Original Article

Cone-beam Computed Tomographic Assessment of Canal Centering Ability and Transportation after Preparation with Twisted File and Bio RaCe Instrumentation

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Abstract

Objective: Use of rotary Nickel-Titanium (NiTi) instruments for endodontic preparation has introduced a new era in endodontic practice, but this issue has undergone dramatic modifications in order to achieve improved shaping abilities. Cone-beam computed tomography (CBCT) has made it possible to accurately evaluate geometrical changes following canal preparation.

This study was carried out to compare canal centering ability and transportation of Twisted File and BioRaCe rotary systems by means of cone-beam computed tomography.

Materials and Methods: Thirty root canals from freshly extracted mandibular and maxillary teeth were selected. Teeth were mounted and scanned before and after preparation by CBCT at different apical levels. Specimens were divided into 2 groups of 15. In the first group Twisted File and in the second, BioRaCe was used for canal preparation. Canal transportation and centering ability after preparation were assessed by NNT Viewer and Photoshop CS4 software. Statistical analysis was performed using t-test and two-way ANOVA.

Results: All samples showed deviations from the original axes of the canals. No significant differences were detected between the two rotary NiTi instruments for canal centering ability in all sections. Regarding canal transportation however, a significant difference was seen in the BioRaCe group at 7.5mm from the apex.

Conclusion: Under the conditions of this in vitro study, Twisted File and BioRaCe rotary NiTi files retained original canal geometry.

Key Words: Centering Ability; CBCT; Cone-Beam Computed Tomography Canal Instrumentation; Ni-Ti rotary systems; Transportation

Journal of Dentistry, Tehran University of Medical Sciences, Tehran, Iran (2014; Vol. 11, No. 4)

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Received: 7 February 2014
Accepted: 12 March 2014

INTRODUCTION

Root canal preparation has been recognized as an important phase in endodontic therapy [1]. One of the difficulties in root canal preparation is deviation from the original path especially in curved root canal systems and when relatively nonflexible instruments are used [2-4]; therefore, a variety of preparation techniques and instruments have been proposed to overcome this problem [5-9].

Apical transportation is difficult to measure because no gold standard exists for this measurement; also, various methods with different limitations are noted in this regard [10, 11]. The presently used methods are comprised of radiographic imaging [12], cross-sectioning [13], and longitudinal cleavage of the samples [14]. In recent years, computed tomography (CT) has been added as a measuring device for this purpose with acceptable results because of its nondestructive nature and the possibility to have precise linear measurements [15, 16].

Recently, manufacturers of rotary Nickel-Titanium (NiTi) instruments have claimed to have improved shaping ability of their products. For example, BioRaCe (FKG Dentaire, La Chaux-de-Fonds, Switzerland) has been recently developed with different tapers, instrumentation sequence and dedicated handles compared to conventional RaCe instrument. It is claimed that adequate apical preparation sizes can be achieved by using BioRaCe with a decreased number of instruments [17]. Another example is the Twisted File (TF) system (SybronEndo, Orange, CA, USA) which is manufactured with twisting to have a triangular cross section with constant tapers of 0.04, 0.06, 0.08, 0.10, and 0.12. In addition, files are available in 5 sizes (i.e. 25–50). It is also claimed that an increase in the instrument flexibility as well as resistance to cyclic fatigue occurs following R-phase heat treatment, twisting of the metal, and special surface conditioning.

Therefore, maintenance of the original canal curvature and minimizing canal transportation even in severely curved root canals are possible. Reports indicate that TF shows higher resistance to fracture than ground files [18-21]. This study was carried out to compare the canal centering ability and canal transportation of Twisted File and BioRaCe rotary NiTi files by means of cone-beam computed tomography (CBCT).

MATERIALS AND METHODS

A total of 150 freshly-extracted mandibular and maxillary first and second molars with mature apices were selected and stored in formalin. Access cavities were prepared by carbide burs (Teeskavan, Iran). A No.15 K-file (Mani, Japan) was placed into one of the mesial canals until it was just visible at the apical foramen. One millimeter was subtracted from the length of the file and considered as the working length (WL) for canal preparation. Canals that did not allow placement of the #15 file to the apex and those that allowed passive placement of #20 file to the apex were excluded. Standardized parallel radiographs were taken of each tooth. Degree of canal curvature was determined for each sample [7, 22-25]. Thirty teeth, each with a radius of curvature of about 3-5 mm and an angle of curvature of 20º - 40º were selected. Specimens were divided into 2 groups of 15. Stratified random sampling was used to allocate samples to the pertinent groups; each experimental group contained equal number of samples with similar root curvatures. Teeth in each group were mounted in an acrylic dish during scanning processes. All teeth were aligned with their long axes parallel to the bottom of the dish. Only one mesial canal was prepared in each tooth. All teeth were scanned before and after preparation with their roots being perpendicular to the beam of a cone beam computed tomography (CBCT) device (NewTom VG, Quantitative Radiology, Verona, Italy) starting from the apical end of the root. The CBCT imaging device provided a high resolution scan, with 0.15mm voxel size, and 0.5 mm axial thickness. Scans were made in 1-, 2.5-, 5- and 7.5-mm distances from the apex.

In group A, teeth were prepared by TF instruments according to the manufacturer's recommendation. The shaping procedure commenced with TF size 25 taper 0.10. The coronal one third or two thirds of the root canal was shaped if passive penetration was possible.

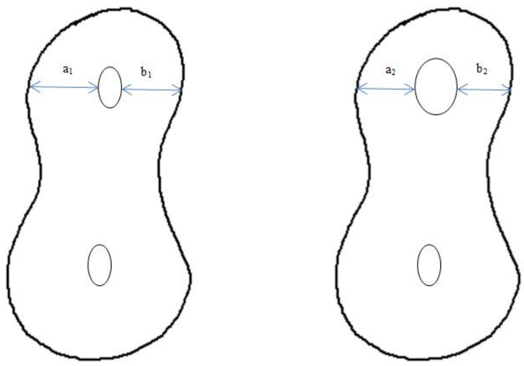

Fig1. Schematic representation of preparation geometry used in this study before (left) and after (right) instrumentation.

TF size 25 taper 0.08 was inserted and used up to the curvature. Finally, TF size 25 taper 0.06 was inserted to WL.

In group B, teeth were prepared by BioRaCe instruments according to the manufacturer's recommendation. After canal negotiation with a #15 K-file, the shaping procedure commenced with BR0 (size #25, 0.08 taper). Shaping continued with BR1 (size #15, 0.05 taper), BR2 (size# 25, 0.04 taper), and BR3 (size#25, 0.06 taper).

BR1, 2, and 3 were inserted to WL. The canals for each group were instrumented at a speed of 500rpm and torque of 150 g/cm using a 4:1 reduction rotary hand-piece (NSK, Japan) powered by ENDO IT electronic device (VDW, Munich, Germany).

Canals were lubricated using an EDTA-containing gel (Meta Biomed, Korea). Recapitulation and irrigation with 2ml of 5.25% NaOCl were performed after use of each instrument.

The pre- and post-instrumentation CBCT images were compared using Version 11.0 Adobe Photoshop CS4 software (Adobe System Inc., San Jose, CA).

The amount of canal transportation was measured by the shortest distance from the inner wall of the canal prior to instrumentation to the periphery of the root both mesially and distally and then comparing this with the same measurements obtained from the instrumented images. The following formula was used to evaluate canal transportation (8):

$|(a1 - a2) - (b1 - b2)|$ where a1 is the shortest distance from the mesial root wall to the mesial margin of the canal prior to preparation, b1 is the shortest distance from distal root wall to the distal margin of the canal prior to preparation, a2 is the shortest distance from the mesial root wall to the mesial margin of the canal after preparation, and b2 is the shortest distance from distal root wall to the distal margin of the canal after preparation.

Table 1. Centering ratio of instrumentation groups in each cross-section

Section (millimeter distance from the apex)	Group	Mean± standard deviation
1	B	0.54±0.33
	A	0.38±0.29
2.5	B	0.49±0.34
	A	0.24±0.29
5	B	0.42±0.27
	A	0.36±0.36
7.5	B	0.36±0.27
	A	0.48±0.33

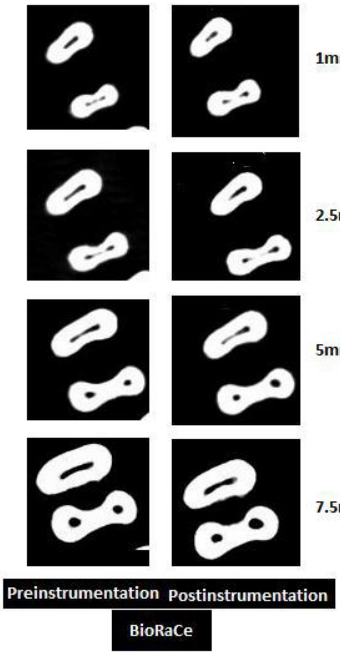

Fig 2. Pre- (A, C, E, and G) and post-instrumentation (B, D, F, and H) horizontal cross sections made by CBCT in the Twisted File group. The numbers at the bottom right of each figure indicate the distance from the apex at which the sections were made in millimeters.

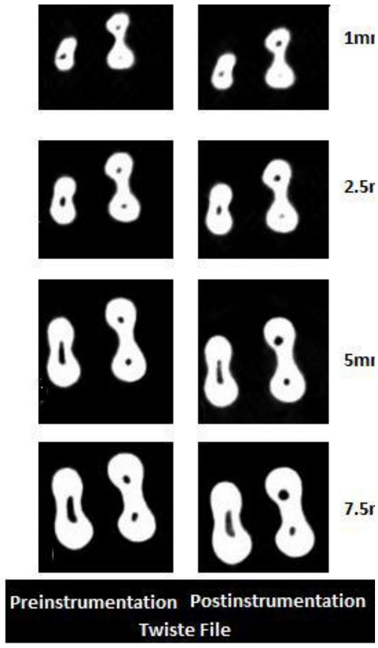

Fig 3. Pre- (A, C, E, and G) and post-instrumentation (B, D, F, and H) horizontal cross sections made by CBCT in BioRaCe group. The numbers at the bottom right of each figure indicate the distance from the apex at which the sections were made in millimeters.

According to this formula, a result other than 0 indicates that transportation has occurred in the canal. The mean centering ratio declares the capability of the instrument to remain centered within the canal. It was measured for each cross-section using the following ratio:
(a1 – a2) / (b1 – b2) or (b1 – b2) / (a1 – a2).
In case the aforementioned numbers are unequal, the lower figure is therefore deemed as the numerator of the ratio.
According to this formula, a result equal to 1 shows that the instrument possessed a perfect centering within the canal.

The centering ratio and the extent of canal transportation were analyzed by two-way analysis of variance (ANOVA). T-test was used to find significant differences between experimental groups. The significance level was set at 95%. All analyses were performed using SPSS 11 software (SPSS Inc, Chicago, IL).

RESULTS

Canal transportation was observed in both experimental groups, but the direction of transportation did not occur uniformly.

Table 2. Canal transportation of instrumentation groups in each cross-section

Section (millimeter distance from the apex)	Group	Mean ± standard deviation
1	B	1.46±1.92
	A	2.34±2.06
2.5	B	2.50±3.01
	A	3.31±3.51
5	B	4.14±3.42
	A	5.72±4.68
7.5	B	6.07±3.48
	A	3.03±2.68

In group A, in sections 1mm short of apex, transportation was found towards mesial aspect of the root canal wall; whereas in other sections, canals were transported to the distal (furcal) wall in other sections.

The results of two-way ANOVA showed that in group B at 7.5 mm from the apex, transportation was significantly higher than that of group A (P=0.01).

In both groups, in other sections, the difference was not statistically significant (P<0.05). In 7.5-mm sections from the apex, group A showed more concentric preparations compared with group B. In other sections (1, 2.5, and 5 mm from the apex) BioRaCe maintained canal centricity more than did TF files. However, this difference was not statistically significant (P<0.05).

DISCUSSION

Transportation is defined within The Glossary of Endodontic Terms as removal of the root canal dentin on the outer wall of the curve within the apical half of the canal as a result of the tendency of instruments to regain their original straight shape during canal preparation [26]. Maintaining original canal shape during instrumentation is one of the most important principles during treatment [27]. Evaluation of shaping ability of various endodontic instruments by computed tomography is advantageous because of its noninvasive nature, in ex-vivo and in-vitro models, and therefore has been used extensively in the literature [15, 16, 21, 28-32]. A major advantage of CBCT is the three-dimensional geometric accuracy compared with conventional radiographs, as well as elimination of structural superimpositions [30]. On the other hand, the main disadvantages of the technique are the high cost of the equipment and the time-consuming scanning and reconstruction procedures [33].

In a recent study RaCe instruments maintained working length well in curved canals and created no changes in canal geometry [34]. In a study in which simulated S-shaped canals were used, no observable transportation was reported for RaCe instruments [17]. In contrast, other authors observed significantly more canal transportation with RaCe files, for example while compared with ProFile and K3 files [1] and with Hero Shaper and ProTaper [35]. Use of stainless steel rotary RaCe files in the preparation sequence and the fact that lower rotational speeds were used compared with those recommended by the manufacturer might have been influential in reporting some unfavorable results for RaCe [17]. In the present study, the use of Bio-RaCe and Twisted File seemed to be almost similar in preventing canal preparation aberrations.

In this study, both files had the same cross section and final apical preparation size.

The speed and torque were also equalized for both groups.

The samples were studied at 1, 2.5, 5 and 7.5 mm from apical foramen; therefore, the final point of preparation, middle and beginning of curvature and finally the coronal (straight) portion of the canals were evaluated.

It has been shown by some authors that TF possesses acceptable flexibility in comparison with other rotary NiTi systems [20].

Final apical size and taper were equalized for both experimental groups in this study (i.e., #25, 0.06 taper). Both files demonstrated acceptable centering ability which can be explained by high flexibility of the two systems. Both files showed canal transportation in the furcal direction; which was in agreement with some other studies [1, 35]. The difference in transportation at 7.5-mm distance from the apex can be attributed to the higher number of instruments used from crown to the apex in BR group with respect to TF and high flexibility of the TF system.

CONCLUSION

According to this in vitro study, TF and BioRaCe rotary files did not differ significantly in terms of canal centering ability and canal transportation.

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