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ISSN 2378-7090

International Journal of Dentistry and Oral Health

Research Article
Volume: 2.7
Open Access

Canal Central Ability of Four Different Endodontic Single-File Systems in Simulated L-Shaped Resin Canals

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Received date: 25 Jun 2016; **Accepted date:** 19 Jul 2016; **Published date:** 25 Jul 2016.

Citation: Saleh ARM, Rashid AA (2016) Canal Central Ability of Four Different Endodontic Single-File Systems in Simulated L-Shaped Resin Canals. Int J Dent Oral Health 2(7): doi http://dx.doi.org/10.16966/2378-7090.213

Abstract

The aim of the present study was to compare the canal central ability of four different single-file instruments: WaveOne (Dentsply Maillefer), Reciproc (VDW), One Shape (Micro Mega) and F360 (Komet). Sixty-four L- shaped canals in resin blocks were instrumented to an apical end using one of the four single-file instruments (size 25) described above (each group, n=16). Preoperative and postoperative images were obtained with a digital camera and superimposed in 2distinctive layers. The amount of resin removed from both the inner and the outer sides of the canal was measured at five different sites: the orifice; the half way of the orifice; the beginning of the curve; the apex of the curve; and the apical end. The amount of resin removed by each instrument was measured using image analysis software. The resin removal was statistically analyzed using a paired *t*-test, analysis of variance, and Tukey's post hoc test. The WaveOne and Reciproc instruments both removed significantly more amounts of resin from the inner side at the beginning and apex of the curve ($P < 0.05$). Canals prepared with the F360 and One Shape instruments were more centered in their cutting compared with the Reciproc and WaveOne instruments.

All the investigated single-file instruments effectively and safely prepared the simulated canals. Instruments with less taper like F360 and One Shape preserve canal anatomy to a greater extent than larger taper instruments.

Keywords: Reciprocation; Single-file; Simulated canals; Canal central ability

Introduction

The introduction of NiTi rotary instruments in the 1990s was an attempt to overcome several undesirable characteristics of stainless steel files. Since then, new rotary files and NiTi instrument systems have been introduced into the dental market and have become very popular in endodontic practice. The flexibility of NiTi instruments enables them to be used in conjunction with automated hand pieces, increasing the efficiency of root canal preparation [1,2]. Despite the advantages of these files, fracturing of NiTi instruments inside the root canal remains an issue [3,4], as does their cost, and the possibility of disease-transmission [5].

The single file is hypothesized as a single instrument used to enlarge the root canal (in the majority of cases), until the desired final size, taper and shape is obtained. Single-file canal preparation was introduced as a novel technique in a preliminary study reported by Yared [6]. He proposed the use of only one reciprocating F2 ProTaper file for the preparation of a root canal. Shortly after, because of the perceived advantages, many companies adopted this technique and introduced to the market distinct files exhibiting unique designs, cross sections, alloys, and motions. Two examples of these files are Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) which are made from M-wire, and these work by reciprocating motion provided by their dedicated motors. Another two examples are One Shape (Micro Mega, Besancon, France) and F360 (Komet Brasseler, Lemgo, Germany), which are made from traditional NiTi alloy, and these work in clockwise full rotational motion.

Single-use endodontic instruments were recommended in order to decrease both instrument fatigue and possible cross- contamination [7], and to reduce the number of NiTi rotary instruments required for canal preparation. The single-file technique was also advocated as being cost-effective and as requiring only a short learning curve for practitioners to adopt the new technique [6,8].

Single-file systems exhibited comparatively good cleaning ability and can be regarded as suitable for the cleaning of even severely curved surfaces using only the one instrument [9].

The present study aims to compare the canal central ability of the four single-file systems: WaveOne, Reciproc, One Shape, and F360. WaveOne and Reciproc are designed specifically to be used in reciprocating motion, while One Shape and F360 are designed to be used in continuous rotation.

Materials and Methods

Simulated canals

Sixty-four simulated L-shaped canals (Endo Training Block-L; Dentsply Maillefer, Ballaigues, Switzerland) with a taper of 0.02, an apical diameter of 0.15 mm, and a length of 16 mm were used in this study.

Pre-operative imaging

A pre-instrumentation image of each simulated canal was recorded using a digital camera (EOS 650D.Canon). The camera was placed centrally and at 90 degrees to the specimen, at a fixed distance from the block. In order to take standardized and reproducible pictures, a camera stand was used. The block was placed on a custom-made template to ensure block placement was fixed (relative to the camera lens) in a mesio-distal view. Three orientation marks were made with a permanent pen on the resin block from the side wall to near the inner and outer curve of the canal (without penetrating into the canal). Each simulated canal was colored with black ink injected with a syringe. Pre-instrumentation images of all resin blocks were obtained and saved as JPEG format files.

Sample distribution

The patency of the canals was confirmed by passing a size 10 K-file just beyond the apex; subsequently, the resin blocks were randomly divided into four groups (n=16 canals/group) and were numbered according to the type of file used to prepare the canals.

The simulated canals were instrumented to the full working length as follows:

Group 1: The WaveOne Primary file (tip size, 25; apical taper, 0.08) was operated by the X-Smart plus motor (Dentsply Maillefer, Ballaigues, Switzerland) in "WAVEONE ALL" mode according to the manufacturer's guidelines. The files were operated in pecking movements and after three in-and-out-movements; the flutes of the file were checked for sign of failure and wiped to remove the debris.

Group 2: The R25 Reciproc file (tip size, 25; apical taper, 0.08) was operated by the X-Smart plus motor (Dentsply Maillefer, Ballaigues, Switzerland) in "RECIPROC ALL" mode according to the manufacturer's guidelines. The files were operated in pecking movements and after three in-and-out-movements; the flutes of the file were checked for sign of failure and wiped to remove the debris.

Group 3: The One Shape file (tip size, 25; taper, 0.06) was used in full clockwise rotation with a rotational speed of 400 rpm operated by the X-Smart plus motor, and the torque was adjusted to 4 N cm. The files were used in a slight pecking motion according to the manufacturer's guidelines.

Group 4: The F360 file (tip size, 25; taper, 0.04) was used in full clockwise rotation with a rotational speed of 300 rpm operated by the X-Smart plus motor, and the torque was adjusted to 1.8 Ncm. The files were used in a slight pecking motion according to the manufacturer's guidelines.

A new instrument was used to prepare four canals in each group according to the previous protocols [7]. Glyde-Prep (Dentsply Maillefer, Ballaigues, Switzerland) was used as a lubricant before the utilization of each instrument and distilled water was used for irrigation during preparation. Measurement of the canals was carried out by a second examiner who was blinded to the experimental groups. A randomly laid down sequence was used to avoid bias towards the fifth-instrumentation groups.

Assessment of canal preparation

A postoperative image of each sample was taken under the same conditions used to take the preoperative image after injecting the block with red ink. The preoperative and post-operative images were superimposed using software (Adobe Photoshop Elements 7.0, Adobe Systems Incorporated, San Jose, CA, USA). The composite image was assessed using the computer program Image J 1.48v software (Wayne Rasband, National Institutes of Health, USA).Two evaluators working together and blind to the groups performed all measurements.

Width measurements

Each superimposed image obtained using Adobe Photoshop details the outline of each original pre-operative canal and the outline of the post-operative canal. By measuring the difference in width between the two images, it was possible to quantify the amount of resin material removed. Measurements were taken at fixed positions in the L-shape canal, and included estimations of the width of the resin removed from the outer and inner aspects of the curve of the original canal.

The removed resin was estimated from measurements taken at five different points using methods outlined by Alodeh and Dummer [10,11]. The inner and outer widths were taken at perpendiculars to the long access of the L-shape canal. The five measurements were:

Position 1, measured at 5mm from the orifice;

Position 2, measured at half-way from the start of the curve to the orifice (7mm from orifice);

Position 3, measured at the beginning of the curve. The point where the canal starts to move away from the long axis of the straight part of the canal;

Position 4, measured at the apex of the curve. This was determined by the crossing of two lines one drawn along the outer border of the straight part of the canal and the second drawn along the outer border of the apical aspect of the canal;

Position 5, measured at apical end. This denotes the end point of the preparation.

Centering ability

Centering ability was assessed for each measuring point by analyzing the amount of resin removed at the inner side versus the amount of resin removed at the outer side using a paired *t*-test ($p<.05$). A canal preparation with no significant differences between the amounts of resin removed at the inner side compared to the amounts of resin removed at the outer side was considered to demonstrate good centering ability.

Statistical analysis

After confirming the normality of each set of data using the Kolmogorov-Smirnov and Shapiro-Wilk tests, the data were analyzed using ANOVA, the post hoc Tukey's test and a paired t-test ($p<0.05$, IBM SPSS Statistics 21; SPSS, Chicago, IL).

Results

Width measurements

Inner width measurements

There was no statistically significant difference in mean values of the inner width of material removal among all single-file systems at the apex of the curve and the apical end. WaveOne and Reciproc files removed significantly greater amounts of resin from the inner side at the beginning of the curve compared to the other single-file systems. The F360 file removed less resin in comparison with the other systems at most points of measurement (Table 1).

Outer width measurements

There was no statistically significant difference in mean values of the outer width of material removal among all single-file systems at the apical end. WaveOne, Reciproc, and One Shape removed significantly more resin at the orifice and half way to the orifice compared to F360. At the beginning and apex of the curve, F360 and Reciproc removed significantly less resin compared to the other systems. F360 removed the least amount of resin in comparison to the other systems at all points of measurement (Table 1).

Centering ability

In regards to centering ability, F360 and OneShape files had a tendency to remove resin more equally from the inner and outer sides of the canal at the apex of the curve in comparison with the other instruments. WaveOne and Reciproc files had a tendency to remove significantly more resin from the inner side than the outer side at the beginning of the curve and apex of the curve.

Inner Canal Wall (mm)						Outer Canal Wall (mm)					
	O	HO	BC	AC	AE		O	HO	BC	AC	AE
WaveOne						WaveOne					
Mean	0.23 ^{a}	0.29 ^{a}	0.38 ^{a}	0.18 ^{a}	0.02 ^{a}	Mean	0.29 ^{a}	0.29 ^{a}	0.16 ^{a}	0.16 ^{a}	0.13 ^{a}
SD	0.03	0.03	0.03	0.02	0.04	SD	0.02	0.01	0.02	0.01	0.05
Reciproc						Reciproc					
Mean	0.19 ^{b}	0.25 ^{b}	0.35 ^{a}	0.26 ^{a}	0.04 ^{a}	Mean	0.26 ^{a}	0.23 ^{a}	0.11 ^{b}	0.14 ^{a}	0.16 ^{a}
SD	0.03	0.03	0.03	0.03	0.02	SD	0.03	0.04	0.02	0.02	0.07
One Shape						One Shape					
Mean	0.19 ^{b}	0.22 ^{c}	0.25 ^{b}	0.12 ^{a}	0.09 ^{a}	Mean	0.29 ^{a}	0.26 ^{a}	0.16 ^{a}	0.19 ^{b}	0.12 ^{a}
SD	0.02	0.02	0.02	0.03	0.02	SD	0.02	0.02	0.02	0.02	0.03
F360						F360					
Mean	0.11 ^{c}	0.13 ^{d}	0.15 ^{c}	0.17 ^{a}	0.05 ^{a}	Mean	0.14 ^{b}	0.17 ^{b}	0.11 ^{b}	0.12 ^{c}	0.10 ^{a}
SD	0.01	0.01	0.01	0.21	0.02	SD	0.01	0.01	0.02	0.02	0.04
	**	**	**				**	*	**	**	

Table 1: Means and standard deviations (SD) of removed resin (mm) at the different measurement points after root canal preparation
Values with the same superscript letters are not statistically different at $P < 0.05$. The maximum difference at each point is also indicated as *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$ (ANOVA and post-hoc Tukey test)

Discussion

The resin blocks used in this study allow for standardization of parameters such as length, width, and curvature. A direct evaluation of the amount of resin removed during the test procedures is facilitated by the superimposition of post and pre instrumentation images [12]. In any comparison of the central cutting and shaping abilities of different root canal instruments, it is essential to standardize apical end preparation [13]. In the present study, all of the investigated instruments had an apical diameter of size 25; this size is recommended for the preparation of curved, narrow canals when hand instruments do not passively reach the full working length.

At the apical end of the preparation, there was no statistically significant difference in resin removal at the inner and outer side of the curve between any of the experimental instruments, indicating that all instruments follow the curvature and preserve the apical foramen position and dimension.

WaveOne and Reciproc showed more removal of resin in the inner wall than One Shape and F360 at the beginning of the curve point, and there is a significant difference among the different single-file systems. In particular, consequently, this would create anger zones formation and a straightening of the canal. Our findings regarding the Reciproc file system are consistent with the results of a previous study [14]. However, our WaveOne system findings differ from the results of another study in which respectable shaping effects were obtained when this instrument was used to prepare both L- and S-shaped simulated canals [15].

At the apex of the curve point, all systems except One Shape cut at the inner surface more than the outer surface. It is noteworthy that more of the canal is preserved at the apex with F360 than with any of the other systems.

According to our study, the F360 file system with a constant 0.04 taper removed less resin than the One Shape file system of constant 0.06 taper, and the One Shape file system removed less than the WaveOne and Reciproc file systems (0.08 taper at the apical 3mm followed by a regressive taper). Furthermore, differences in the taper of each of these file systems may account for many of the observed differences. The difference in the cross section is the reason for the dissimilarities in the shaping ability between Reciproc and WaveOne, and this was reported in the previous studies [16].

The two main findings of the present study were that less tapered single-file instruments caused less canal transportation compared with more tapered instruments and that instrument taper is the main factor determining the shaping ability of the instruments with an L-shaped canal. These findings are consistent with those previously reported by Saleh et al. [17].

Conclusion

Within the limitations of the present study, all of the investigated single-file instruments effectively and safely prepared the simulated canals. However, instruments with less taper like F360 and One Shape preserve canal anatomy more effectively than larger taper instruments.

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