

Comparison of the Shaping Ability of WaveOne Reciprocating Files with or without Glide Path in Simulated Curved S-shaped Root Canals

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Received : 24-01-17.

Accepted : 16-05-17.

Published : 20-06-17.

INTRODUCTION

Recently, a large variety of nickel–titanium (NiTi) rotary systems with improved cutting efficiency and flexibility have become commercially available. However, the major concern associated with the use of these instruments is the possibility of unexpected fracture during clinical use.^[1] The fractures are classified as “torsional failure” or “flexural fatigue.”^[2,3] This limitation has motivated researchers and manufacturers to introduce reciprocating motion in the systems to minimize torsional and flexural stresses, leading to a lower risk of instrument fracture.^[4,5] This motion also increases canal-centering ability and reduces the risk of

ABSTRACT

Objectives: The aim was to compare the shaping ability of WaveOne reciprocating files with or without glide path in simulated curved S-shaped root canals.

Materials and Methods: Forty ISO #15, 0.02 taper, clear resin Endo Training Bloc-S blocks were studied. The simulated curved S-shaped canals were dyed using ink, preinstrumentation images were scanned, and resin blocks were prepared and divided into Group A: PathFile and WaveOne and Group B: WaveOne. All canals were postoperatively scanned. Pre- and postoperative images were superimposed and evaluated at 12 defined measuring points. The efficacy of the systems was compared based on the amount and direction of canal transportation, centering ability, amount of material removed, and presence of canal aberrations. Mann–Whitney U-test and independent *t*-test were used for statistical comparison.

Results: Both systems produced transportation at all levels and straightened the curved S-shaped canals. No significant differences in the amount and direction of transportation and amount of material removed were observed between the groups at each level ($P > 0.05$). However, Group A had significantly greater centering ability at the coronal straight zone ($P = 0.018$) and apical curvature ($P = 0.014$) levels than did Group B. Moreover, Group B showed more canal aberrations than did Group A.

Conclusion: Within the limitations of the present study, the creation of a glide path with the PathFile system improved the centering ability of the WaveOne reciprocating file in the apical and straight coronal portions of the simulated curved S-shaped root canals and reduced the incidence of canal aberrations.

KEYWORDS: Dental equipment, endodontics, nickel–titanium instruments, root canal preparation

root canal deformation and disengages the instrument from the dentin before it can lock into the canal.^[6-9]

Despite the introduction of a variety of engine-driven NiTi instruments and preparation techniques, S-shaped root canals still present a challenge. Although several previous studies have used simulated S-blocks,^[10-15] these may exhibit limitations and may fail to accurately represent the anatomic variability of the human root

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How to cite this article: Yilmaz A, Kucukay ES, Istektepe M, Sisli SN, Ersev H, Karagoz-Kucukay I. Comparison of the shaping ability of waveone reciprocating files with or without glide path in simulated curved S-shaped root canals. J Int Soc Prevent Communit Dent 2017;7:S13-7.

Access this article online	
Quick Response Code: 	Website: www.jispcd.org
	DOI: 10.4103/jispcd.JISPCD_32_17

canal system.^[16] However, these simulated resin canals allow direct visual comparison of the shaping ability of tested endodontic instruments and have thus been widely used to demonstrate differences in the performance of instruments under standardized conditions.^[10,11,13,15,17]

Previous studies have reported that both ProTaper rotary instruments (Dentsply Maillefer) and ProTaper hand instruments (Dentsply Maillefer) may result in canal transportation and straightening of the root canal.^[13,15,18] Zhang *et al.*^[15] and Bonaccorso *et al.*^[12] reported that the greater taper of finishing files may be responsible for the transportation and straightening of severely curved canals. Moreover, similar cross-sectional designs of WaveOne and ProTaper Universal systems may result in similar transportation and straightening outcomes.^[19] Ding-Ming *et al.*^[13] reported that these files produce high lateral forces at the apical curvature, leading to transportation. WaveOne Primary files have a taper of 0.08, similar to that of the ProTaper finishing files ($F1 = 0.07$, $F2 = 0.08$, and $F3 = 0.09$) and may, therefore, be responsible for the transportation and straightening of simulated root canals.^[12,14,15] Previous studies have also indicated that ProTaper instruments used in combination with less tapered hand or rotary instruments in severely curved canals may be useful for overcoming this problem.^[12,14,15]

The WaveOne NiTi reciprocating system is a recently introduced single-file, single-use system consisting of three files as follows: small (#21/0.06) for fine canals where a #10 K-file is very resistant to movement; primary (#25/0.08) for a majority of the canals where a #10 K-file moves longitudinally with ease and is loose or very loose; and large (#40/0.08) for large canals where a #20 hand file or larger goes to the full length. The files are manufactured with M-wire NiTi alloy which exhibits better resistance to cyclic fatigue.^[20]

It has been suggested, however, that the use of a glide path is beneficial for improving the performance of reciprocating instruments.^[16,21] NiTi rotary instruments have been reported to preserve the original canal shape better than stainless-steel manual instruments.^[22] PathFile (Dentsply Maillefer) NiTi rotary instruments have been designed to create a glide path and are available in three sizes (13, 16, and 19) and three lengths (21, 25, and 31 mm).

Therefore, the aim of the present study was to compare the shaping ability of WaveOne reciprocating files with or without glide path in simulated S-shaped curved root canals.

MATERIALS AND METHODS

Forty standard clear resin Endo Training Bloc-S blocks (Dentsply Maillefer) with ISO #15, 0.02 taper canals were used in this study. The actual length of

the canals was 12 mm, with an additional 4.5 mm conical access area. Each block was numbered, and the simulated curved S-shaped canals were dyed using black ink (Pelikan, Hannover, Germany) injected with a syringe. Preinstrumentation images were scanned using a specially designed setup that allows guidance during superimposition and then saved as JPEG files. Thereafter, distilled water was used to remove the dye, and the resin blocks were divided into two groups ($n = 20$) and prepared as follows:

Group A: The simulated canals were prepared using PathFile 1, 2, and 3 to create the glide path. The sizes 13, 16, and 19 PathFile drills with 0.02 taper were used at 300 rpm to the full working length. Thereafter, WaveOne Primary reciprocating files (#25, length 25 mm, and taper 0.08) were used in a reciprocating, slow, in-and-out pecking motion, in accordance with the manufacturer's instructions. The flutes of the instruments were cleaned after three pecks. The X-Smart Plus motor (Dentsply Maillefer) was used with the preprogrammed WaveOne motor settings. During instrumentation, copious irrigation with water was performed after each file, and all preparations were performed by one operator experienced in the use of rotary instruments.

Group B: The simulated canals were prepared using WaveOne Primary reciprocating file, as described in Group A, but no glide path was prepared.

All canals were postoperatively scanned and saved as JPEG files. Pre- and postoperative images were layered and superimposed using image analysis software (Photoshop CS4, Adobe, San Jose, CA, USA). Twelve defined measuring points were traced along the entire length of each block and perpendicular to the long axis of the root canal. These levels were traced according to the method described by Madureira *et al.*^[10] Four levels were traced on the root canal image and numbered as follows: 1, at the start of the root canal; 3, at the end of the straight coronal zone before the first curve; 2, between the levels 1 and 3; and 12, at the working length. In addition, seven more equidistant levels were traced between levels 3 and 12 and numbered as 4, 5, 6, 7, 8, 9, and 10. Level 11 was traced at the midpoint between 10 and 12 [Figure 1]. Finally, the images were evaluated at three zones: coronal straight zone (CZ) from level 1–3, first curvature zone from level 4–7, and apical curvature zone from level 8–12.

The amount of resin removed from the inner and outer sides of the canals was measured by viewing the superimposed images at 150% magnification using the ImageJ 1.46r computer software (National Institutes of Health, Bethesda, MA, USA).

The efficacy of the systems was compared based on the following factors: the amount and direction of canal transportation, centering ability, amount of material removed, and presence of canal aberrations (apical zip, ledge, danger zone, and narrowing) [Figure 2]. The amount of transportation was the absolute value of the difference between the widths of resin removed from the two aspects of the canal, whereas direction of transportation was determined by the side with wider resin removal. Centering ratio was calculated by dividing the narrower width of resin removal by the wider one,^[11] while apical zip associated with an elbow was defined as a narrow coronal region and an irregular, widened area at the end point of preparation where resin had been excessively removed from the outer aspect of the canal.^[23-25] A ledge was defined as an irregular area of resin removed from the outer aspect of the curved portion of the canal not associated with the preparation at the end point. Danger zone was defined as the area where excess resin had been removed from the inner aspect of the curve,^[23-25] whereas narrowing was defined as a narrower coronal region created in the straight portion of the S-shaped canal by gradually lessening resin removal extending from the continuum of the inner aspect of the coronal curve to the orifice.^[11]

Data were statistically compared using Mann–Whitney U-test and the independent *t*-test, with a confidence interval of 95%.

RESULTS

TRANSPORTATION

Both systems produced transportation at all levels, while material removal, generally occurring in the inner aspect of the curvatures, led to straightening of the simulated

curved S-shaped canals [Figure 3]. No statistically significant differences in the amount and direction of transportation were observed between the two groups at each level ($P > 0.05$) [Table 1].

CENTERING RATIO

Group A showed significantly higher values of centering ratio at the CZ ($P = 0.018$) and apical curvature zone ($P = 0.014$) levels than did Group B [Table 2].

MATERIAL REMOVAL

There were no statistically significant differences in the amount of material removed between the groups at each level ($P > 0.05$).

CANAL ABERRATIONS

Group B showed more canal aberrations than Group A, and the incidence of these aberrations was associated with the groups [Table 3].

DISCUSSION

In the present study, we chose to use simulated curved S-shaped canals to compare the shaping ability of WaveOne system with or without glide path based on the technique of superimposition of pre- and post-operative root canal outlines. This technique allowed direct visual comparison of changes throughout the S-shaped canal.

Our findings of better centering ability at the apical curvature level and reduced number of canal aberrations may have resulted from the use of less tapered instruments to create a glide path. This led to a more gradual preparation toward the apex and reduced excessive instrument binding^[26] and brushing on the canal walls^[16] with the single greater taper WaveOne instrument and the subsequent canal transportation.^[12] However, Bürklein *et al.*^[27] reported that less tapered

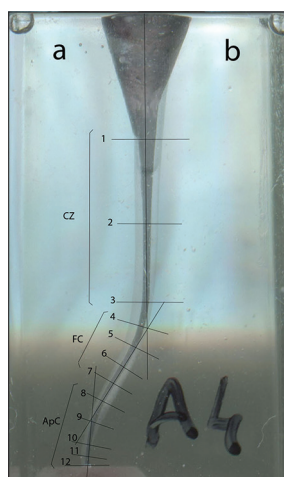


Figure 1: Representative image of the defined levels of 12 measuring points and the zones. “a” and “b” represent the two aspects of the simulated root canal. CZ = Coronal straight zone, FC = First curvature, ApC = Apical curvature

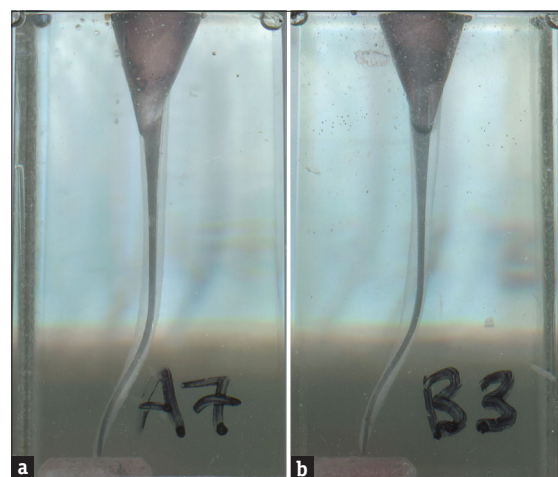


Figure 2: Representative superimposed images of simulated canals instrumented with (a) Group A-PathFile + WaveOne and (b) Group B-WaveOne

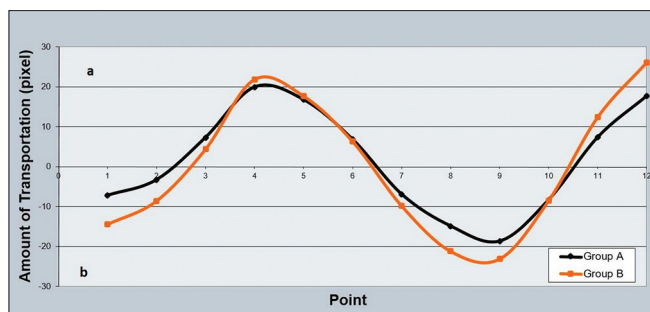


Figure 3: Direction and amount of transportation of root canal wall, measured from original canal wall. “a” and “b” refer to the two sides of the root canal, as illustrated in Figure 2. The measurements were made at 12 measuring points in the canal from coronal (1) to the apical end point (12)

Table 1: Mean transportation±standard deviation (in pixels) detected in three zones in both groups

Zones/groups	Group A	Group B	MW	P
Coronal	4.77±3.75	6.66±4.2	151	0.185 ^a
First curvature	9.17±4.76	10.17±5.29	177	0.534 ^a
Apical curvature	4.94±3.34	7.33±5.75	165	0.344 ^a

^aP>0.05 - identical letters represent values that were not statistically different

Table 2: Centering ratio means±standard deviation (in pixels) observed in three zones in both groups

Zones/groups	Group A	Group B	t	P
Coronal	0.77±0.1	0.7±0.07	2.46	0.018 ^b
First curvature	0.59±0.07	0.56±0.07	1.42	0.163 ^a
Apical curvature	0.48±0.17	0.36±0.11	2.57	0.014 ^b

^aP>0.05 - identical letters represent values that were not statistically different, ^bP>0.05 - identical letters represent values that were statistically different

Table 3: Incidence of aberrations

Canal aberrations	Zip/elbow	Ledge	Danger zone	Narrowing
Group A	5	2	3	17
Group B	4	6	6	19

instruments should be used when preparing S-shaped canals, even in the presence of a glide path.

Berutti *et al.*^[16] investigated the influence of glide path on canal curvature and axis modification by instrumentation of simulated resin blocks using WaveOne. They found a significantly greater alteration in the canal curvature in the absence of glide path, and the results of the present study were in agreement with these results. Although no significant difference was observed, we found higher values for transportation toward the inner aspect of the curvature in the absence of a glide path, suggesting straightening of the canal. However, it should be kept in mind that straightening was observed even with glide path preparation, and this was in agreement

with the findings of Berutti *et al.*,^[28] who reported a consequent decrease in the working length of curved root canals of extracted teeth. They recommended a second check of the working length after canal flaring and before preparation of the apical portion of the root canal, especially with the WaveOne system, which is designed to shape the root canal to the full working length using only one instrument.

Although glide path preparation was reported to have no significant effect on canal straightening^[27] and the centering ability^[29] of reciprocating instruments, Berutti *et al.*^[16] found that it significantly reduced the axis modification. Lim *et al.*^[30] reported that WaveOne and Reciproc reciprocating systems remained more centered following glide path creation in the apical level of simulated curved canals, whereas Nazarimoghadam *et al.*^[31] showed a significant reduction in canal transportation in the apical third of these canals. Their results support the findings in this study which showed significantly higher values for centering ability with glide path preparation. Studies conducted on curved root canals of extracted teeth also yielded similar results.^[21,32] Although the difference was not statistically significant, de Carvalho *et al.*^[21] reported better centering ability when PathFile instruments were used before another single reciprocating NiTi instrument (25/.08) compared with that in the absence of glide path creation. They stated that the values observed in the no glide path group indicate a decreased ability of the reciprocating instrument to adhere to the central axis of the root canal, thus demonstrating the instrument’s tendency to not follow the original canal path when a glide path is not created. Canal aberrations, which lead to inadequate shaping and filling of the root canals, may have a negative influence on the disinfection and long-term prognosis of root canal therapy.^[3] Berutti *et al.*^[16] reported that preflaring of the root canal tends to minimize procedural errors and is corroborated by findings presented in our study that the incidences of canal aberrations were reduced when glide path preparation was performed.

CONCLUSIONS

Within the limitations of the present study, the creation of a glide path using the PathFile system improved the centering ability of the WaveOne reciprocating file in the apical and straight coronal portions of simulated curved S-shaped root canals and also reduced the incidence of canal aberrations. However, due to the differences in the mechanical characteristics of resin blocks and human teeth,^[33] care should be taken when extrapolating the results of the present study to clinical cases. Further

studies using human teeth are needed to confirm the results.

FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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