Shaping Ability of Three Nickel-Titanium Rotary Instruments in Simulated L-Shaped Canals: Oneshape, Hero Shaper, and Revo-S

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Research Article

Keywords: ANOVA, Tukey, Chi-square tests, OneShape, Hero Shaper

Posted Date: May 13th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-504454/v1

Version of Record: A version of this preprint was published at BMC Oral Health on July 26th, 2021. See the published version at https://doi.org/10.1186/s12903-021-01734-6.

Abstract

Background

This study aimed to compare the shaping ability of OneShape, Hero Shaper, and Revo-S instruments in simulated L-shaped canals.

Methods

forty-eight simulated L-shaped canals were prepared to an apical size of 25 using OneShape, Hero Shaper, and Revo-S (all from Micro-Mega SA, Besançon, France), (n = 16 canals/group) systems. The amount of resin removed after each canal's preparation was measured and compared after producing a composite image made from the superimposition of pre and post-instrumented canals. Canal aberrations and the preparation time were also recorded. The data were statistically analyzed by using ANOVA, Tukey, and Chi-square tests.

Results

One file fractured during instrumentation in Revo-S group. A significant difference was found at the apical end of the prepared simulated canal between the groups, with Revo-S showing the least amount of resin removal from the inner side of the canals and Hero Shaper showing the highest amount of resin removal from the outer side ($P < 0.05$). Regarding the total width of the canals after preparation, a significant difference was found between the groups at the apical end and the straight portion of the canals, and Revo-S removed the least amount of resin at the straight portion of the canals ($P < 0.05$). No statistically significant differences were found between the different instruments regarding canal aberrations' incidence ($P > 0.05$).

Conclusions

all of the files showed a tendency to straighten the canals, whereas OneShape files maintained the original canal curvatures well.

Introduction

The instrumentation aims to shape the canals to facilitate cleaning and obturation, preventing disease progression and promoting healing. Rotary Niti (nickel-titanium) instruments are designed to shape the canals. Their performance and safety have always been a subject of interest among practitioners in the presence of anatomical challenges. Canal curvature is a parameter that can challenge the performance of a file; hence respecting the anatomy of a canal in the presence of curvature is a desired characteristic of any rotary instrument considering the root canal morphology[1, 2].

The OneShape (Micro Méga, Besançon, France) is a single-file canal preparation system made of conventional Niti alloy that works on full clock rotation. This system was introduced to the market after two reciprocating single-file systems named WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) and Reciproc (VDW, Munich, Germany) promising results. The OneShape file has a tip size of 25 and a constant taper of 0.05 with different cross-sections along its length, changing from S-shaped to concave triangular shape near the tip. This system requires only one file working in a clockwise rotation to prepare the canals up to the apical size of 25. These features have decreased the preparation time by OneShape compared to other single and full sequence file systems[3, 4]. The file has features such as Anti Breakage Control (ABC) and asymmetric file design, which is claimed by the manufacture to increase the safety of the system[5].

Hero Shaper (Micro Méga, Besançon, France) is a full-sequence system introduced as a modification of Hero 642 in terms of helix pitch and helix angle with a shortened handle. Hero Shaper files have a positive rake angle, large inner core, and ABC, incorporated into the design to increase the files' efficacy and safety. The system consists of six files with tip sizes of 20, 25, and 30 and is grouped in tapers of 0.4 and 0.6. The manufacturer suggests three protocols, namely yellow, red, and blue, based on canals' anatomy to be instrumented. A sufficient amount of studies are availed on this system to make it a proper baseline for the evaluation of rotary instruments.

Revo-S (Micro-Mega SA, Besançon, France) is another full-sequence system introduced after Hero Shaper by the same company, which consists of three files with a constant apical size of 25. The main feature of this system is the asymmetry in the cross-section[6]. This feature is claimed to enhance curved canals' negotiation[7] due to the files' increased flexibility. The manufacturer also claims that the file's helical design facilitates debris movement away from the apex because of increased available volume between the file and the canal's surface. This asymmetric design was not incorporated in Revo-SC2. Claimed by the manufacture, this file's symmetry balances the forces and ensures the instrument's guidance up to the apical region. Like Hero Shaper, this system also benefits from variable pitch angle.

Although Hero shaper and Revo-S might be considered traditional systems compared to the latest rotary instruments, especially the new wave of single-file systems. These are the products of constant changes and improvements in NiTi instruments' designs through a short period by the same manufacturer. Evaluation of these systems' behavior may give us some insights into the effect of changes on our understanding of different designs and sequences of rotary files on their shaping ability. Therefore, this study aimed to evaluate three Niti files' shaping ability regarding their centricity in simulated L-shaped canals.

Materials And Methods

Simulated Canals

Forty-eight simulated L-shaped canals were used in this study (Endo Training Block-S; Dentsply Maillefer, Ballaigues, Switzerland, with 0.02 taper, 0.15 mm apical diameter, 17 mm length, and 40 curvature). The patency of the canals was confirmed by passing a size 10 K-file just beyond the apex, and the unity in the angles and length of the curvatures were confirmed before distribution of the blocks by taking pictures of the samples on a photography stand. After assuring that the samples are standard, they were randomly divided into three groups (n =16 canals/group) and were numbered.

Instrumentation of L-shaped canals

A new instrument was used for each canal in all groups. Glyde-Prep (Dentsply Maillefer, Ballaigues, Switzerland) was used as a lubricant before using each instrument, and saline was used for irrigation during preparation. The canals were instrumented using the protocols suggested by the manufacturer described in the following sections without glide path preparation or additional use of hand files except for recapitulation with a size 10 K-file.

Group A:

The OneShape file (tip size, 25; apical taper, 0.06) was used in a full clockwise rotation generated by an X-Smart motor (Dentsply Maillefer, Ballaigues, Switzerland), and the speed and torque were adjusted to 400 rpm and 4 Ncm. The files were used in a slight pecking motion according to the manufacturer's instructions. The flutes of the instrument were cleaned after each retrieval of the file from the simulated canal.

Group B:

The Hero Shaper files were used following the yellow sequence with file size 25 taper 0.6 used as a modification to the protocol to achieve the same apical size and taper of prepared canals as that of other groups. According to the manufacturer's torque guide, the motor was set at the speed of 400rmp with the torque of 1 to 2 set for each instrument. The instrument sequence was as follows:

1. A 0.06 taper size 20 instrument for 2/3 of the WL.
2. A 0.04 taper size 20 instrument for the full WL.
3. A 0.04 taper size 25 instrument for the full WL.
4. A 0.04 taper size 30 instrument for the full WL.

Group C:

The Revo-S files were used up to the size 25 and taper of 0.06 in a full clockwise rotation with a rotational speed of 400 rpm generated by the X-Smart motor (Dentsply Maillefer, Ballaigues, Switzerland), and the torque was adjusted to 2 Ncm. The files were used in a slight pecking motion according to the manufacturer's instructions. The instrument sequence was as follows:

1. A 0.06 taper size 25 instrument (SC1) 2/3 of the WL.
2. A 0.04 taper size 25 instrument (SC2) for the full WL.
3. A 0.06 taper size 25 instrument (SU) for the full WL.

An experienced operator prepared all canals, and a total of 48 L-shaped canals were prepared. Canals were irrigated during preparation by using saline. A new instrument was used to prepare four canals only, and the flutes of all instruments were cleaned after retrieval of the instruments from the canals during instrumentation or after three pecks.

Image analysis and assessment of canal preparation

All canals were injected with black ink (Parker Quink, Parker, France) to obtain a clear pre-operative image. The canals were photographed using a digital camera (**Sony Alpha DSLR-A100 camera with DSLR-A100 macro lens, Sony, Japan) on a fixed stand with constant settings**. The canals were rinsed with saline before and after instrumentation. The canals were subsequently filled with red ink (Parker Quink, Parker, France) and were photographed again under identical conditions.

The pre-and post-instrumentation images were superimposed into a composite image using a computer software program (Adobe Photoshop Elements 7.0, Adobe Systems Incorporated, San Jose, CA, USA). A measuring template was superimposed on the composite images. The amount of resin removal due to instrumentation was measured using ImageJ 1.46r software (Wayne Rasband, National Institutes of Health, USA) perpendicularly to the surface of the canal at 22 measuring points (11 on each side of the canal). The measurement points (MP) were arranged in 1-mm steps: points 0 corresponded to the canal's endpoint, 7 to the beginning of the curve, and points 7 to 10 belonged to the straight portion of the canal. A second examiner who was blinded to all experimental groups carried out the canal shapes' assessments before and after instrumentation.

The canal preparation time, which included total active instrumentation, cleaning of the instruments' flutes, and irrigation, was recorded. The amount of time spent to change the files or adjust stoppers was excluded to facilitate the files' efficacy. Canal aberrations were determined by two clinicians blinded to the canal preparation instruments by using composite images. Assessments were performed based on an apical zip, narrowing, ledge, and the danger zone. The canal aberrations were defined according to Ersev et al.[8]

Statistical analysis

Statistical evaluations were performed with SPSS software (IBM SPSS Statistics 21, SPSS Inc., Chicago, USA). The normality of the data was verified for each set of measurements by using the Kolmogorov-Smirnov test. The results were statistically analyzed using one-way analysis of variance (ANOVA) and the posthoc Tukey test. ANOVA and the posthoc Tukey were also used to analyze the preparation times, and the Chi-square test was used to analyze the incidence of canal aberrations. The significance level was set at *P*<0.05.

Results

Only one SC2 file in the Revo-S group fractured during instrumentation. Consequently, the sample was substituted with a new one, and another set of instruments were used. No sign of deformation was noticed visually on Revo-S and Hero Shaper files, but all the OneShape files showed deformity signs.

A significant difference was found at the apical end of the prepared simulated canal (MP 0) between the groups, with Revo-S showing the least amount of resin removal from the inner side of the canals and Hero Shaper showing the highest amount of resin removal from the outer side (*P* < 0.05; Table 1). Revo-S removed the highest amount of resin from the inner side of the canals at the endpoint of curvature, however not significantly different from the other groups. Hero Shaper showed the least amount of resin removal from the canals' outer surface at the curvature's apex but the highest amount of resin removal from the outer side at the beginning of the canals (*P* < 0.05, Table 1). Revo-S removed significantly less resin from the outer side at the canals' straight portion (*P* < 0.05, Table 1). OneShape showed the highest centricity at the terminal portion of the canals and the curvature's beginning, followed by Revo-S. This pattern was reversed at the other points of canals by Revo-S, showing a higher centricity than OneShape (Figure 1).

Table 1: Means of removed resin (mm) and standard deviations (SD at the different measurement points after root canal preparation

	Inner Canal Wall (mm from the apex)											Outer Canal Wall (mm from the apex)							
	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7
OneShape																			
Mean	0.07	0.08	0.10	0.11	0.15	0.22	0.25	0.23	0.22	0.22	0.21	0.09	0.12	0.13	0.16	0.18	0.16	0.17	0.
SD	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.
Hero Shaper																			
Mean	0.06	0.08	0.10	0.11	0.15	0.23	0.26	0.24	0.23	0.22	0.21	0.12	0.12	0.13	0.16	0.16	0.14	0.16	0.
SD	0.02	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.03	0.04	0.02	0.02	0.03	0.02	0.
Revo-S																			
Mean	0.05	0.08	0.10	0.13	0.16	0.22	0.24	0.23	0.22	0.22	0.20	0.09	0.11	0.13	0.16	0.17	0.14	0.16	0.
SD	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.
	*											*				*			*
*P < 0.05; **P < 0.01; (ANOVA and post-hoc Tukey test)																			

Regarding the total width of the canals after preparation, a significant difference was found between the groups at the apical end and the straight portion of the canals only, with Revo-S removing the least amount of resin at the straight portion of the canals (*P* < 0.05; Table 2).

Table 2: Means of canal width after instrumentation (mm) and standard deviations (SD at the different measurement points after root canal preparation

	Measurement points (mm from the apex)										
	0	1	2	3	4	5	6	7	8	9	10
OneShape											
Mean	0.31	0.37	0.42	0.47	0.54	0.59	0.65	0.71	0.76	0.82	0.88
SD	0.04	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02
Hero Shaper											
Mean	0.34	0.38	0.42	0.49	0.52	0.60	0.66	0.73	0.78	0.83	0.89
SD	0.04	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
Revo-S											
Mean	0.31	0.37	0.43	0.49	0.54	0.59	0.63	0.69	0.74	0.79	0.85
SD	0.03	0.03	0.03	0.03	0.05	0.04	0.04	0.04	0.03	0.04	0.03
	*						*	**	***	**	**

*P < 0.05; **P < 0.01; ***P < 0.001(ANOVA and post-hoc Tukey test)

Canal aberrations

The results of the canal aberrations are presented in table 3. No statistically significant differences were found between the different instruments regarding canal aberrations' incidence (figure 2, Chi-square test, $P > 0.05$).

Table 3: Incidence of aberrations

	OneShape	Hero	Revo-S
Ledge	0	2	1
Danger Zone	0	0	0
Narrowing	0	1	0
Zip and Elbow	1	3	1

Chi-square test, no significant difference ($P > 0.05$).

Centering ability

OneShape showed the highest centricity along the simulated canals, followed by Revo-S (Figure 1). Hero Shaper tends to cause more straightening by removing the higher amount of resin from the outer than inner side of the canals at the apical part. The least centricity was also noticed by the same file at the beginning of the curvature (MP 5-6), shown in Figure 1.

Preparation time

Considering the preparation time, a significant difference ($P < 0.05$) was found between OneShape (63.7 s) and Hero Shaper only (73.6 s); no significant difference was found between Revo-S (68.8 s) and the other two files ($P < 0.05$).

Discussion

This study aimed to compare the OneShape single file system's shaping ability with Revo-S and Hero Shaper. Revo-S and Hero Shaper were used in this study as they have some common features in design with OneShape because all these three systems are products of the same company. L-shaped simulated resin blocks were used in this study as a traditional method of shaping ability evaluation. Although there are experimental settings to evaluate the shaping ability of rotary instruments in natural teeth, resin blocks are still being used because of their advantages[9, 10]. Simulated canals are standard in canal curvature, length, diameter, and hardness. Also, it is easy to measure changes on them after instrumentation[11, 12]. On the other hand, care must be exercised while extrapolating the studies' results on resin blocks. Resin blocks are softer than natural teeth, and the debris formed during instrumentation is not that of a natural tooth. Therefore, the files might not be as safe and efficient during natural tooth preparation[11]. It is also important to remember that the root canals in natural teeth are not merely a single canal presented in simulated resin canals. The root canal system is more complicated than a single canal in natural teeth[13].

The simulated L-shaped canals in this study were prepared up to the size of 25 to make the comparison between the files easier because OneShape, when used as a single file, prepares canals to the minimum size of 25. The Hero Shaper system's yellow sequence was modified using the file 25 taper 0.06 instead of the file 30 taper 0.04 to reach a closer prepared canal shape compared to the other two systems.

Amount of resin removed

More centricity with OneShape at the apex can be because only one file was passed to the canal's apex. However, in the other two systems, the apex was instrumented twice with files of the same size but different tapers to achieve the final shape. This could attribute to the more amount of resin removal from the outer side of the canals at the terminal point of the canals. Consequently, the increased number of passes and preparation time in Revo-S and Hero-Shaper full sequence systems can cause eccentricity at the apical point[14].

File separation and canal aberrations

Only one SC2 rotary file fractured. All of the instruments prepared the simulated canals to the full length. Each rotary file sequence is used to prepare only one canal. Hero created two ledges and three zip and elbow and a narrowing effect among these rotary files, although it was not statistically significant compared to other groups.

Conclusions

Within this study's parameters, all of the files showed a tendency to straighten the canals, whereas OneShape files maintained the original canal curvatures well. Single files that are less tapered should be preferred when preparing severely curved canals to maintain the original canal curvatures.

Declarations

Ethics approval and consent to participate: This article does not contain any studies with human participants or animals performed by any of the authors.

Consent for publication: For this type of study, formal consent is not required.

Availability of data and materials: The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests: Author PVG declares that he has no conflict of interest. Author ST declares that he has no conflict of interest. Author AMS declares that he has no conflict of interest.

Funding: None

Authors' contributions: PVG and ST write and drafted the manuscript, AMS did the experiment, AMS, PVG, and ST set up the experiment and recorded the reports, also reviewed the manuscritp and revised it, PVG and ST did the statistical analysis

Acknowledgements: None

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Figures

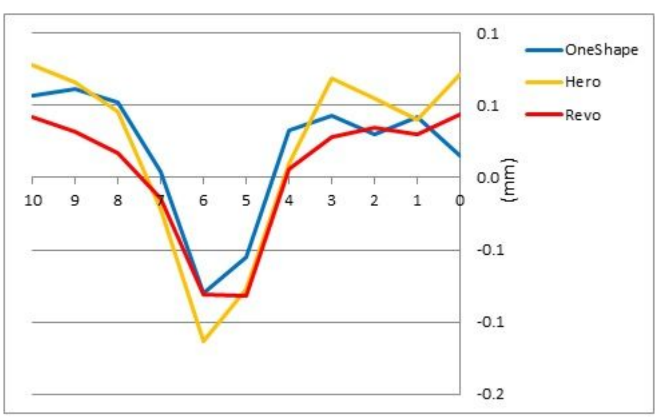

Figure 1

Direction and the amount of canal transportation (mm) at different measurement points.

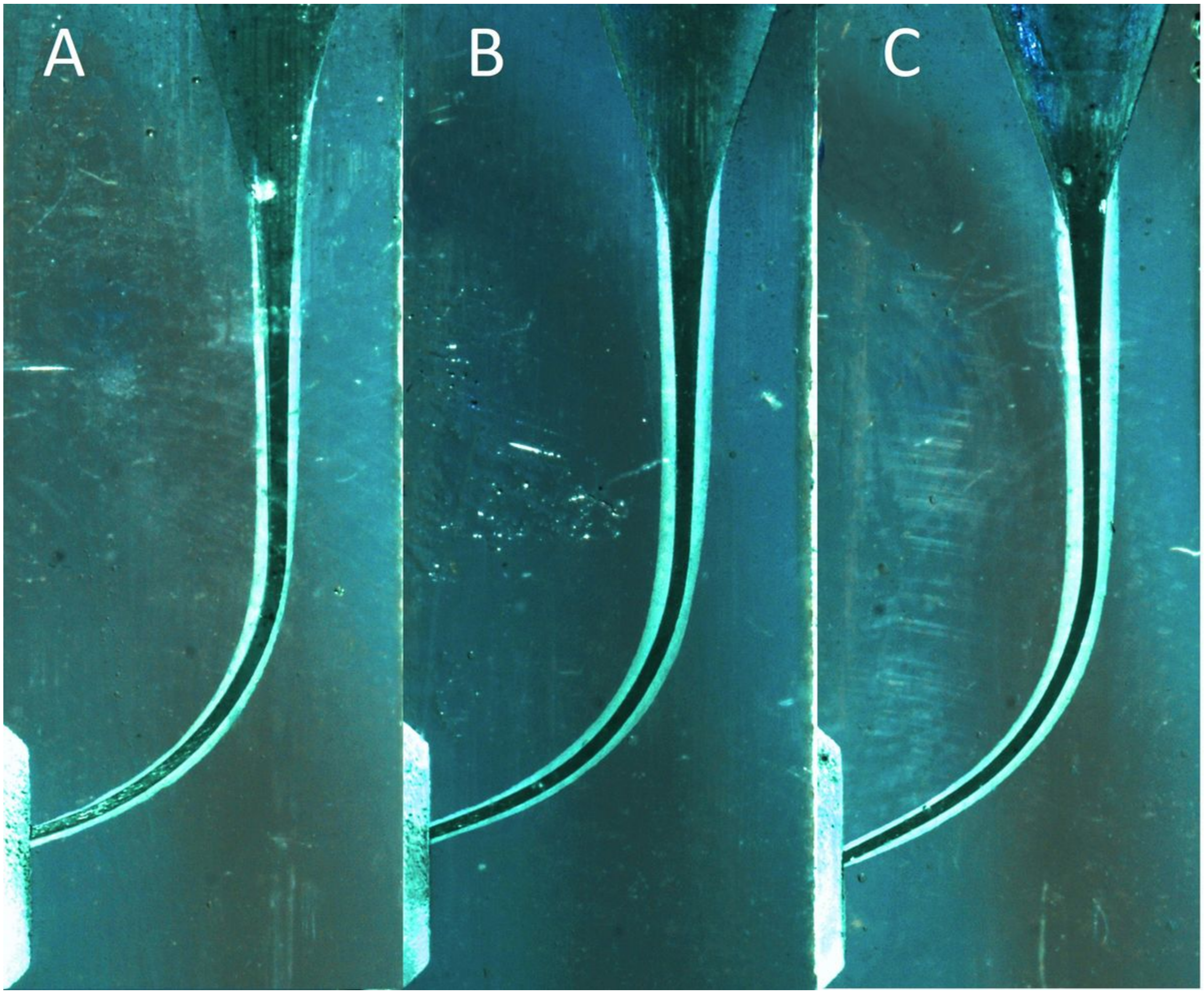

Figure 2

Representative images of the simulated canals instrumented using (A) HeroShaper, (B) Revo-S, (C)OneShape