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# APICAL TRANSPORTATION AND CENTERING ABILITY: A COMPARISON OF TWO-SINGLE FILE SYSTEMS AFTER INSTRUMENTATION TO THE MAJOR FORAMEN AND AFTER OVERINSTRUMENTATION IN CURVED ROOT CANALS

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## Abstract

This study was conducted to compare apical transportation and centering ability to the major foramen after instrumentation and overinstrumentation with M-wire Reciproc® 25 and WaveOne® primary in severely curved canals of extracted teeth. Thirty mesiobuccal root canals of extracted mandibular and maxillary molars were prepared with M-wire Reciproc® 25 or WaveOne® primary to the foramen and 1 mm beyond the foramen. Digital images of the apical foramen before and after instrumentation and overinstrumentation were taken with a digital camera (Olympus, E330, DC 7.4V) coupled with a stereomicroscope (Olympus, CX41, E330, Japan). Each image taken after the instrumentation of the foramen was superimposed on the preliminary image. Apical transportation and centering ability were calculated. The M-wire Reciproc® 25 had a higher mean value for transportation and a lower mean value for centering ability ( $p < 0.05$ ) than the WaveOne® primary when they were used 1 mm beyond the foramen. After overinstrumentation, M-wire Reciproc® 25 produced higher transportation of the major foramen than WaveOne® primary.

**Keywords:** Apical transportation - centering ability - Reciproc® - WaveOne®.

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# CAPACITÉ DE TRANSPORT ET DE CENTRAGE APICAL: COMPARAISON DE SYSTÈMES DE LIMES APRÈS INSTRUMENTATION AU FORAMEN PRINCIPAL ET APRÈS SURINSTRUMENTATION DANS LE CAS DE RACINES À CANAUX COURBES

## Résumé

Cette étude a été menée pour comparer le transport apical et le centrage canalaire de deux instruments, le M-wire Reciproc® 25 et le WaveOne® primary, après instrumentation et surinstrumentation, dans des canaux de dents extraites présentant une courbure sévère.

Trente canaux mésio-vestibulaires de dents extraites mandibulaires et maxillaires ont été utilisés.

Ils ont été préparés avec les instruments M-wire Reciproc® 25 ou WaveOne® primary, d'abord au foramen puis 1 mm au-delà du foramen. Des images numériques du foramen apical ont été prises avec une caméra numérique (Olympus, E330, DC 7.4V) couplée avec un stéréomicroscope (Olympus, CX41, E330, Japan) avant puis après instrumentation et surinstrumentation. Chaque image prise après l'instrumentation du foramen a été superposée à l'image préliminaire. Le transport apical et le centrage canalaire ont été calculés. Des analyses de variance répétées suivies d'analyses univariées ont été effectuées. Aucune différence significative n'a été observée après l'utilisation du M-wire Reciproc® 25 ou du WaveOne® primary à la longueur de travail ( $p > 0.05$ ). Le M-wire Reciproc® 25 avait une valeur moyenne plus élevée que le WaveOne® primary pour le transport apical et une valeur moyenne plus faible pour le centrage canalaire ( $p < 0.05$ ), lorsqu'ils sont utilisés 1 mm au-delà du foramen. L'utilisation au foramen du M-wire Reciproc® 25 ou du WaveOne® primary ne présentait aucun danger. Après surinstrumentation, M-wire Reciproc® 25 a produit un transport plus élevé du foramen apical que WaveOne® primary.

**Mots-clés:** transport apical - centrage canalaire Reciproc®- WaveOne®.

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## Introduction

Canal cleaning and shaping procedures are considered to be the most important phases in endodontic therapy. Respecting the mechanical and biological objectives is key to the success of the endodontic treatment [1]. Nowadays the use of one instrument with reciprocating movement can achieve this goal [2]. Thus, M-wire Reciproc® (VDW) and WaveOne® (Dentsply Tulsa Dental Specialties and Dentsply Maillefer) are introduced as single-file systems, used in a reciprocating motion. While performing shaping technique, these two instruments are able to reach the major foramen (2-4). One of the main mechanical objectives for canal shaping is to maintain the original form and spatial position of the apical foramen. Studies demonstrated that WaveOne® preserved canal anatomy and maintained the position of the foramen [4, 5]. Few articles showed no significant difference between the shaping and centering ability of WaveOne® and Reciproc® instruments [6- 8]. Apical transportation coronal to the major foramen was compared between these two systems [9, 10], but to date no study has compared apical transportation at the foramen. In some cases, overinstrumentation can happen when the working length has been overestimated, even when it was established with an accurate electronic apex locator regardless of its brand [11-14]. A significant decrease in the canal length was detected after the use of WaveOne® reciprocating files in curved canals. Overinstrumentation then could occur if the working length is not checked before the preparation of the apical third of the root canal [15].

The aim of the present study was to evaluate apical transportation and centering ability after instrumentation to the main foramen and after overinstrumentation 1 mm beyond the foramen with M-wire Reciproc® 25 and WaveOne® primary.

## Materials and methods

### Selection of root canals

Thirty mesiobuccal root canals with a major foramen width less than size 20 taken from extracted mandibular and maxillary molars with complete root formation and no history of endodontic treatment were chosen. Teeth were disinfected and immersed in H<sub>2</sub>O<sub>2</sub>+glycerol solution in room temperature. Canals were selected following these criteria:

- They allowed the placement of a size 10 K-file to the major foramen without pre-curving.
- They did not allow passive placement of a size 15 K-file to the foramen even after preflaring the coronal third.
- They presented an angle of curvature ranging between 20° and 40° according to Schneider method [16] and a radius between 3.69 mm and 14.93 mm according to the Pruett technique [17].

Two radiographs, one orthogonally and second rotated 90°, were taken and transferred to AutoCAD program (Autodesk, software, USA) in order to verify the presence of a single curvature, and define the measurement for each root canal.

### Preparation of model

A gutta percha sliding box was used as a positioner under microscope (Fig. 1). This allowed to photograph the major foramen in a stabilized position before instrumentation and to regain the same position after instrumentation. The root canals were fixed in four holes created in a perforated lid. Then, one of the sides of the box was eliminated in order to allow the perforated transparent lid to slide in. Afterwards, the box was fixed on the stereomicroscope (Olympus, CX41, E330, Japan) with metal blade. The foramen of each root canal was observed under a lens (PLAN C, 4x/0.1, Philippines). The operator stabilized each root with a light-cured flow composite when he was able to see the external limit of the major foramen in a continuous

pattern. In order to take images in the same position, the distance between the lens and the apex was preserved for each root canal before and after instrumentation. The major foramen was photographed with a digital camera (Olympus, E330, DC 7.4V) coupled with the stereomicroscope and under a LED (1x3) source of light. This first image was assigned as the preliminary image.

### Root canal preparation

The canals were randomly divided into two groups of 15 canals each. Group R was assigned for shaping with M-wire Reciproc® 25 and group W with WaveOne® primary.

The working length for all canals was determined with a size 10 K-file (Dentsply, Maillefer). The file was introduced into the canal with the presence of RC Prep (Premier Dental Product Company) until the file tip became visible through the foramen under microscope. Then the file was withdrawn until the tip was tangential to the apical foramen. The silicone stop was adjusted to the nearest flat anatomical tooth landmark as a cervical reference. The distance between the file tip and the silicone stop was measured under microscope with a ruler (Dentsply, Maillefer). All working lengths were between 16 and 19 mm.

The same protocol was applied in both groups for all root canals and was completed by one operator.

Preflaring the coronal third: both M-wire Reciproc® 25 or WaveOne® primary instruments were coated with RC Prep (Premier) to act as a lubricant and used with a 6:1 reduction hand-piece (Sirona, VDW) powered by a motor (VDW, Silver), with respectively reciproc all function for Reciproc® 25 instruments and waveone all for WaveOne® primary instruments. The preflaring was completed with a pecking motion according to the manufacturers' instructions followed by a brushing motion against the safety walls to eliminate all interferences. It should be noted that, even after preflaring, a size 15 K Flexofile (Dentsply, Maillefer) was not able to reach the

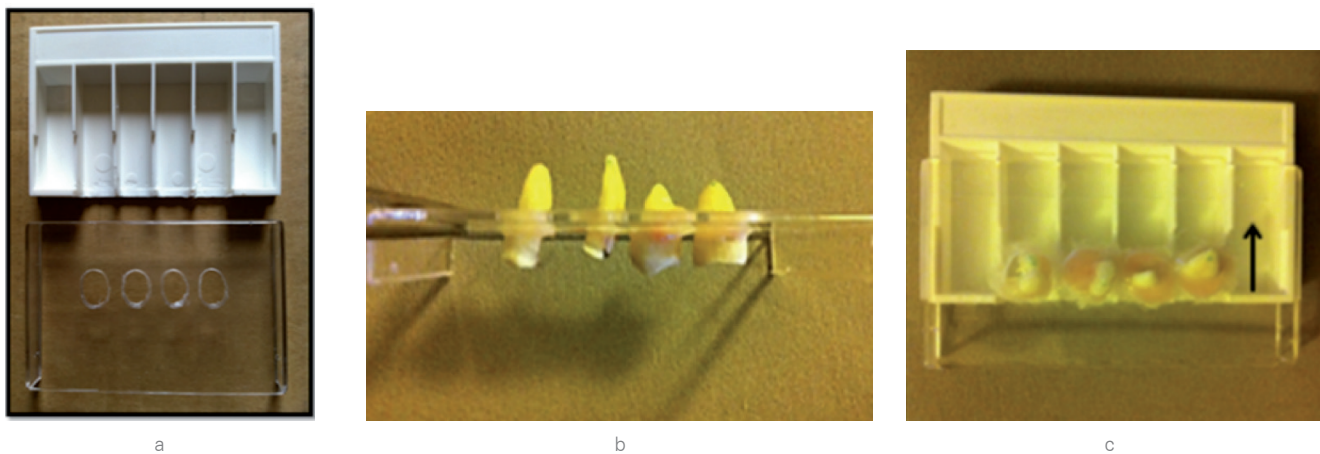


Fig. 1: (a) Gutta percha sliding box with one side eliminated and the perforated transparent lid; (b) The transparent lid with the fixed root canals in the four holes; (c) Gutta percha sliding box as a positioner.

apical foramen. The working length was reevaluated to detect any decrease in the canal length as a consequence of preflaring.

Glide path: Pathfiles® 13, 16 and 19 (Dentsply, Maillefer) were used respectively at a speed of 300 rpm and a torque of 3.5 n/cm<sup>2</sup> up to the working length, thus creating a smooth glide path. A second image was processed in a similar manner as the preliminary image to evaluate their effect on the morphology and position of the apical foramen.

Preparation of the middle and apical third: the same M-wire Reciproc® 25 or WaveOne® primary was used to shape the rest of the canal with only a pecking motion until it reached the apical foramen at the working length. A third image of the apical foramen was taken.

Overinstrumentation: The same M-wire Reciproc® 25 or WaveOne® primary was used in the same manner to instrument the canal 1 mm beyond the apical foramen and a final image was taken.

In all the groups and for each canal, all instruments were single use, irrigation was performed after preflaring, after 3 pecking motions and each change of instrument, with 2 ml of a 5.25% NaOCl solution using a 5 ml luer lock plastic syringe with a 27 gauge Endo-Eze® irrigator tip (Ultradent

Products, USA). Apical patency was maintained using a size 10 K-file.

In order to compare the position and shape of the apical foramen before and after instrumentation, an AutoCAD program (Autodesk, Software, USA) was used to resize all images in the same manner (85.37 cm in width, 69.09 cm in length and a resolution of 314 pixels). The same program allowed to trace the external limit of the apical foramen and to materialize it in color (Fig. 2, yellow before instrumentation, red after instrumentation). Each image taken after the instrumentation of the foramen was superimposed on the preliminary image using a CS3 extended Adobe Photoshop program (San Jose, CA, USA) (Fig. 2). The apical transportation was measured in the direction of maximum curvature according to the method developed by Bergmans et al. (18) ( $T = T' - T$ ). The centering ability was calculated in the direction of maximum curvature according to the method described by Gambill et al. (19) ( $T'/T''$ ).

#### Statistical analysis

The Statistical Package Software for Social Science (SPSS for Windows, Version 18.0, Chicago, IL, USA) was used to analyze the values of apical transportation and centering ability. Significance was considered at  $p \leq 0.05$ . The Intraclass Correlation Coefficient

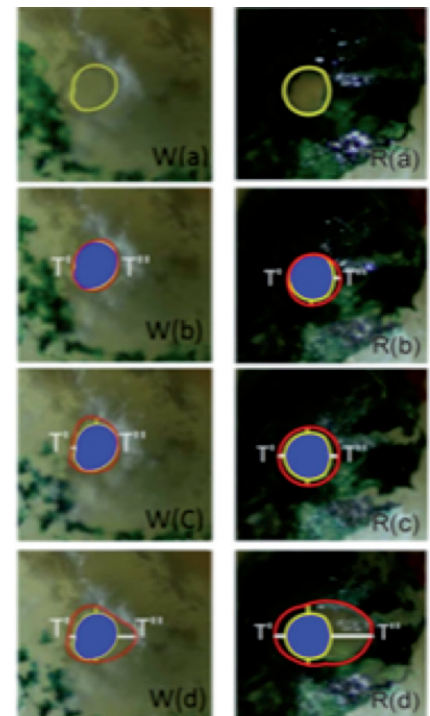


Fig. 2: (a) Preliminary image of the major foramen. (b) Image superimposed on the preliminary image after use of Pathfiles. (c) Image superimposed on the preliminary image after use of Reciproc and WaveOne to the foramen. (d) Image superimposed on the preliminary image after overinstrumentation with Reciproc and WaveOne 1 mm beyond the foramen. (W=WaveOne, R=Reciproc).

	N	Groups	Mean ± SD	p-value (t-test)
Angle (degree)	15	Reciproc	31.53 ± 6.685	p = 0.602
	15	WaveOne	32.80 ± 6.472	
Radius (mm)	15	Reciproc	7.79 ± 2.970	p = 0.833
	15	WaveOne	7.58 ± 2.440	
Working Length (mm)	15	Reciproc	17.67 ± 1.012	p = 0.096
	15	WaveOne	17.06 ± 0.902	

Table 1: Homogeneity of the two groups R and W (N = 15 canals each group).

	N	Groups	Mean ± SD	p-value
After use of Pathfiles	15	Reciproc	0.0275 ± 0.0257	p > 0.05
	15	WaveOne	0.0149 ± 0.0100	
After use of Reciproc and WaveOne to the foramen	15	Reciproc	0.0465 ± 0.0476	p > 0.05
	15	WaveOne	0.0365 ± 0.0335	
After use of Reciproc and WaveOne 1 mm beyond the foramen	15	Reciproc	0.0920 ± 0.1025	pP < 0.05*
	15	WaveOne	0.0590 ± 0.0461	

\* p = 0.015.

Table 2: Absolute values (mean ± SD) for apical transportation (mm) after Pathfiles and after instrumentation to the foramen and 1 mm beyond the foramen.

(ICC) was calculated to verify the reproducibility of apical transportation and centering ability measurements. The homogeneity of the two groups with respect to the angle, radius and working length was assessed using a t-test (Table 1).

## Results

The apical transportation of each instrument is shown in table 2 and figure 3. The M-wire Reciproc® 25 had a higher mean value for transportation (p = 0.015, p < 0.05) than the WaveOne® primary when they were used 1 mm beyond the foramen. No significant difference was observed after the use of M-wire Reciproc® 25 or WaveOne® primary to the working length (p > 0.05).

The mean centering ability for each instrument is detailed in table 3 and figure 4. The M-wire Reciproc® 25 showed a lower mean value for centering ability (p = 0.026) when it was used 1 mm beyond the foramen. However, the mean centering ability

was significantly different than ratio 1 with all instruments in all cases (Ratio 1 indicates perfect centering ability, and ratio 0 indicates worst centering ability).

## Discussion

For each root canal, the difficulty was to take an image of the major foramen in the same position with the digital camera coupled with the stereomicroscope, before and after instrumentation. Using a gutta percha sliding box (Fig. 1) as a positioner under the stereomicroscope and preserving the same distance between the microscope lens and the foramen of each root canal before and after instrumentation made it easier to take images in the same position. Studies comparing the effects of endodontic instruments on the apical foramen should always consider details about the preoperative canal geometry.

In this study, the two groups R and W were homogeneous. The use of a t-test (Table 1) was crucial to verify

the homogeneity of the two groups R and W regarding the angle, the radius and the working length. Although the working lengths were between 16 and 19 mm, this did not affect the final results due to the homogeneity of the two groups. The fact of choosing similar teeth with similar canal curvature, working length, radius and apical diameter for each group helped reduce the number of parameters.

Despite the fact that M-wire Reciproc® 25 has the ability to reach the full root canal working length without a glide path [20], in the present study, the selection of root canals with an apical foramen width less than size 20 made the creation of a smooth glide path with the Pathfiles® a prerequisite before using both instruments. Otherwise, the effects of instruments with a tip 25 on the apical foramen will be meaningless and incorrect. Berutti et al. [21] found that the use of Pathfiles® after a size 10 K-file preserved the original pathway of the canal and maintained the position of the foramen compared with stainless



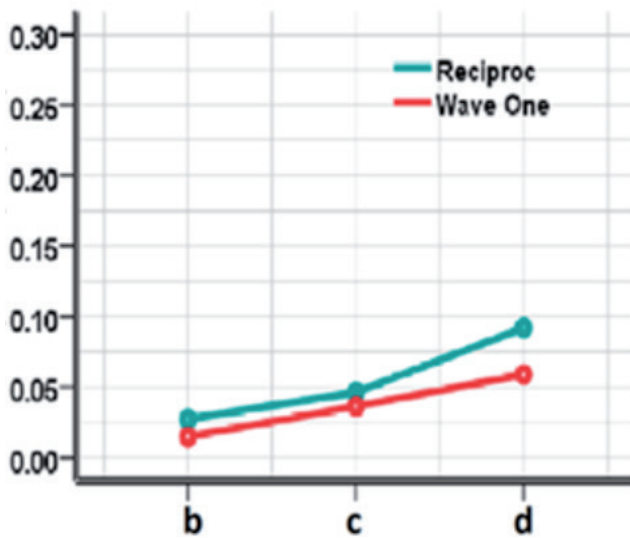


Fig. 3: The mean value of foramen transportation. (b) After use of Pathfiles; (c) After use of Reciproc and WaveOne to the foramen; (d) After use of Reciproc and WaveOne 1 mm beyond the foramen.

	N	Groups	Mean $\pm$ SD	p-value
After use of Pathfiles	15	Reciproc	0.2873 $\pm$ 0.1903	p > 0.05
	15	WaveOne	0.3601 $\pm$ 0.1963	
After use of Reciproc and WaveOne to the foramen	15	Reciproc	0.3607 $\pm$ 0.2459	p > 0.05
	15	WaveOne	0.4380 $\pm$ 0.2025	
After use of Reciproc and WaveOne 1 mm beyond the foramen	15	Reciproc	0.3307 $\pm$ 0.2772	p < 0.05*
	15	WaveOne	0.5073 $\pm$ 0.2402	

\* p = 0.026.

Table 3: Absolute values in ratio (mean  $\pm$  SD) for centering ability after Pathfiles and after instrumentation to the foramen and 1 mm beyond the foramen.

steel size 15 and 20 K-files. It should be noted that in the present study, the use of Pathfiles® created a little deviation towards the outer aspect of the curve, which agreed with the study of De Carvalho et al. [22] who also found that the glide path technique with Pathfiles® promoted minimal apical transportation. But this deviation was verified statistically as insignificant. A decrease in canal length was detected after instrumentation with WaveOne® primary files in severely curved canals [15]. In the present study, a decrease in canal length was found with the two reciprocating files after preflaring the coronal third of the root canal, mainly in severely curved canals. A reevaluation of the working length was done to avoid overextension of

these instruments when they are used to the foramen. You et al. [6] used a brushing motion with the Reciproc® and WaveOne® to avoid micro cracks induced by the pecking motion in the apical third of the canal. In the present study the use of brushing motion in the coronal third was intended to eliminate all interferences that might prevent a size 15 K-file from reaching the foramen, even though the 15 K-file could not reach the foramen, another way to verify that the foramen was less than size 20.

The most important finding of the present study is that M-wire Reciproc® 25 induced higher apical transportation and modification compared to WaveOne® primary when the two files were used 1 mm beyond the foramen.

This may be explained by the difference in design of these two instruments. Indeed, the S-shaped cross section with two sharp cutting edges of the Reciproc® along the entire working part makes its profile more aggressive. According to Plotino et al. [23] M-wire Reciproc® demonstrated statistically higher cutting efficiency than WaveOne® primary instruments. Bürklein et al. [24] found that the presence of radial lands at the tip in the WaveOne® reduced canal transportation. According to McSpadden [25] the lack of radial land and flexibility was the main factor involved in apical transportation. Webber et al. [4] reported that the radial lands in combination with the reciprocating motion maintained the WaveOne® file centered into the

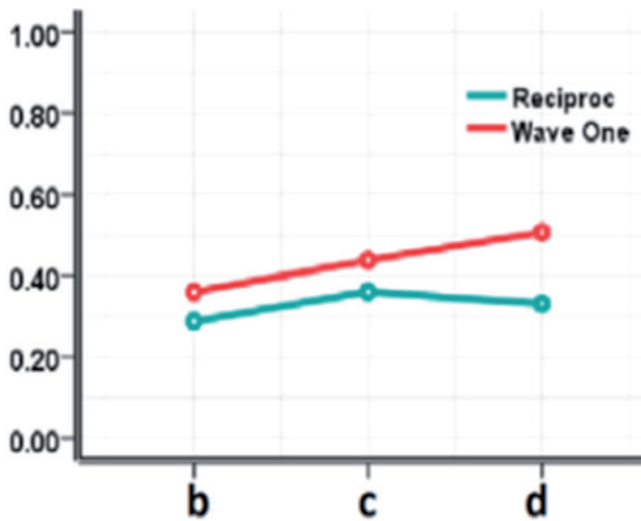


Fig. 4: The mean value of centering ability in ratio. (b) After use of Pathfiles; (c) After use of Reciproc and WaveOne to the foramen; (d) After use of Reciproc and WaveOne 1 mm beyond the foramen.

canal. On the other hand, the study of Lim et al. [26] in simulated curved canals showed less apical transportation with Reciproc® in comparison with WaveOne® at – 1mm and – 2 mm of the apical foramen without prior hand filing, but after hand filing with a size 15 K-file, no significant difference was found with the two instruments. Bürklein et al. [27] assessed the consequences of the use of these two instruments in severely curved root canals without prior filing; no difference was revealed with the two systems. Saber et al. [10] evaluated apical transportation at 1.5 mm coronal to the major foramen; no significant difference between WaveOne® and Reciproc® was found. The findings in these studies are in agreement with the present study as no significant difference was found when the two instruments were used to the working length. Only little deviation was observed towards the outer aspect of the curve when these two instruments were used to the foramen, insignificant statistically.

## Conclusion

Within the limitations of this study it was found that despite the little deviation that occurred towards the outer aspect of the curve, M-wire Reciproc® 25 and WaveOne® primary were safe to use to the foramen as working length. However, in severely curved canals, additional effort should be taken to avoid over-instrumentation of the apical foramen with these instruments, especially with M-wire Reciproc®.

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