Comparative Study of Different Novel Nickel-Titanium Rotary Systems for Root Canal Preparation in Severely Curved Root Canals

Ismail Davut Capar, DDS, PhD, Huseyin Ertas, DDS, PhD,* Evren Ok, DDS, PhD,† Hakan Arslan, DDS, PhD,* and Elif Tarim Ertas, DDS, PhD‡*

Abstract

Introduction: We compared the effects of 6 different rotary systems on transportation, canal curvature, centering ratio, surface area, and volumetric changes of curved mesial root canals of mandibular molar via cone-beam computed tomographic (CBCT) imaging. **Methods:** Mesiobuccal root canals of 120 mandibular first molars with an angle of curvature ranging from 20°–40° were divided into 6 groups of 20 canals. Based on CBCT images taken before instrumentation, the groups were balanced with respect to the angle and radius of canal curvature. Root canals were shaped with the following systems with an apical size of 25: OneShape (OS) (MicroMega, Besancon, France), ProTaper Universal (PU) F2 (Dentsply Maillefer, Ballaigues, Switzerland), ProTaper Next X2 (Dentsply Maillefer), Reciproc (R) R25 (VDW, Munich, Germany), Twisted File Adaptive (TFA) SM2 (SybronEndo, Orange, CA), and WaveOne primary (Dentsply Tulsa Dental Specialties, Tulsa, OK). After root canal preparation, changes were assessed with CBCT imaging. The significance level was set at $P = .05$. **Results:** The R system removed a significantly higher amount of dentin than the OS, PU, and TFA systems ($P < .05$). There was no significant difference among the 6 groups in transportation, canal curvature, changes of surface area, and centering ratio after instrumentation. **Conclusions:** The 6 different file systems straightened root canal curvature similarly and produced similar canal transportation in the preparation of mesial canals of mandibular molars. R instrumentation exhibited superior performance compared with the OS, TFA, and PU systems with respect to volumetric change. *(J Endod 2014;40:852–856)*

Key Words

Cone-beam computed tomographic imaging, OneShape, ProTaper Next, ProTaper Universal, Reciproc, root canal transportation, root canal volume, Twisted File Adaptive, WaveOne

Root canal instrumentation should preserve the existing apical foramen with a flared shape from the apical to the coronal ends and not change the original canal curvature (1). However, during preparation, especially when preparing curved canals, iatrogenic errors, such as ledges, zips, perforations, and root canal transportation, can occur (2). Technological advancements in rotary nickel-titanium (NiTi) instruments have led to new design concepts and easier and faster techniques that preserve the original canal shape with considerably less iatrogenic error (3, 4). Numerous root canal shaping techniques with all of the NiTi systems and different kinematics have been advanced to maintain the original canal shape and thus remain better centered (5, 6).

A new concept for NiTi files has recently been introduced with different working motions that finish root canal shaping with only a single file. Two of these single-file systems, Reciproc (VDW, Munich, Germany) and WaveOne (WO) (Dentsply Tulsa Dental Specialties, Tulsa, OK), are used in a reciprocating motion and are made of a special NiTi alloy (M-Wire) to increase flexibility and improve cyclic fatigue of the instrument. An instrument with a reciprocating motion turns a shorter angular distance than a rotary instrument, providing lower stress values. Therefore, a reciprocating instrument should have a prolonged fatigue life (7). However, for progressing to the apex, a reciprocating file that uses an equal bidirectional movement needs more inward pressure, will cut less effectively than a similar-sized rotary file, and is more limited in augering debris out of the canal (8).

The Twisted File Adaptive (TFA) (SybronEndo, Orange, CA) is a novel file that uses a combined continuous rotation and a reciprocating motion. The file uses continuous rotation when the file is exposed to a minimal or no applied load and uses reciprocal motion when it engages dentin and load is applied. Manufacturers claimed that this adaptive technology and twisted file design using R-phase treatment increases debris removal and flexibility and allows the file to adjust to intracanal torsional forces depending on the amount of pressure placed on the file.

The OneShape (OS) file (MicroMega, Besancon, France) is another single-file system that is used in a traditional, continuous, rotational motion. The OS file has an asymmetric cross-sectional geometry that generates traveling waves of motion along the active part of the file.

The ProTaper Next (PN) (Dentsply Maillefer, Ballaigues, Switzerland) is another novel NiTi file system; it has an offset design and progressive and regressive percentage tapers on a single file and is made from M-Wire technology. Having various percentage tapers functions to decrease the screw effect and dangerous taper lock by minimizing the contact between a file and dentin (9). In the apical portion, PN instruments (X1, X2, and X3) have less taper (0.04, 0.06, and 0.07, respectively) than ProTaper Universal (PU)

From the Departments of *Endodontics and ‡Oral Diagnosis and Radiology, Faculty of Dentistry, İzmir Katip Çelebi University, İzmir, Turkey; and †Department of Endodontics, Faculty of Dentistry, Şifa University, İzmir, Turkey.

Address requests for reprints to Dr Ismail Davut Capar, Department of Endodontics, Faculty of Dentistry, İzmir Katip Çelebi University, Izmir 35620, Turkey. E-mail address: capardt@hotmail.com

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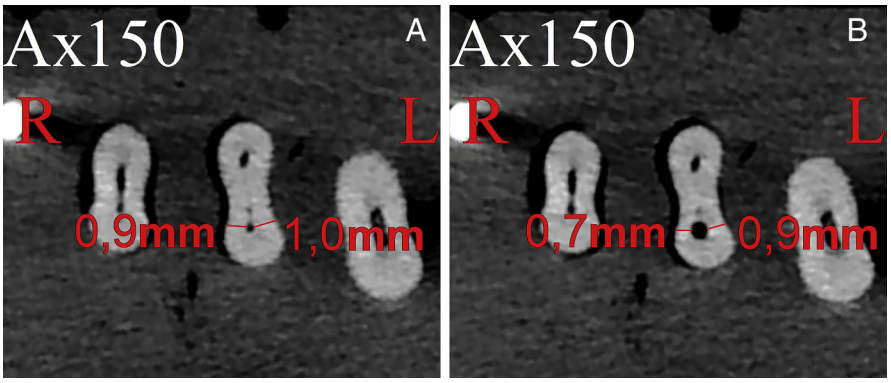

Figure 1. Measurements of root canal transportation (*A*) before instrumentation and (*B*) after instrumentation.

finishing files (F1, F2, and F3 and 0.07, 0.08, and 0.09, respectively). The advantages of PN files include being able to cut a larger envelope of motion compared with a similarly sized file with a symmetrical mass and axis of rotation with the aid of having an offset asymmetric design. Thus, smaller and more flexible PN files can cut the same size preparation as a larger and more rigid file with a centered mass and axis of rotation (8).

Investigations of the shaping effect of these new NiTi systems with different design features and kinematics are important for understanding how the differences affect their performance; however, the effect of these new NiTi rotary systems on root canal geometry has not yet been compared. Thus, we aimed to evaluate and compare the volume of removed dentin, change of surface area, canal transportation, and canal centering ability in extracted human teeth using CBCT scanning after using 6 different NiTi rotary systems.

Materials and Methods

We used curved mesial roots of mandibular molars extracted for reasons not related to this study. Radiographs of teeth in both the buccolingual and mesiodistal directions were taken for selecting the samples. Only teeth with 2 separated mesial canals and no significant calcifications were included. We fixed 120 teeth in a silicone impression material and scanned them for morphometric evaluation of the preinstrumented root canals by using CBCT imaging (NewTom 5G; QR, Verona, Italy). Exposure parameters were kept constant before and after instrumentation, and an 8 × 8 cm field of view was preferred with a high-resolution denture scan mode using a 36-second scanning time and a 5.4-second exposure time. Tube potential and tube current were automatically determined from scout views by the CBCT machine. Axial slice thickness was 0.075 mm with a pixel size of 0.075 mm.

The CBCT images of the samples were analyzed with NNT software (New Net Technologies Ltd, Naples, FL) using a Dell Precision T5400 workstation (Dell, Round Rock, TX). Mesiobuccal canal curvature angles of the teeth were measured according to Estrela et al (10). Briefly, 2 straight lines of the same length were used. The first line showed the continuity of the apical region, and the second line followed the middle and coronal thirds of the root canal. The midpoint of each line was determined, and a circle was drawn to pass over the midpoints. The center of the circle was marked, and 2 lines representing the radii were drawn to the midpoints. The angle between the radii was geometrically measured, and the canal curvature was expressed in degrees. The specimens were allocated to 1 of 6 groups (n = 20) based on the canal curvature angle and radius. Teeth were accessed with a diamond bur, and the working length determination of mesiobuccal canals was determined by inserting a size 10 K-type file to the root canal terminus and subtracting 1 mm from this measurement. A glide path was performed via a size 15 K-type file. RC-Prep (Premier Dental Products, Plymouth Meeting, PA) was used in all canal preparations, and the root canal was irrigated with 2 mL 2.5% sodium hypochlorite solution after each instrument change. Each instrument was

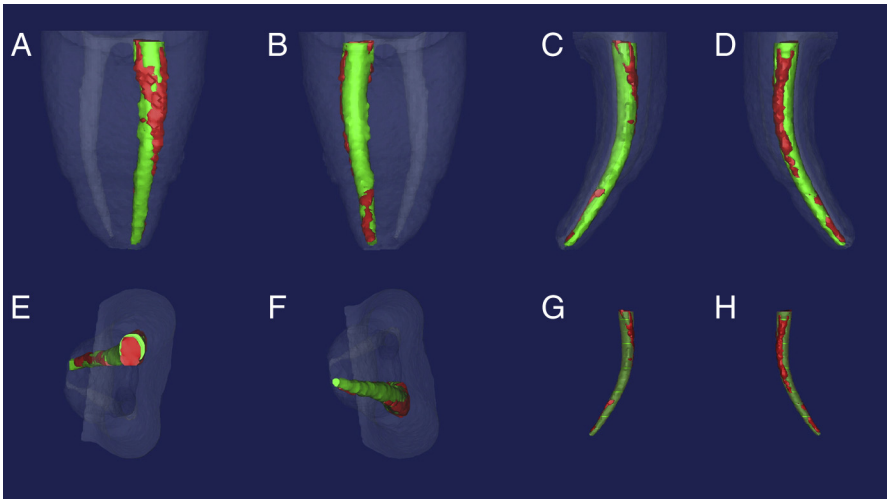

Figure 2. Representative images of 3-dimensional superimposed reconstructions. *Red* indicates preoperative area; *green* indicates postoperative area. (*A–H*) Representative images of WaveOne group at different angles.