Shaping ability of two rotary instruments in simulated canals: stainless steel ENDOflash and nickel-titanium HERO Shaper

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Abstract

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Aim To compare the shaping ability of two rotary instruments in simulated curved canals: stainless steel ENDOflash Files (KaVo, Biberach, Germany) and the recently introduced nickel-titanium HERO Shaper instruments (Micro-Mega, Besançon, France).

Methodology Simulated root canals with 35° curves in resin blocks were prepared to size 30, .04 taper (HERO Shaper) using a crowndown technique or size 30, .02 taper (ENDOflash) using a rotary motion and a rotation speed of 400 or 250 rpm respectively. In both groups, irrigation was performed with 1 mL distilled water after each instrument size and Glyde (Dentsply Maillefer, Ballaigues, Switzerland) were used. Canals ($n = 17$ per group) were scanned before, during and after preparation. The assessment of preparation shape was carried out with a computer image analysis program. Material removal was measured at seven points beginning 1 mm from the end-point of the canal. Statistical analysis was performed using Wilcoxon's test and Fisher's exact test ($P < 0.05$).

Results No instrument fractures, apical blockage or loss of working length(WL) occurred. More zips (10 vs. 4) and more strippings (17 vs. 0) were created with ENDOflash compared with the HERO Shaper. There were significant differences in terms of the amount of resin removed on the inner wall of the curvature obtained with the two instruments ($P < 0.0001$). On average, HERO Shaper instruments removed material more evenly on the outer and inner wall of the curvature. Considering the different points of measurement, there were significant differences between the two systems both on the inner and outer walls at WL-1, 2, 5 and 6 mm ($P < 0.05$). The HERO Shaper had a more centred enlargement compared with the ENDOflash.

Conclusions Stainless steel rotary ENDOflash instruments did not perform as well as HERO Shaper instruments and created an increased risk of root canal transportation. Nickel-titanium rotary HERO Shaper instruments maintained the original curvature significantly better.

Keywords: controlled torque, root canal preparation, rotary nickel-titanium file, simulated canal, stainless steel file.

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Introduction

One of the difficulties of root canal preparation is to manage the curvature of the canal whilst maintaining instruments in the central axis towards the apical foramen. Recently, flexible rotary nickel-titanium (NiTi) instruments with increased tapers and different designs have been developed. Many studies have been carried out on these new instruments and they appear to be a major advantage in the preparation of curved root canals. NiTi rotary instrumentation allows effective shaping and have the ability to maintain curvature in severely curved canals (Short *et al.* 1997, Thompson & Dummer 1997a,b, Bryant *et al.* 1998a,b, Hülsmann *et al.* 2003). However, there is concern regarding the cost and resilience of these instruments (Zuolo & Walton 1997, Sattapan *et al.* 2000).

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Recently, a new rotary device: the ENDOflash system (KaVo, Biberach, Germany) has been developed that uses .02 stainless steel files and a controlled-torque handpiece that is claimed to minimize the fracture incidence of the files. However, manual stainless steel files are known to be less flexible and can straighten curvatures, thereby creating procedural errors such as apical or coronal transportation, zipping, stripping, elbow formation or ledges (Weine *et al.* 1975, Briseno Marroquin *et al.* 1996).

Many improvements have been made in the design of NiTi rotary instruments to allow a better canal shape and centring of the preparation. As an example, the HERO 642® instruments have been enhanced recently by the HERO Shaper (Micro-Mega, Besançon, France). Its thread varies according to the taper and the manufacturer claims that it increases efficiency, flexibility and strength whilst avoiding self threading. Few studies have presented on the ENDOflash system (Fariniuk *et al.* 2001, 2003) and none has yet examined the shaping ability of HERO Shaper instruments. However, HERO 642 instruments were studied by Thompson & Dummer (2000a,b) and others, and they found that these instruments prepared simulated canals without creating blockages but their taper was poor.

The aims of this study were to compare the shaping ability and the centring ability of the canal of two rotary instruments in simulated curved canals: the stainless steel ENDOflash files and the recently marketed NiTi HERO Shaper instruments.

The parameters studied were centring of the preparation, canal aberrations, instrument deformation and fracture and loss of working length (WL).

Materials and methods

Specimen preparation

Thirty-four simulated root canals with 35° curves in clear resin blocks were used. The diameter and the taper of all simulated canals were equivalent to an ISO size 10. The canals were 18 mm long in total with a straight part of 11 mm and a curved part of 7 mm. The first 5 mm were prepared and they were cone-shaped.

The canals were randomly divided into two groups and prepared with either HERO Shaper® rotary NiTi instruments (Micro-Mega) or with stainless steel rotary ENDOflash® (KaVo).

Instruments and preparation techniques

ENDOflash system

The ENDOflash system is a rotary controlled-torque device that uses stainless steel files in a reaming motion. These files are .02 K-Flexofiles with a noncutting tip used with a specific controlled-torque X40 reduction handpiece. The rotational speed is 250 rpm and the torque is adjusted according to the file diameter: the white position is for size 15 files, yellow for size 20 files and red for size 25 files and higher.

The HERO Shaper is used with a reduction contra-angle (100 : 1) with an air or electric motor. The HERO Shaper files have .06 and .04 taper and a noncutting tip and a triple helix cross-section with three cutting edges. The cutting angle is positive and the pitch is adapted, i.e. the larger the taper, the longer the pitch. The helix angle increases from the tip to the shank to avoid threading. The instruments were used in a crowndown manner with a rotational speed of 400 rpm.

The first penetration in the simulated canal was performed with a conventional size 10 K file hand instrument (Micro-Mega) to the WL, and the latter was adjusted for all simulated canals to 18 mm. Patency of the simulated root canal was checked before preparation.

Group 1 ($n = 17$) – Simulated root canals were instrumented using stainless steel ENDOflash® instruments with a rotary motion technique. ENDOflash files® progressed to the WL from size 15 to 30 in sequence, i.e. each file 15, 20, 25 and 30 was placed consecutively the WL.

Group 2 ($n = 17$) – Simulated root canals were prepared using the HERO Shaper® in a crowndown manner as recommended by the manufacturer. According to root canal anatomy and its difficulty, the simulated canals had a substantial curvature (35°) and so the yellow sequence for difficult cases with severely curved canals was chosen. The four instruments used were: size 20, .06 taper, size 20, .04 taper, size 25, .04 taper and size 30, .04 taper, and the root canals are prepared according to the following sequence:

Size 20, .06 taper up to two-thirds of the WL, i.e. up to 12 mm,

Size 20, .04 taper at the WL, size 25, .04 at the WL and then size 30, .04 at the WL.

Each instrument was used to enlarge a maximum of five canals according to manufacturer's recommendations. Before use, each instrument was coated with Glyde® (Dentsply Maillefer, Ballaigues, Switzerland) as a lubricant and 1 mL of distilled water was used after each instrumentation step for irrigation. All canals were enlarged by the same operator.

Assessment of preparation

Specimens ($n = 17$ per group) were scanned before, during and after preparation (EPSON 1240 U; Epson, Nagano, Japan). The five images per simulated canal were coloured according to the file and superimposed. To improve the outlines, root canals were filled with black India ink. Preparation shape was assessed with computer image analysis programs: Image J 1.28 (National Institutes of Health Public Domain Program, USA) and Photoshop 5.0 (Adobe, San Jose, CA, USA).

Material removal, e.g. the difference between the canal configuration before, during and after instrumentation was measured one dimensionally both for the inner and the outer side of the curvature at seven measuring points beginning 1 mm from the WL and perpendicular to the surface of the canal. This resulted in seven inner and seven outer measuring points for each simulated canal. The surfaces and amount of material removed on each wall of the curvature were measured with Image J software on digitized images by substracting the pre-instrumentation images from the post-instrumentation images.

Superimposition of pre-, per- and postoperative images of each canal prepared allowed also the assessment of canal aberrations as defined below: (Thompson & Dummer 2002),

- zip: transportation of the apical portion of the canal, excess resin had been removed from the outer aspect of the canal.
- stripping: thinning of the inner root wall with eventual perforation, excess resin had been removed from the inner aspect of the curve.
- elbow formation: occurred concurrently with an apical zip and formed a narrower region more coronally.
- ledge: artificially created irregularity on the surface of the root canal wall, resin was removed from the outer aspect of the curved portion of the canal and was not associated with preparation at the end-point.
- perforation: occurred along the outer aspect of the curve and was not confluent with the original canal (Fig. 1).

Instruments were examined after every use and permanently deformed or fractured instruments recorded. The number of times the instruments had been used was also checked.

Statistical analysis

Quantitative comparisons were used for root canal aberrations and fracture or deformation instruments. Statistical analysis was performed using Wilcoxon's test

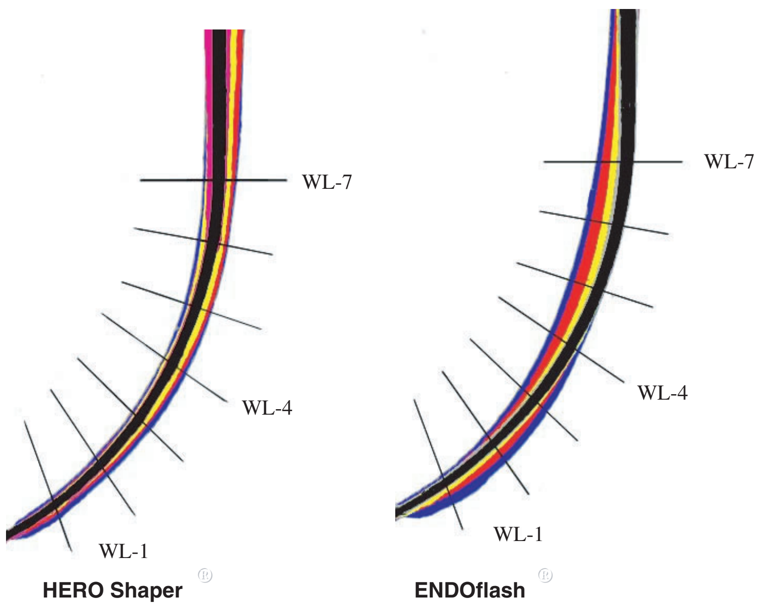

Figure 1 Diagram showing the seven measuring points from the WL and the superimposition of each diameter after instrumentation with ENDOflash and HERO Shaper files. For the ENDOflash (original canal: black, no. 15: grey, no. 20: yellow, no. 25: red, no. 30: blue). For the HERO Shaper (original canal: black, .06/20: pink, .04/20: yellow, .04/25: red, .04/30: blue).

and Fisher's exact test with a *P*-value <0.05. Root canal surfaces, amounts of material removed and root canal deviations were analysed.

Results

Instrument failure

Instrument failures are detailed in Table 1. No instrument fractures occurred in either group. However, whilst no deformation occurred with the ENDOflash files, many deformations appeared on the HERO Shaper files. These occurred on seven .04 files: 3 size 20, 3 size 25 and 1 size 30.

Table 2 shows the different aberrations created in the two groups. More zips (10 vs. 4) and strips (17 vs. 0) were created with the ENDOflash versus the HERO Shaper. One elbow occurred on a simulated canal prepared with the ENDOflash.

Change of working length

No apical blockage or loss of WL occurred with either instrument. All canals remained patent following instrumentation.

Root canal surfaces and shapes

Considering the variation of root canal surfaces (Table 3), there was a significant difference between the two systems at diameters 20, 25 and 30. Concerning the amount of material removed (Table 3), there were significant differences between resin removal on the inner wall of the curvature with the two instruments ($P < 0.0001$). There was no significant difference between the inner and outer walls of simulated canals prepared by the HERO Shaper or between the outer walls of the HERO Shaper and the ENDOflash.

Comparison of the inner walls showed significant differences at WL-5 and 6 mm. (Fig. 2). Each diameter of ENDOflash files removed more material closer to the WL. The same trend was noted for the HERO Shaper files, even if the preparation was more centred.

On the other hand, there was a significant difference at WL-1 and 2 mm (Fig. 3) on the outer wall. The

Table 1 Number of separated or deformed instruments. For the HERO Shaper instruments, $n = 4$ for each

Instrument	Taper/diameter	Fracture	Deformation
ENDOflash		0	0
HERO Shaper	.06/20	0	0
	.04/20	0	3
	.04/25	0	3
	.04/30	0	1

Table 2 Number of root canal aberration according to the type of preparation

Aberration type	EndOflash ($n = 17$)	HERO Shaper ($n = 17$)
Zip	10	4
Stripping	17	0
Elbow formation	1	0

Table 3 Mean of root canal surfaces and SD according to canal wall and file diameter after instrumentation of simulated canals with the two systems

	Inner wall	Outer wall	No. 20	No. 25	No. 30
ENDOflash					
Mean	0.034* ** ***	0.021**	0.015	0.028	0.041
SD	0.022	0.018	0.011	0.021	0.025
HERO Shaper					
Mean	0.021*	0.020***	0.018	0.024	0.027
SD	0.011	0.008	0.007	0.007	0.009
			0.05	0.05	0.0001

*$P < 0.0001$, **$P < 0.0001$, ***$P < 0.0001$.

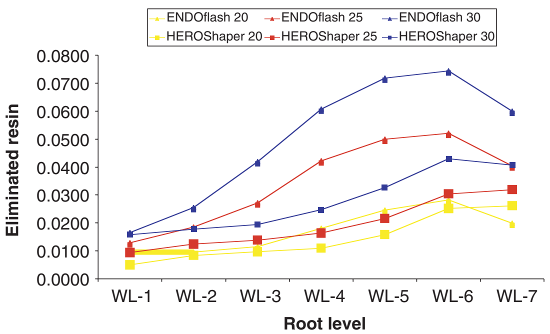

Figure 2 Amount of removed material on the inner wall by the two systems according to root level.

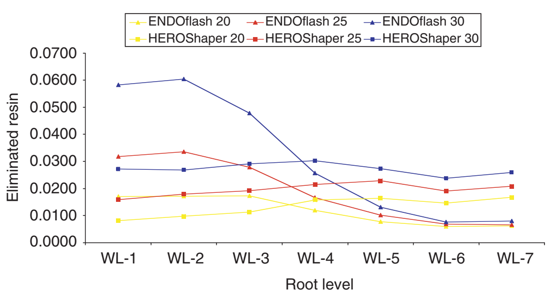

Figure 3 Amount of removed material on the outer wall by the two systems according to root level.

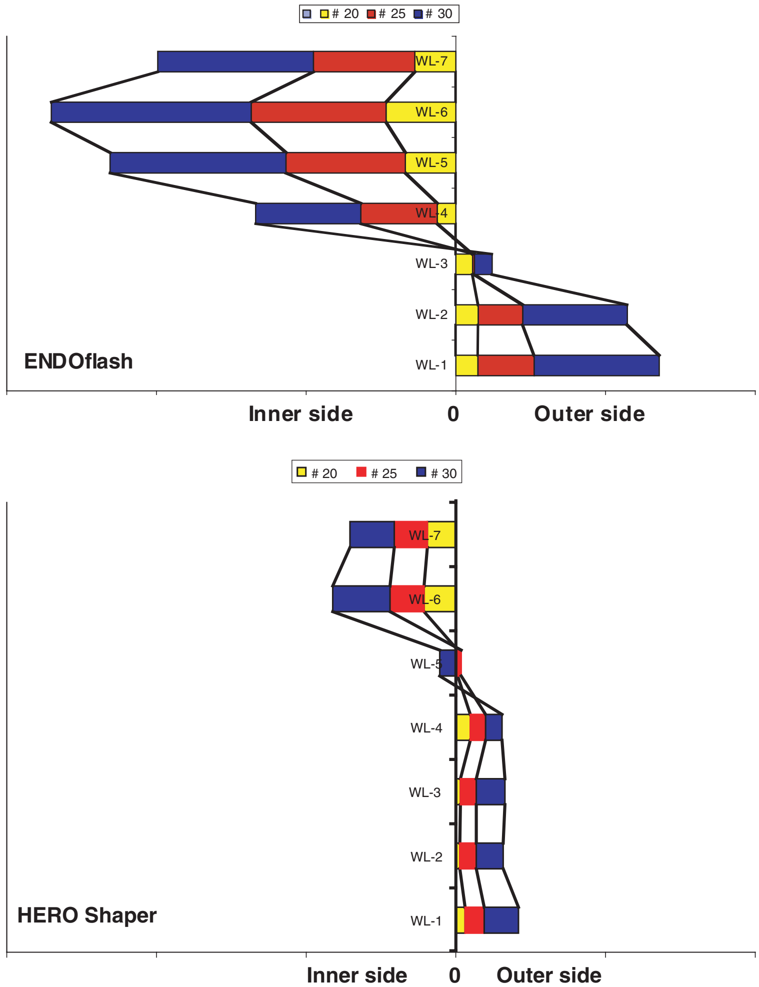

Figure 4 Deviations from the central axis of ENDOflash and HERO Shaper Files according to diameter, root level and canal wall.

ENDOflash files removed more resin at WL-1 and 2 mm. Considering the deviations from the central axis of the canal (Fig. 4), ENDOflash files removed more inner-wall material than HERO Shaper files at 5–7 mm from the WL. On average, the HERO Shaper instruments removed material more evenly both on the outer and inner wall of the curvature. Considering the different points of measurement, there were significant differences between the two systems both on the inner and outer walls at WL-1, 2, 5 and 6 mm ($P < 0.05$). The HERO Shaper showed a more centred enlargement compared with the ENDOflash.

Discussion

This study was completed on resin-simulated canals because they give highly reproducible results (Schäfer *et al.* 1995, Al-Omari *et al.* 1997). Shape, size, taper, and curvature of the canal are standardized and advantages of resin blocks have been extensively discussed (Schäfer *et al.* 1995, Thompson & Dummer 1997a,b). Simulated canals in resin blocks do not reflect the real anatomy of canal, but they do allow the comparison of shaping ability and the behaviour of different instruments (Schäfer *et al.* 1995). At the same time it must be appreciated that the resin material does not cut in the same way as dentine and the resin may be softened by heat generated with rotary instruments (Kum *et al.* 2000).

The manufacturer's recommendations regarding the maximum number of uses of these instruments, i.e. 5, was followed and no fracture occurred in either instrument, a finding in keeping with previous reports of Flexofiles used manually (Schäfer 2001, Schäfer & Lohmann 2002, Schäfer & Florek 2003). Indeed, it would seem that using continuous rotation with a steel

Flexofile-type instrument does not lead to fracture or deformation, providing the torque is controlled in accordance with the diameter of the instrument. In fact, instrument fracture results from excessive stress placed on an instrument or through cyclic fatigue occurring when an instrument that has already been weakened by metal fatigue is placed under stress. In this study, adapting torque to the instrument and to the stress exerted allowed progressive disengagement, thereby limiting the risk of fracturing. Moreover, Flexofiles are known to be more flexible than K-files and sustain plastic deformation (Bonetti Filho *et al.* 1998). However, it seems essential to check the cutting edge of the instrument at each use and to reject any files that seem distorted or damaged.

On the other hand, whilst several authors have reported fracturing of rotary NiTi instruments on various simulators (Bryant *et al.* 1998b, Fariniuk *et al.* 2001, Schäfer 2001, Schäfer & Lohmann 2002, Schäfer & Florek 2003), no fracturing has been reported with the HERO Shaper instrument to date. Thompson & Dummer (1997a,b) also reported no fracturing when they tested the ProFile .04. The finding that no fractures occurred for both Endoflash and HERO Shaper could also be related to the triangular-like instrument cross-sections (triple-helix cross-section for the HERO Shaper) that result in a larger core of metal.

The HERO Shaper instruments, showed several deformations such as unwinding, whilst there was no macroscopic evidence of damage to ENDOflash files. Such deformation was only observed on instruments with .04 tapers and mainly in diameters 20 and 25. The protocol for the HERO Shaper always begins with a .06 instrument over two-thirds of the WL that implies that the first instrument used for the apical third (size 20, .04 taper) undergoes maximum stress. The deeper the instrument is inserted, the greater the number of flutes in contact with the resin. It was also observed in this study that deformations did not lead to fracture; so, if torque, rotational speed and operator experience are controlled, incidence of fracture could be greatly minimized. On the other hand, the ENDOflash instruments had no macroscopic evidence of deformation, unlike manual Flexofiles (Martin & Blaskovic-Subat 1997, Schäfer 2001, Schäfer & Lohmann 2002, Schäfer & Florek 2003), suggesting the efficacy of controlling torque as the files are subjected to a stress never exceeding a level which would induce threading effects.

Root canal aberrations

Zips, stripping and elbow formation were the aberrations found most frequently, occurring mostly with simulators prepared with ENDOflash files. This is in agreement with previous studies demonstrating the high rate of zipping with Flexofiles compared with NiTi devices (Calberson *et al.* 2002, Hata *et al.* 2002, Schäfer & Lohmann 2002). It is widely known that stainless steel instruments have a greater tendency to straighten out curvatures and transport the foramen owing to their lack of flexibility. In this study, this phenomenon was amplified by the fact that it was not possible to curve the instruments, because they were used in continuous rotation. Stripping that is associated with excessive material removal and to the straightening of the internal part of the curvature, always occurred with ENDOflash device, as already noted by Al-Omari *et al.* (1997), Bishop & Dummer (1997), Schäfer (2001), Schäfer & Lohmann (2002), Schäfer & Florek (2003) with manual Flexofiles.

The HERO Shaper removed approximatively the same degree of resin on the inner and outer walls of the curvature, on both walls ($P = 0.867$), whereas the ENDOflash removed more material on the inner wall and did not remain centred on the initial canal. The action of the devices also differed according to canal level. The ENDOflash removed more material on the external wall of the curvature at the apical level (WL-1, 2 and 3 mm), a finding in agreement with that of Schäfer & Florek (2003). Flexofiles are therefore more aggressive on the apical third of the external wall of the curvature. Diameter 25 and 30 stainless steel instruments straighten curves owing to their rigidity and to the fact that they do not bend under constant rotation. Canals enlarged with Flexofiles are prone to prepare only one side of the root canal because of the restoring forces of stainless steel and thus showed more transportation towards the outer aspects of the curves (Schäfer 2001).

On the coronal part of the curvature at WL-5 to WL-7, the excessive removal of material observed with the HERO Shaper was probably because of the use of a more rigid size 20, .06 taper instrument up to two-thirds of the WL, i.e. at WL-6 mm. On the other hand, removal of material with ENDOflash instruments on the inner wall between WL-4 and 7 mm (and especially between WL-5 and 6 mm) was even greater. As in the apical portion, the deviation became greater as the diameter increased.

Finally, the passage from the internal to the external wall of the curvature through the central axis of the canal did not occur at the same level with the two devices (Fig. 4). With the HERO Shaper, the point of crossover with the central axis of the preoperative canal occurred between levels WL-5 and 6 mm for size 20, .04 taper and size 25, .04 taper, suggesting that this was because of use of the size 20, .06 taper instrument that instrumented the root canal to WL-6 mm. With the size 30 file, crossover occurred between WL-4 and 5 mm owing to its greater rigidity. With the ENDOflash, the crossover occurred between WL-4 and 3 mm, i.e. more apically than with the HERO Shaper. This could be due first to the lack of a .06 instrument in the sequence to eliminate the root canal irregularities on the coronal part; secondly to a straightening of the files and consecutively, of the preparation, secondary to the excessive material removal on the inner wall of the curvature in the coronal part, in turn resulting in a widening of the action of the file towards the apical part of the external wall.

Conclusion

For preparing simulated curved canals, stainless steel rotary ENDOflash instruments proved less effective than HERO Shaper instruments and had an increased risk of root canal transportation.

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