Computed Tomographic Evaluation of Canal Shape Instrumented by Different Kinematics Rotary Nickel-Titanium Systems

Abeer M. Marzouk, BDS, MSc, PhD, and Angie G. Ghoneim, BDS, MSc, PhD

Abstract

Introduction: This study evaluated the effects of 2 different kinematics rotary nickel-titanium (NiTi) systems, Twisted File (TF), a continuous rotation full-sequence system, and WaveOne (WO), a reciprocating single-file system, on transportation, curvature, and volumetric changes of curved root canals by using cone-beam computed tomography. **Methods:** Forty mesiobuccal canals of mandibular molars with angle of curvature ranging from 25°–35° were divided according to the NiTi rotary system used in canal preparation into 2 groups of 20 samples each, TF group and WO group. Canals were scanned by using an i-CAT cone-beam computed tomography scanner before and after instrumentation to evaluate canal transportation at coronal, middle, and apical thirds, canal curvature, and volumetric changes. The significance level was set at $P \leq .05$. **Results:** TF system recorded significantly lower mean of canal transportation than WO group at all canal thirds (apical $P = .034$, middle $P = .003$, and coronal $P = .012$). In both groups the apical third recorded the significantly least amount of transportation ($P < .05$). There was no significant difference between the 2 groups in canal curvature and volumetric changes after instrumentation ($P > .05$). **Conclusions:** Both TF and WO NiTi systems can be safely used to the full working length, resulting in satisfactory preservation of the original canal shape. *(J Endod 2013;39:906–909)*

Key Words

Canal transportation, computed tomography, root canal volume, twisted file, waveOne file

From the Department of Endodontics, Faculty of Oral and Dental Medicine, Cairo University, Cairo, Egypt.

Address requests for reprints to Dr Angie Galal Ghoneim, Department of Endodontics, Faculty of Oral and Dental Medicine, Cairo University, Cairo, Egypt. E-mail address: engyghoneim@hotmail.com

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Schilder (1) has emphasized that root canal preparation should present a flare shape from apical to coronal, preserving the apical foramen and not altering the original canal curvature. However, in curved canals these goals are not easy attainable, and root canal instrumentation becomes more difficult because there is a tendency for all preparation techniques and instruments to divert the prepared canal away from its original axis (2). Several root canal preparation techniques together with rotary nickel-titanium (NiTi) systems and different kinematics have been developed that are intended to maintain original canal shape and therefore remain better centered (3, 4).

Recently, a new concept of root canal preparation has been evolved by introducing the WaveOne reciprocating single-file system that is claimed to prepare the root canal to adequate size and taper with only one file. Single use, reciprocating motion, and M-wire alloy are the main characteristics of these instruments. The M-wire alloy increases instrument flexibility and improves its resistance to cyclic fatigue (5). Reciprocating motion consists of a counterclockwise cutting direction motion and a clockwise direction, instrument-releasing motion. Because of the fact that the counterclockwise angle is greater than the clockwise one, it is suggested that the instrument continuously moves toward the apex (6). Furthermore, the reciprocating motion is similar to balanced force technique that proved to maintain the curvature with minimal distortion of the root canal shape (7, 8).

Twisted File, a continuous rotation full-sequence NiTi system, has been developed by Sybron Endo (Orange, CA) with 3 unique design features, namely the R-phase heat treatment, twisting of the metal, and special surface conditioning. These features proved to increase the instrument's resistance to fracture (9), provide greater flexibility (10), maintain the original canal center, and minimize canal transportation (11, 12).

With these new NiTi systems, investigations of their shaping effect are becoming more important to understand how the design features and different kinematics affect their performance. Consequently, the aim of this study was to evaluate and compare several parameters of root canal preparation, namely changes in canal curvature, transportation, and volume of removed dentin produced by2 different rotary NiTi systems, Twisted File and WaveOne, in extracted human teeth by using cone-beam computed tomography (CBCT).

Materials and Methods

Root Canal Preparation

Forty extracted human mandibular first molars with 2 separate mesial canals and intact, mature root apices were included in the study. The teeth were selected on the basis of their similar characteristics of length (20–22 mm) and mesiobuccal canal curvature (25°–35°) measured with CBCT according to Estrela et al (13) and Özer (14).

Teeth were accessed by using Endo-Access bur (Dentsply, Maillefer, Ballaigues, Switzerland), and the mesiobuccal canals were localized and explored with a size 10 K-file (Dentsply). Distal roots with the respective part of the crown were sectioned at the furcation level and discarded. Working length (WL) was established at ×8 magnification by using surgical microscope (Opmi-Pico; Karl Zeiss, Jena, Germany) by inserting size 10 K-file to root canal terminus and subtracting 1 mm from this measurement. The crowns were flattened to standardize the WL at 18 mm. A glide path was performed by using a size 15 K-file.

Specimens were randomly divided into 2 equal experimental groups (n = 20) according to the rotary NiTi file system used in canal instrumentation, Twisted File (TF) group (Sybron Endo) and WaveOne (WO) group (Dentsply Tulsa Dental Specialties, Tulsa, OK). Root canal instrumentation was performed by a single operator in strict accordance to the manufacturers' instructions. In the TF group, the shaping procedure commenced with TF size 25 taper 0.08 to prepare the coronal one-third. TF size 25 taper 0.06 was used until 2 mm short of WL. Shaping continued to the full WL with TF size 25 taper 0.04, followed by 0.06 and 0.08. In the WO group, a primary reciprocating WaveOne file size 25 taper 0.08 was used in a reciprocating, slow in-and-out pecking motion. The flutes of the instrument were cleaned after 3 pecks.

RC-Prep (Premier Dental Products, Plymouth Meeting, PA) was used in all canal preparations, and irrigation was performed with 2 mL 5.25%NaOCL after each file. WaveOne torque control motor (Dentsply Tulsa Dental Specialties) was used to operate all files. Each instrument was used to prepare 4 canals corresponding to single use.

Image Analysis

The roots were positioned in a custom-made specimen holder and scanned before and after instrumentation by using i-CAT CBCT scanner (Xoran-Technologies, Imaging Science International, Hatfield, PA). Exposure parameters were 120 kV and 5 mA. The field of view was 8 cm in diameter and 8 cm in height. Slices were 800 × 800 pixels, with a pixel size of 0.125 mm. The acquired data were viewed to calculate the following parameters.

Transportation

Three cross-section planes at levels 3, 7, and 11 mm from the apical end of the root were viewed through the explorer mode. The preinstrumented and postinstrumented shortest distances from the edge of the canal to the periphery of the root were measured in mesial and distal directions by using i-CAT Vision software. Transportation was calculated according to the formula of Gambill et al (15): $(x_1\text{-}x_2) - (y_1\text{-}y_2)$, where x_1 and x_2 represent the shortest preinstrumentation and postinstrumentation mesial distances, respectively, and y_1 and y_2 represent the shortest preinstrumentation and postinstrumentation distal distances, respectively.

Canal Curvature

All images scanned before and after instrumentation by CBCT were converted for viewing with image analysis software (Invivo 5 Anatomage, San Jose, CA) to determine canal curvature changes according to the method previously described (13, 14). Two straight lines of equal lengths were used. The first line represented 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 canal curvature was expressed in degrees.

Volume

Mesiobuccal canal in each specimen was traced before and after instrumentation, and the total volume was measured. The volume of removed dentin was determined in mm^3 for each root canal by subtracting the uninstrumented canal volume from the instrumented canal volume. Volumetric measurements were taken by using Simplant Pro 12.03 for Intel X86 Platform V 12.0.3.14, operating system Windows XP SP3 (1992–2008 Materialise Dental n.v.; Technologielann 15, Leuven, Belgium).

Statistical Analysis

The homogeneity of the 2 groups, concerning preinstrumentation canal curvature, was assessed by using the Student *t* test.

Data were presented as means and standard deviation. The Friedman test was used to compare between canal transportation in different segments. Wilcoxon signed rank test was used for pair-wise comparisons between segments. Volume and canal curvature data (preoperatively and postoperatively) showed parametric distribution; thus, the Student *t* test was used to compare between the 2 groups. Canal transportation, change, and % changes in canal curvature data showed nonparametric distribution; thus, the Mann-Whitney *U* test was used to compare between the 2 groups. The significance level was set at $P \leq .05$. Statistical analysis was performed with IBM SPSS Statistics Version 20 for Windows (Chicago, IL).

Results

Comparing the mean of transportation (mm) among the 3 tested levels in each group, the WO group recorded statistically significant lower mean of transportation at apical level than the middle and coronal ones, with no significant difference between them. The TF group recorded statistically significant differences in the mean of transportation among the 3 tested levels, with the apical level showing the lowest transportation value. WO recorded significantly higher mean of transportation than the TF group at the 3 levels (Table 1). The results revealed no significant difference between the 2 systems concerning postinstrumentation canal curvature changes (Table 2). Instrumentation by either of the 2 tested files revealed no significant difference in canal volume changes (Table 3).

Discussion

In the present study, the shaping ability of TF (a continuous rotation, full-sequence system) and WO (a reciprocating single-file system) was evaluated by CBCT. The experimental design had 3 different variables in each NiTi system, the movement kinematics, the number of files used, and the manufacturing process. It is not possible to isolate the influence of each variable on the results.

It was previously reported (16) that apical transportation of more than 0.3 mm could negatively affect the sealability of the obturating material. None of the apical transportation values recorded in this study exceeded this limit. The superiority of the apical transportation compared with the other 2 levels may be attributed to the noncutting tip design of the tested instruments, which acts as a guide to allow easy penetration with minimal apical pressure (17), and the standardized master apical file size (18). It could also be attributed to the increased diameter and decreased flexibility of the NiTi instruments at the coronal portion. This study proved that the multiple-file TF system resulted in significantly lower canal transportation than the single WO file at all levels. Several studies (11, 12, 19) demonstrated superior results of TF related to canal transportation and maintaining canal curvature, when compared with other NiTi files manufactured by

TABLE 1. Mean and Standard Deviation Values of Transportation (mm) at Different Canal Levels in the 2 Groups

Level	Twisted file	WaveOne	*P* value
Apical (3 mm)	$0.09^{c} \pm 0.04$	$0.14^{b} \pm 0.05$	.05*
Middle (7 mm)	$0.13^{b} \pm 0.05$	$0.22^{a} \pm 0.05$	.05*
Coronal (11 mm)	$0.19^{a} \pm 0.04$	$0.24^{a} \pm 0.04$	.05*
P value	.001*	.001*	

Means with different superscript letters are statistically significantly different.
*Significant at $P \leq .05$.