Basic Research—Technology

Micro-Computed Tomographic Evaluation of 2 Nickel-Titanium Instrument Systems in Shaping Root Canals

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Abstract

Introduction: Cleaning and shaping without making procedural errors have always been a challenge in endodontics, particularly when the root canals are curved. Several rotary instruments have been developed to minimize such errors. The purpose of this study was to compare the shaping ability of 2 rotary file systems, BioRace (BR; FKG, La Chaux-de-Fonds, Switzerland) and ProTaper Next (PTN; Dentsply Maillefer, Ballaigues, Switzerland), during the preparation of curved root canals in extracted teeth using micro–computed tomographic imaging. **Methods:** A total of 20 first and second human mandibular molars with 2 separate mesial canals were scanned before and after root canal preparations using the SkyScan 1176 X-ray microtomograph (Bruker microCT, Kontich, Belgium) at a resolution of 17.42 μm. Canals were prepared using the BR and PTN systems. The percentage of dentin removed after preparation, root canal volume increase, untreated canal walls, structure model index, degree of canal transportation, and centering ability were also measured. **Results:** There were no significant differences between the 2 groups in the removed dentin after preparation and determination of the root canal volume, percentage of untreated canal walls, structure model index, degree of canal transportation, and centering ability ($P > .05$). **Conclusions:** In conclusion, within the limitations of this *ex vivo* study, instrumentation of moderately curved mesial roots with 2 independent root canals and foramina using the BR and PTN rotary file systems were equally effective. Both instrumentation systems caused negligible procedural errors with minimal apical transportation. (*J Endod 2016;42:496–499*)

Key Words

Apical transportation, BioRace, micro–computed tomographic imaging, M-Wire, nickel-titanium instrument, ProTaper Next

Cleaning and shaping of the root canal system without making procedural errors have always been a challenge in endodontics, particularly in curved canals. Several nickel-titanium (NiTi) rotary instruments have been developed to minimize errors such as ledges, strip perforations, excessive thinning of canal walls, loss of working length (WL), and apical transportation. ProTaper Next (PTN; Dentsply Maillefer, Ballaigues, Switzerland) is a set of rotary instruments with M-Wire technology and is an offset mass of rotation (1, 2). The system includes 5 shaping instruments: X1 (17.04), X2 (25.06), X3 (30.07), X4 (40.06), and X5 (50.06), which are all characterized by an innovative off-centered rectangular cross section that has been claimed to give the files a snakelike swaggering movement as it advances into the root canal (1, 2). This design feature may have an impact on the screwing effect, intraoperative torque values, and cleaning ability of the instruments (3). In addition, the taper is not constant; all of the files have a variable taper along their active cutting blades.

The BioRace system (BR; FKG, La Chaux-de-Fonds, Switzerland) consists of instruments that are manufactured from a conventional austenite NiTi electropolishing surface treatment and have a noncutting safety tip and triangular cross section with alternating cutting edges (4). Varying diameters and tapers of this sequence reduce the contact area of each instrument with the canals walls, thereby minimizing stress and providing the ability to safely reach the WL. The basic set includes 6 instruments: BR0 (25.08), BR1 (15.05), BR2 (25.04), BR3 (25.06), BR4 (35.04), and BR5 (40.04).

X-ray micro–computed tomographic (micro-CT) imaging offers a noninvasive technique for the 3-dimensional (3D) assessment of different variables of mechanical preparation including the amount of prepared surfaces (5–7).

The purpose of this *ex vivo* study was to compare the shaping ability of 2 rotary systems (BR and PTN) on the preparation of moderately curved mesial root canals of mandibular molars using micro-CT imaging.

The null hypothesis tested was that there was no difference between the 2 rotary NiTi systems regarding changes in the 3D geometry such as the root canal volume, untouched area, structure model index (SMI), removed dentin, centering ability, and canal transportation.

Materials and Methods

Teeth Selection

This study was revised and approved by the local ethics committee (NP1.006.972). In total, 20 first and second mandibular human molars with fully formed apices were selected from a pool of 86 freshly extracted teeth and stored in a 0.1% thymol solution.

The inclusion criteria consisted of only molars with a moderately curved mesial root (10°–20°) according to Schneider's method (8) and 2 independent root canals and foramina in which a size 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) could be placed at the WL. Tooth size was standardized at 18 mm by grinding the occlusal surfaces with a diamond disk (Buehler, Lake Bluff, IL), and coronal access was achieved using diamond burs.

Micro-CT Scans

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

Next, the images were reconstructed with NRecon v.1.6.9 software (Bruker microCT) using the modified Feldkamp cone-beam reconstruction algorithm with a beam-hardening correction of 40% and a ring artifact correction of 10, resulting in 800–900 cross sections per specimen.

Root Canal Preparation

Both Groups. The WL was established with a size 10 K-file using 2.5% sodium hypochlorite (NaOCl) as the irrigant. Under a dental operative microscope set at 8× magnification, it was withdrawn 1 mm, and the WL was determined when the tip of the instrument could be seen through the major foramen.

A glide path was created by scouting a stainless steel size 15 K-file (Dentsply Maillefer) 2 mm up to the WL. The patency of the canals was maintained throughout the procedure using a 21-mm #10 K-file (Dentsply Maillefer), and the final apical preparation was set to size 25. Instruments were driven with the X-Smart electric motor (Dentsply Maillefer) according to the manufacturer's instructions, and each instrument was used to prepare 4 canals (3, 9, 10). A single operator with extensive experience in both systems performed the instrumentation of all specimens. None of the instruments fractured.

Between each preparation step, the instrument was cleaned, and irrigation was performed with 5 mL 2.5% NaOCl in disposable syringes and 30-G NaviTip needles (Ultradent, South Jordan, UT). A final rinse with 5 mL 17% EDTA was delivered for 3 minutes followed by 5 mL 2.5% NaOCl. The root canals were dried with absorbent paper points (Dentsply Maillefer) and then were repositioned in the sample holder for postoperative scanning.

PTN. Instruments were used with a rotational speed of 300 rpm, and the torque was adjusted to 2.0 Ncm. The instrumentation sequence was performed using the following parameters: ProTaper Universal SX (35.03) at two thirds of the WL and X1 (17.04) and X2 (25.06) at the full WL using a gentle in-and-out brushing motion.

BR. Instruments were used with a rotational speed of 500 rpm and torque of 1.0 Ncm as follows: PreRace (FKG, La Chaux-de-Fonds, Switzerland) (30.06) at two thirds of the WL and BR1 (15.05), BR2 (25.04), and BR3 (25.06) at the full WL using 4 gentle in-and-out strokes.

Evaluation Methodology

The evaluated specimens served as their own controls for the assessments. The pre- and postinstrumentation images were superimposed by using the 3D registration function of the DataViewer v.1.5.1 software (Bruker microCT). The recorded images were processed using CTAn v.1.14.4 software (Bruker microCT) to calculate quantitative parameters and construct visual 3D models. The volume of interest for each specimen, extending from the furcation region to the apex of the mesial root, was set by integrating regions of interest in all of the cross sections. The gray scale range was required to recognize the dentin before and after instrumentation was determined by using a density histogram with the global threshold method. Comparisons between the original segmented scan were performed to ensure the accuracy of the segmentation. Task lists were applied to generate separated binary images of the root canal space and dentin using a custom-processing tool (9).

The volume of the root canals, amount of dentin removal, and surface area were calculated by subtracting the values for the treated canals from those recorded for the untreated counterparts. Matched images of the surface areas of the canals before and after preparation were examined to evaluate the percentage of the noninstrumented canal wall surface (number of static voxel surface to the total number of surface voxels). The cross-sectional appearance, round or more ribbon shaped, was expressed as the SMI, which varied from 1 (parallel plates) to 4 (perfect ball) (11).

Root Canal Transportation

For root canal transportation analysis, axial sections corresponding to distances of 3, 6, and 9 mm from the anatomic apex were selected. Canal transportation was calculated in millimeters using the formula $([X1-X2]-[Y1-Y2])$ as described by Gambill et al (12) where X1 is the shortest distance between the mesial portions of the root and uninstrumented canal, X2 is the shortest distance between the mesial portions of the root and instrumented canal, Y1 is the shortest distance between the distal portions of the root and uninstrumented canal, and Y2 is the shortest distance between the distal portions of the root and instrumented canal. Pre- and postoperative measurements were compared to reveal the presence or absence of deviations in canal anatomy and to identify the most affected region (Fig. 1A–C). According to this formula, a result of 0 indicated no canal transportation. A negative result indicated transportation away from the furcation region, and a positive result indicated transportation toward the furcation region.

Centering Ability

The centering ratio, which measures the ability of the instrument to remain in a central position within the root canal, was calculated for each cross section using the values obtained in the assessment of root canal transportation with the ratio of $(X1-X2)$ to $(Y1-Y2)$ (12). If these numbers were not equal, then the lower figure was considered to be the numerator of the ratio. According to this formula, a result of 1 indicated the optimal centering ability (13).

Statistical Analysis

Residual normality as an assumption of analysis of variance was confirmed using the Shapiro-Wilk test. The means were compared using 1-way analysis of variance based on the generalized linear mixed model with repeated measures. All analyses were calculated using the SAS system (SAS, Cary, NC), and the level of significance was established at 5%.