to fracture (8, 9) and provide greater flexibility (10).

The ProFile GT Series X (GTX; Dentsply, Tulsa Dental Specialties, Tulsa, OK), the new generation of ProFile GT, is characterized by innovative M-wire NiTi technology, more open blade angles, variable-width lands, and a 1-mm maximum shank diameter (11). The variable-width lands are claimed to minimize taper lock in the canal and produce larger chip space between the cutting flutes, accordingly increasing the cutting efficiency without transportation.

Revo-S (RS; Micro-Mega, Besancon Cedex, France), another NiTi rotary system, was developed with a distinctive asymmetric cross-section intended to decrease the stress on the instrument (12). The manufacturer claims that this particular instrument geometry facilitates canal penetration and the upward removal of debris. To date, the effect of these new NiTi rotary systems on root canal geometry has not been compared. Therefore, the aim of the present study was to evaluate and compare the effect of using different NiTi rotary systems (ie, Revo-S, TF, GTX, and ProTaper [PT; Dentsply Maillefer, Ballaigues, Switzerland]) on the volume of removed dentin, canal transportation, and canal centering ability in extracted human teeth using cone-beam computed tomography (CBCT) scanning.

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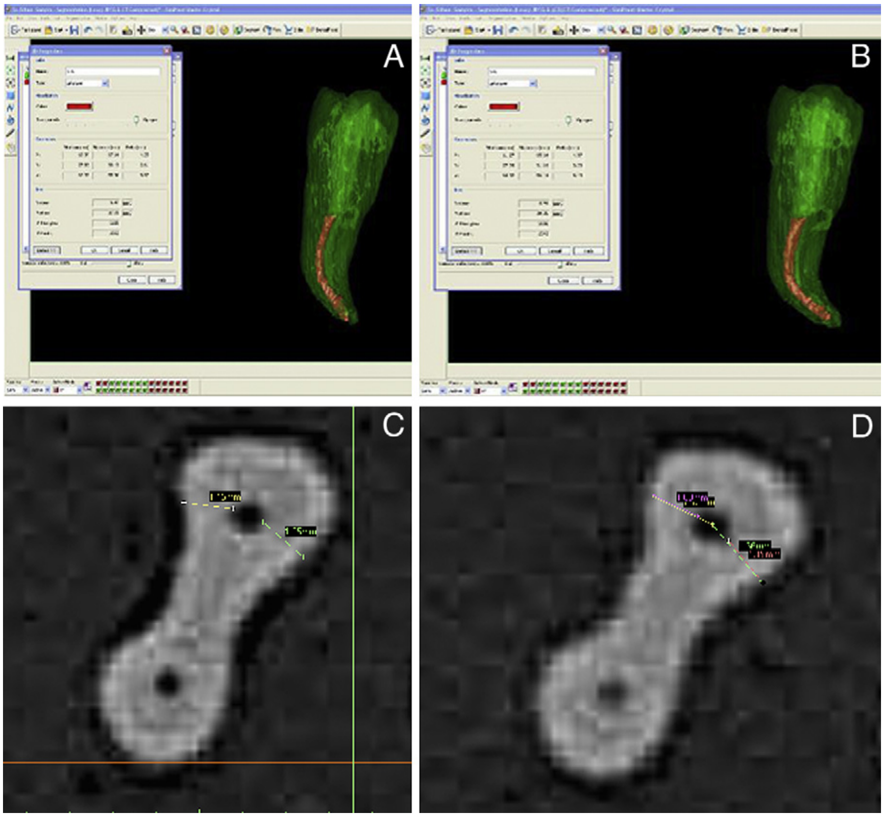

Figure 1. Volumetric changes measurements (*A*) before instrumentation and (*B*) after instrumentation. Canal transportation measurements (*C*) before instrumentation and (*D*) after instrumentation.

Materials and Methods

Selection and Specimen Preparation

Forty extracted human mandibular first molars with an average length of 20 to 21 mm, curved mesial roots, 2 separate mesial canals, and apical foramina were selected. Teeth were accessed using an Endo-Access bur (Dentsply Maillefer), and the meisobuccal canals were localized and explored with a size 10 K-file (Dentsply Maillefer). Mesiobuccal canal curvatures were assessed according to Schneider's technique (13). Only canals with curvature (25°-40°) were included in the study. Distal roots with the respective part of the crown were sectioned at the furcation level and discarded. The determination of the working length was performed at magnification ×8 using a surgical microscope (Opmi-Pico; Karl Zeiss, Jena, Germany) by inserting a #10 K-file to the root canal terminus and subtracting 1 mm from this measurement. Specimens were coded and randomly divided into 4 equal experimental groups (n = 10) according to the rotary NiTi file system used in canal instrumentation: the RS group, the TF group, the GTX group, and the PT group.

Root canal instrumentation was performed by a single operator in strict accordance with the manufacturers' recommendations for each system. All files were operated by a 1:16 gear reduction handpiece powered by an electric torque control motor (Dentaport; J Morita, Tokyo, Japan). Each canal was prepared to the working length in a crown-down sequence, and the final apical preparation was set to size 30 in each group. Between each file size, copious irrigation with 2 mL 5.25% NaOCl was performed using a 27-G needle (Stropko NiTi Needle, SybronEndo), and patency was maintained using a size #10 K-file. Each instrument was discarded after use in 5 canals.

Image Analysis

The roots were positioned in a custom-made specimen holder in which they were aligned perpendicularly to the beam and scanned before and after instrumentation using the i-CAT CBCT scanner (Imaging Science International, Hatfield, PA). Exposure parameters were 120 kV and 3 to 7 mA. The field of view had an 8-cm diameter and was 8 cm high. Slices were 640 × 640 pixels, and the pixel size was 0.13 mm. The acquired data were viewed, and measurements were performed by the software SimPlant View 12.03 for Intel X86 Platform V 12.0.3.14, operating system windows XP SP3 (1992-2008 Materialise Dental n.v., Technologielann 15, 3001 Leuven, Belgium). The mesiobuccal canal was traced, and the total volume was measured (Fig. 1*A* and *B*). Four cross-section planes at levels 1.3, 2.6, 5.2, and 7.8 mm from the apical end of the root were viewed through the explorer mode. The shortest distance from the canal wall to the external root surface was measured in the mesial and distal directions for the mesiobuccal root canal. The distance was measured on the reconstructed 2-dimensional image without reduction by using the measure length tool (Fig. 1*C* and *D*). Measurements were recorded before and after instrumentation to calculate the following: (1) the volume of removed dentin determined in mm^3 for each root canal by subtracting the uninstrumented canal volume from the instrumented canal volume, (2) the degree of canal transportation at each level according to the following formula (14): $(x_1\text{-}x_2) - (y_1\text{-}y_2)$, and (3) the canal centering ratio at each level according to the following ratio (14): $(x_1\text{-}x_2)/(y_1\text{-}y_2)$ or $(y_1\text{-}y_2)/(x_1\text{-}x_2)$, where x_1 is the shortest distance from the mesial edge of the root to the mesial edge of the uninstrumented canal, x_2 is the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal, y_1 is the shortest distance from the distal