Micro–computed Tomographic Evaluation of the Shaping Ability of XP-endo Shaper, iRaCe, and EdgeFile Systems in Long Oval-shaped Canals

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Abstract

Introduction: This study evaluated the shaping ability of the XP-endo Shaper (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland), iRaCe (FKG Dentaire SA), and EdgeFile (EdgeEndo, Albuquerque, NM) systems using micro–computed tomographic (micro-CT) technology. **Methods:** Thirty long oval-shaped canals from mandibular incisors were matched anatomically using micro-CT scanning (SkyScan1174v2; Bruker-microCT, Kontich, Belgium) and distributed into 3 groups ($n = 10$) according to the canal preparation protocol (ie, XP-endo Shaper, iRaCe, and EdgeFile systems). Coregistered images, before and after preparation, were evaluated for morphometric measurements of the volume, surface area, structure model index (SMI), untouched walls, area, perimeter, roundness, and diameter. Data were statistically compared between groups using the 1-way analysis of variance post hoc Tukey test and within groups with the paired sample t test ($\alpha = 5\%$). **Results:** Within groups, preparation significantly increased all tested parameters ($P < .05$). No statistical difference was observed in the mean percentage increase of the volume (∼52%) and surface area (10.8%–14.2%) or the mean percentage of the remaining unprepared canal walls between groups (8.17%–9.83%) ($P > .05$). The XP-endo Shaper significantly altered the overall geometry of the root canal to a more conical shape (SMI = 2.59) when compared with the other groups ($P < .05$). After preparation protocols, changes in area, perimeter, roundness, and minor and major diameters of the root canals in the 5 mm of the root apex showed no difference between groups ($P > .05$). **Conclusions:** The XP-endo Shaper, iRaCe, and EdgeFile systems showed a similar shaping ability. Despite the XP-endo Shaper had significantly altered the overall geometry of the root canal to a more conical shape, neither technique was capable of completely preparing the long oval-shaped canals of mandibular incisors. *(J Endod 2017;■:1–7)*

Key Words

Micro–computed tomography, nickel-titanium instruments, reciprocating motion, root canal preparation, single-file system

Significance

The concept of using a single nickel-titanium instrument to mechanically prepare the entire root canal is interesting because it may be cost-effective and may shorten the learning curve for practitioners to adopt the new technique. In this study, the single-file XP-endo Shaper showed a similar shaping ability as the EdgeFile and iRaCe multiple-file systems.

The main goal of root canal preparation is to remove the inner layer of the dentin while allowing the irrigant to reach the entire length of the canal space, eradicating bacterial populations or at least reducing them to levels that allow for periradicular tissue healing (1, 2). However, it is widely recognized that fulfilling this goal with the available endodontic armamentarium may be a challenging task when preparing flattened or oval-shaped root canals (2–5). Therefore, to make canal shaping more efficient and predictable, several nickel-titanium (NiTi) instruments with an optimal geometry and surface have been developed within the last decades.

The iRaCe system (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) was introduced as a simplified sequence of the original RaCe system (FKG Dentaire SA). Its active cutting regions are electrochemically polished and have twisted areas with alternating cutting edges (6). Research findings on iRaCe instruments have shown some advantageous properties compared with other systems regarding the maintenance of the canal curvature (7). In recent years, the EdgeEndo company (Albuquerque, NM) has launched 4 different constant tapered systems (X1, X3, X5, and X7) to be used with the same handpiece, speed, kinematics, and torque as their specified competitor's recommended settings. The reciprocating (X1) and rotary (X3, X5, and X7) instruments are made of an annealed heat treated NiTi alloy brand named Fire-Wire (EdgeEndo), which has been claimed to increase the cyclic fatigue resistance and torque strength of the instruments (8). More recently, a new file system known as the XP-endo Shaper (FKG Dentaire SA) was introduced. This snake-shaped instrument is made of a proprietary alloy (MaxWire [FKG Dentaire SA] [Martensite-Austenite electropolish-fleX]) that reacts at different temperature levels (9). The file has an initial taper of .01 in its M phase when it is cooled, but, upon exposure to body temperature (35°C), the taper changes to .04 according to the molecular memory of the A phase (10). As stated by the manufacturer, the tip of the XP-

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endo Shaper, the Booster Tip, has 6 cutting edges and enables the instrument to start shaping after a glide path of at least ISO 15 and to gradually increase its working field to achieve ISO 30 (9).

Several methodologies were developed to evaluate the shaping ability of NiTi systems, but currently 3-dimensional nondestructive high-resolution X-ray micro–computed tomographic (micro-CT) imaging is considered the gold standard (11). Even though there is accumulating evidence on the efficacy of several rotary and reciprocating systems, comprehensive knowledge regarding the shaping ability of the XP-endo Shaper, iRaCe, and EdgeFile (EdgeEndo) systems is still lacking. Therefore, the purpose of this *ex vivo* study was to evaluate the shaping ability of these instruments in long oval-shaped root canals of mandibular incisors using micro-CT imaging technology.

Material and Methods

Tooth Specimen Selection and Groups

After local ethics committee approval, 100 noncarious, straight, single-rooted human mandibular incisors with fully formed apices were randomly selected from a pool of extracted teeth, mounted on a custom attachment, and imaged separately at an isotropic resolution of 26.7 μm using a micro-CT device (SkyScan 1174v.2; Bruker microCT, Kontich, Belgium). The scanner parameters were set at 50 kV, 800 μA, 180° rotation around the vertical axis, and a rotation step of 0.7° using a 1-mm-thick aluminum filter. The acquired projection images were reconstructed into cross-sectional slices using NRecon v.1.6.9 software (Bruker-microCT) with a beam hardening correction of 10%, smoothing of 3, ring artifact correction of 3, and an attenuation coefficient ranging from 0.002 to 0.120.

Preoperative 3-dimensional (3D) models of the root and root canals were rendered (CTVol v.2.2.1, Bruker microCT) for qualitative evaluation of the canal configuration. Then, 3D and 2-dimensional (2D) parameters of the root canals were calculated according to a previous publication (12) using CTAn v.1.14.4 software (Bruker microCT). 3D measurements (root canal length, volume, surface area, and the structure model index [SMI]) were based on a surface-rendered volume model of the root canal in the 3D space extending from the cementoenamel junction level on the buccal aspect of the root to the apex, whereas 2D morphometry (area, perimeter, roundness, and minor and major diameters) was performed at a 1-mm interval in the 5 mm of the root apex on individual binarized cross-sectional images of the root canal starting 0.5 mm from the apical foramen. The canal shape was classified by calculating the mean aspect ratio, defined as the ratio of the major to the minor diameter, of all slices in the 10 mm of the root apex. A canal was identified as a long oval-shaped canal when the ratio of the long to short canal diameter was >2 (ie, when 1 dimension was at least 2 times that of a measurement made at right angles) (13).

Aiming to enhance the internal validity of the experiment, 30 mandibular incisors with a single long oval-shaped root canal were selected and matched to create 10 groups of 3 teeth based on the morphologic aspects of the root canal systems. Then, 1 tooth from each group was randomly assigned to 1 of the 3 experimental groups (n = 10) according to the canal preparation protocol (ie, XP-endo Shaper, iRaCe, or EdgeFile). After checking the normality assumption (Shapiro-Wilk test) and homoscedasticity (Levene test), the degree of homogeneity (baseline) of the 3 groups with respect to the 2D (area, perimeter, roundness, and diameter) and 3D root canal (length, volume, surface area, and SMI) morphometric parameters was statistically confirmed at a significance level of 5% (P > .05, 1-way analysis of variance test) (Tables 1 and 2).

TABLE 1. Pre- and Postoperative Parameters Evaluated in the Root Canal System of 30 Mandibular Incisors after Different Root Canal Preparation Protocols

Parameters		Group 1 (XP-endo Shaper, n = 10)		Group 2 (i-RaCe, n = 10)		Group 3 (EdgeFile, n = 10)		P value
		Mean ± SD	Median (range)	Mean ± SD	Median (range)	Mean ± SD	Median (range)	
Length	Before (mm)	21.28 ± 1.68	21.84 (18.1–22.8)	21.58 ± 0.74	21.55 (20.6–22.8)	20.30 ± 0.98	20.60 (18.6–21.7)	.57
Aspect ratio	Before	2.55 ± 0.52	2.59 (1.55–3.40)	2.81 ± 0.75	2.93 (1.73–3.84)	2.76 ± 0.68	3.05 (1.68–3.76)	.63
Volume	Before (mm^3)	4.26 ± 1.59	3.67 (2.4–7.8)	4.39 ± 1.52	4.10 (3.4–8.4)	4.13 ± 1.0	3.78 (2.9–5.7)	.30
	After (mm^3)	6.35 ± 1.77	6.18 (3.4–9.6)	6.65 ± 2.23	6.04 (4.7–12.2)	6.17 ± 1.28	6.05 (4.1–7.6)	.83
	Increase (Δ%)	52.9 ± 19.0	52.1 (22.1–82.0)	52.5 ± 21.9	44.9 (25.6–90.5)	52.2 ± 28.1	38.4 (25.6–104.0)	.40
Surface area	Before (mm^2)	33.44 ± 6.74	32.93 (22.2–43.4)	35.72 ± 10.04	34.77 (25.8–60.1)	34.01 ± 7.15	32.77 (23.7–44.5)	.07
	After (mm^2)	36.77 ± 6.67	38.67 (24.5–45.6)	40.73 ± 11.23	37.54 (30.2–66.7)	38.24 ± 7.72	36.05 (26.6–48.6)	.22
	Increase (Δ%)	10.8 ± 7.1	9.8 (1.5–24.9)	14.2 ± 4.8	14.3 (7.3–22.3)	12.7 ± 5.9	12.0 (6.2–22.9)	.41
SMI	Before	2.11 ± 0.42	2.24 (1.2–2.5)	2.02 ± 0.42	1.94 (1.5–2.5)	1.96 ± 0.32	1.91 (1.3–2.3)	.68
	After	**2.59 ± 0.25**[a]	**2.68 (2.1–2.8)**	**2.34 ± 0.28**[a,b]	**2.36 (1.8–2.6)**	**2.28 ± 0.30**[b]	**2.31 (1.8–2.6)**	**.04**
	Increase (Δ%)	26.2 ± 22.8	19.9 (9.9–86.5)	18.1 ± 22.8	19.9 (9.9–86.5)	17.7 ± 10.9	12.7 (8.6–37.0)	1.40
Unprepared area	After (%)	9.42 ± 7.67	5.88 (2.6–23.2)	8.17 ± 4.01	6.65 (3.8–14.5)	9.83 ± 8.18	7.47 (2.0–30.0)	.09

SD, standard deviation; SMI, structure model index.

Bold values with different superscript letters in the same line indicate a statistically significant difference between groups (1-way analysis of variance, P < .05).