Comparative Study of 6 Rotary Nickel-Titanium Systems and Hand Instrumentation for Root Canal Preparation in Severely Curved Root Canals of Extracted Teeth

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Abstract

Introduction: Some improvements have been developed with new generations of nickel-titanium (NiTi) rotary instruments that led to their successful and extensive application in clinical practice. The purpose of this *in vitro* study was to compare the root canal preparations performed by using GT Series X and Twisted File systems produced by innovative manufacturing process with Revo-S, RaCe, Mtwo, and ProTaper Universal systems manufactured directly from conventional nitinol and with stainless steel K-Flexofile instruments. **Methods:** The mesiobuccal root canals of 140 maxillary first permanent molars that had between 30°–40° curvature angle and 4- to 9-mm curvature radius of the root canal were used. After root canal preparations made by using GT Series X, Twisted File, Revo-S, RaCe, Mtwo, and ProTaper Universal NiTi rotary systems and stainless steel K-Flexofile instruments, transportation occurred in the root canal, and alteration of working length (WL) was assessed by using a modified double-digital radiographic technique. The data were compared by the post hoc Tukey honestly significant difference test. **Results:** NiTi rotary systems caused less canal transportation and alteration of WL than K-Flexofile instruments ($P < .05$). There was no significant difference between NiTi rotary system groups at any levels ($P > .05$) except 2.5 mm from the WL. At this level ProTaper Universal system caused significant canal transportation ($P < .05$). **Conclusions:** GT Series X and Twisted File rotary systems produced with innovative process were concluded to shape the curved canals to result in minimal canal transportation, similar to Revo-S, RaCe, Mtwo, and ProTaper Universal rotary systems manufactured by traditional methods. *(J Endod 2013;39:278–282)*

Key Words

M-wire, root canal instrumentation, rotary instrument, Twisted File

A successful endodontic treatment is believed to depend on thorough cleaning and shaping of root canals (1–3). In morphologic studies of Peters et al (4, 5) and Hubscher et al (6), complexity of root canal anatomy has been put forth explicitly. Variations of canal sections, in-canal irregularities, and associated curvature diversity render procedure failures almost inevitable. Shaping the root canal by preserving curvature is one of the main parameters used for analysis of the methods or instruments developed for root canal preparation (7). Nickel-titanium (NiTi) rotary instruments have been continuously changing in the last 20 years to successfully realize this parameter. One of these alteration fields is the studies focused on the direct chemical structure of the alloy to make NiTi alloy more durable and more effective. Therefore, the M-wire NiTi material, which is suggested to be more flexible than the 55-nitinol and more resistant to cyclic fatigue and with more cutting efficiency, has been produced. The first rotary instrument system generated from this material was GT Series X (Dentsply Tulsa Dental Specialties, Tulsa, OK) (8). Other progress in the production of NiTi rotary instruments is Twisted File (SybronEndo Orange, CA) rotary instrument system produced with plastic deformation via R-phase heat application and bolt contortion. The instruments belonging to this system have been claimed to be more flexible and more resistant to cyclic fatigue, to proceed in the center of the canal, especially in curved canals, and to have minimized canal transportation (9).

In studies investigating the shaping ability of endodontic instruments, double-digital radiographic techniques (10–13) and micro–computed tomography (4, 9, 14, 15) are currently used for assessment of canal transportation. The double-digital radiographic techniques are easy to use, inexpensive, and potentially informative depending on the subject under investigation but lack the capacity to reveal volumetric data (16).

The new materials and methods used in the production of NiTi rotary instruments may contribute to the development of root canal preparation; however, the number of studies investigating these new materials and methods comparatively is limited. The aim of this study was to compare the shaping ability of 6 different NiTi rotary systems and stainless steel K-Flexofile by measuring canal transportation in the mesiobuccal canals of maxillary first molars that had a canal curvature between 30°–40° and root curvature radius between 4–9 mm.

Materials and Methods

The maxillary first permanent molars that had completed apical maturation, continued from the mesiobuccal root canal access to the apical foramen and at a maximum #15 K-Flexofile (Dentsply Maillefer, Ballaigues, Switzerland) instrument pinched in the apical narrowing site, and were extracted because of periodontal or

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prosthetic reasons, were used. After the preparation of the access cavity with Endo Z drills (Dentsply Maillefer), ISO #10 K-file was advanced into the root canal until its tip was observed in the apical foramen. Working length (WL) was determined by subtracting 1 mm from the length at the time the file was first seen.

An experimental setup was prepared to be able to use the radiograph subtracting method before and after the preparation, as described by Iqbal et al (10) and Maggiore (17) for the analysis of the effect of preparation systems on root canal transportation. A turntable was formed, enabling the placing of the teeth in the same position before and after the preparation. A #15 K-Flexofile instrument was placed in the root canal, and the turntable was gradually turned and a series of radiographs were taken until a straight image of the instrument in the root canal was ensured. The tooth was then rotated 90° to reveal the maximum curvature of the root canal (18). The radiographic image at this point was recorded as the final preoperative image. The maximum root curvature angle and the root curvature radius of the instrument in the canal were determined by using the method of Pruett et al (19) with AutoCAD 2007 (Autodesk Inc, San Rafael, CA). A total of 140 maxillary first molars with a root curvature angle of 30°–40° and a root curvature radius of 4–9 mm were included in the study. The analysis of variance and the post hoc Tukey statistical analysis methods were used to allocate the teeth into 7 different groups with 20 in each, similar with respect to the root curvature angle and curvature radius.

Each instrument was used in 4 canals and was then discarded in all groups; however, the instruments that were deformed before reaching this number were discarded. Irrigation was performed with 2 mL 2.5% NaOCl solution after each file. Apical preparation was completed with 30/.06 instruments by using the instrument order instructed by the manufacturer in group 1 (Twisted File), group 2 (GT Series X), group 3 (Revo-S; MicroMega, Besançon, France), group 4 (RaCe; FKG, La Chaux-de-Fonds, Switzerland), and group 5 (Mtwo; VDW, Munich, Germany). Apical preparation was completed with F3 file by using the instrument order instructed by the manufacturer in group 6 (ProTaper Universal; Dentsply Maillefer). In group 7 (K-Flexofile), instrumentation was performed by using the crown-down method with triangular flexible stainless steel K-Flexofile instruments with noncutting tip design. Apical preparation was completed with the ISO 30/.02 instrument.

The prepared samples were placed onto the radiographic imaging setup in the position in which the preoperative images were obtained, and postoperative radiographic imaging of each sample was performed. The final digital radiographs obtained before and after the preparation were downloaded in jpeg format by using the digital radiographic imaging system and carried onto the Adobe Photoshop CS2 software (Adobe Systems Inc, San Jose, CA).

The images were passed through the Paint Daub artistic filter of simple brush type with size 6 and accuracy of 10. The maximum values in the submenu selected through the artistic filter were chosen, and the borders of the image were postered. The distance between the point at which a line was drawn parallel to the longitudinal axis of the coronal third of the canal on the postered final preoperative radiograph (the point at which the canal curvature began) and tip of the canal instrument was divided into 5 equal parts by using the AutoCAD software. Six levels were obtained for measurement. The furthest most point of the instrument corresponding to D0 was named L1, and the point at which the canal curvature began was named L6; the remaining equal parts were named L2, L3, L4, and L5 from the apical to the coronal. The distance of the canal instrument corresponding these levels to the apical foramen was determined in millimeters, and the mean values were calculated for all samples (Table 1).

The postered images were transferred to the AutoCAD software to draw the central axis of the K-Flexofile instrument on the final preoperative image and the last instrument used for preparation of the related group on the postoperative image. Afterwards, a series of horizontal lines joining the outer borders of the instrument were drawn. The central axis of the instrument was obtained by joining the midpoint of each of the horizontal lines. The reflection of the Cartesian system was drawn, and perfect superimposition of the images before and after the preparation was obtained. Thus, the transportation in the described levels could accurately be measured by using the AutoCAD software.

TABLE 1. Means of Distances from D0 Corresponding to Different Levels (n = 140)

Level	Mean (mm)
L1	0
L2	1.1 ± 0.09
L3	2.5 ± 0.96
L4	3.7 ± 0.85
L5	5.0 ± 0.76
L6	7.1 ± 0.89

The distance between the preoperative and postoperative instrument tips at the D0 point was measured by using the previously mentioned setup and the subtracting method. Thus, alteration of WL was also determined.

The maximum, minimum, mean, and standard deviation values of the canal transportation amounts at the levels of each group and WL were calculated. The mean values of these groups were compared by using the analysis of variance and the post hoc Tukey honestly significant difference statistical tests. A P level <.05 was accepted as statistically significant.

Results

Transportation occurred in all samples (Table 2). At the L1 level, K-Flexofile group yielded the significantly highest mean transportation value (0.181 ± 0.077 mm) ($P < .05$), and the others showed lower (Twisted File, 0.084 ± 0.045 mm; GT Series X, 0.094 ± 0.034 mm; Revo-S, 0.107 ± 0.045 mm; RaCe, 0.1 ± 0.045 mm; Mtwo, 0.096 ± 0.063 mm; and ProTaper Universal, 0.118 ± 0.09 mm) ($P > .05$). At the L2 level, K-Flexofile group yielded the significantly highest mean transportation value (0.162 ± 0.07 mm) ($P < .05$), and the others showed lower (Twisted File, 0.087 ± 0.046 mm; GT Series X, 0.087 ± 0.03 mm; Revo-S, 0.093 ± 0.037 mm; RaCe, 0.111 ± 0.053 mm; Mtwo, 0.089 ± 0.056 mm; and ProTaper Universal, 0.105 ± 0.062 mm) ($P > .05$). At the L3 level, ProTaper Universal and K-Flexofile groups showed the significantly highest mean transportation values (0.05 ± 0.004 mm and 0.05 ± 0.006 mm, respectively) ($P < .05$); meanwhile, Twisted File (−0.011 ± 0.005 mm), GT Series X (−0.012 ± 0.004 mm), Revo-S (−0.013 ± 0.004 mm), RaCe (−0.012 ± 0.004 mm), and Mtwo (−0.011 ± 0.007 mm) values recorded lower ($P > .05$). At the L4 and L5 levels, it was found that there was no statistically significant difference between all of the groups (Twisted File, −0.04 ± 0.012 and −0.074 ± 0.058 mm; GT Series X, −0.034 ± 0.02 and −0.08 ± 0.043 mm; Revo-S, −0.046 ± 0.013 and −0.085 ± 0.05 mm; RaCe, −0.044 ± 0.025 and −0.086 ± 0.061 mm; Mtwo, −0.031 ± 0.012 and −0.08 ± 0.064 mm; ProTaper Universal, −0.026 ± 0.016 and −0.069 ± 0.041 mm; and K-Flexofile, −0.057 ± 0.012 and −0.114 ± 0.048, respectively) ($P > .05$). At the L6 level, whereas the K-Flexofile group (−0.136 ± 0.058 mm) led to a statistically significantly higher degree of transportation than the Twisted File group (−0.08 ± 0.053 mm) ($P < .05$), there was no significant difference between the other groups (GT Series X, −0.089 ± 0.043 mm; Revo-S, −0.097 ± 0.046 mm; RaCe, −0.099 ± 0.054 mm; Mtwo, −0.088