



Surface Changes Of WaveOne™ and Reciproc® Instruments after Using Three Times for Preparation of Simulated Curved Canals with and without Glide Path

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ARTICLE INFO

Article Type:

Original Article

Received: 17 Dec 2018

Revised: 21 Mar 2019

Accepted: 09 Apr 2019

Doi: 10.22037/iej.v14i2.22758

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ABSTRACT

Introduction: This study evaluated the occurrence of morphological changes on the surface of the instruments WaveOne™ and Reciproc® when used in the preparation of simulated curved canals with and without glide path (generated with the Pathfile™ system), after the first, second, and third uses. **Materials and methods:** Sixty-four resin blocks, which simulated curved root canals, were used and instrumented with a variety of instruments, grouped according to manufacturer and conditions of simulated canal preparation. Simulated canals were instrumented with WaveOne™ (GW1 group) and Reciproc® (GR1 group) according to manufacturers' recommendations, respectively. In contrast, GW2 and GR2 groups' simulated canals were submitted for construction of glide path with the PathFile™ system before the use of WaveOne™ and Reciproc® instruments, respectively. Each instrument was used three times; after each use, each instrument was analyzed by using scanning electron microscopy (cervical, middle, and apical thirds of the instrument) in order to characterize the occurrence of changes (fracture, twist, and crack). Data were described using means and standard deviations. We used generalized linear models to compare differences between factors (region, manufacturer, glide path, and number of uses). SPSS-15 software was used, with a significance level of 5%. **Results:** Without glide path, WaveOne™ instruments tended to fracture more frequently ($P=0.003$), twist more frequently ($P=0.05$), and crack more frequently ($P=0.022$), with increasing use, with statistically significant differences. With glide path, both WaveOne™ and Reciproc® instruments cracked less frequently ($P=0.001$); Reciproc® instruments did not exhibit superficial changes, such as fractures and/or twists. **Conclusion:** In this *in vitro* study Reciproc® instruments exhibited superior performance, compared with WaveOne™ instruments, particularly when glide path with the PathFile™ system was used; both instruments may be used, safely, three times to prepare curved canals.

Keywords: Endodontics; Root Canal Preparation; Root Canal Therapy; Scanning Electron Microscopy

Introduction

With the advent of NiTi, new tools have emerged which, due to their flexibility and resistance to torsion, facilitated root canal preparation compared to manual continuous rotation [1-8]. This has resulted in reducing working time and operator fatigue [9], as well as the risk of operative accidents [1, 3, 10]. However, greater rigidity of the instruments, based on their increased taper, has limited their use in roots and flattened

curves, increasing the risk of fracture and requirement for drilling [4, 6, 11]. To overcome these limitations, cross-sections of conical instruments and angles between the tip and active sections were changed [12].

Forming techniques have been proposed using an instrument, with reciprocal rotation movement [3-6, 8, 10, 13-18], which resembles the handling performed by manual instrumentation (as advocated by Roane *et al.* [19]). Such alternate movement was developed to increase the centralization

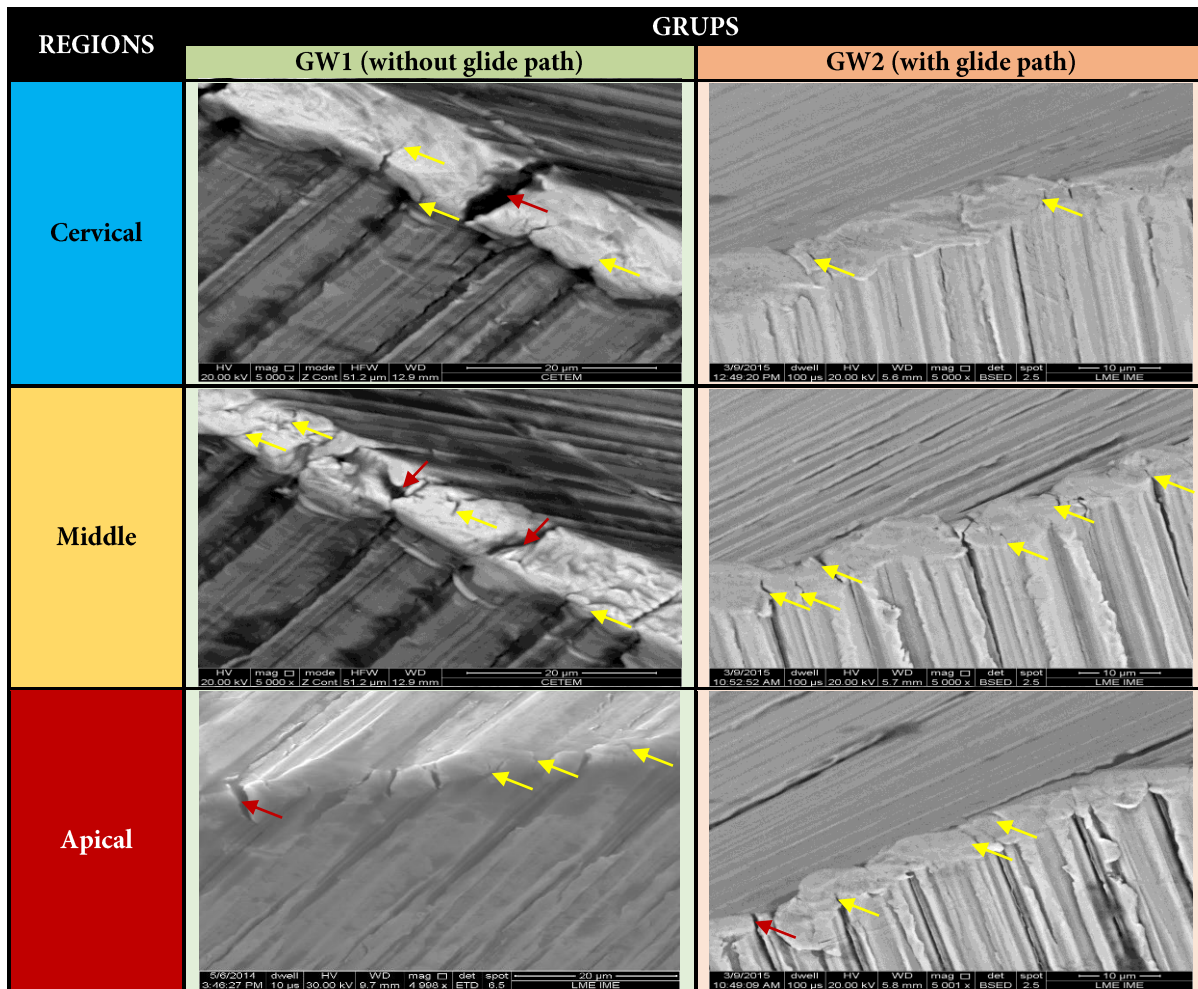


Figure 1. Micrographs of the GW1 and GW2 files surfaces after their third use (red arrow = fracture; yellow arrow=crack. Increase of 5,000 \times)

of root canal preparation and reduce the risk of deformation, as it allows relief of torsional and flexural tensions [6, 7, 17, 20-22].

The dynamics of this movement comprise counterclockwise rotation (cutting direction), followed by narrower clockwise rotation (instrument release direction), allowing continuous and progressive advancement towards the apical direction [16, 18].

Studies have shown that this movement favors the resistance of cyclic fatigue in relation to movement by continuous rotation [17, 18, 20, 22]. Compared with rotational systems, this system has not introduced differences in terms of debris removal and formation of smear layer [1], thus maintaining the original axes of curved root canals during preparation [7, 17, 22, 23].

Endodontic instruments WaveOne™ and Reciproc®, which use the M-wire alloy, employ the principle of alternated reciprocal motion [4]; notably, they are marketed with indication for single use [5, 10, 17, 21, 22, 24]. To improve the performance of these instruments, the use of a glide path with specific instruments for this purpose is suggested, which

reduces the possibility of torsion fracture of files with reciprocal movements [2, 12, 25-29].

Single-instrument systems constitute a contemporary technology with regard to the preparation of root canals; various aspects of these systems are the focus of active research [1, 5, 17, 21, 22, 30]. A major concern for this type of system is the maintenance of quality and safety upon reuse [5, 15, 30, 31]. Therefore, this study aimed to evaluate the occurrence of morphological changes on the surface of the alloy of WaveOne™ and Reciproc® instruments when used in the preparation of simulated curved canals with and without glide path (generated with the PathFile™ system), after the first, second, and third uses, by means scanning electron microscopy (SEM).

Material and Methods

This study received exemption from the Ethics Committee on Research because it was performed *in vitro*, using 64 blocks of resin

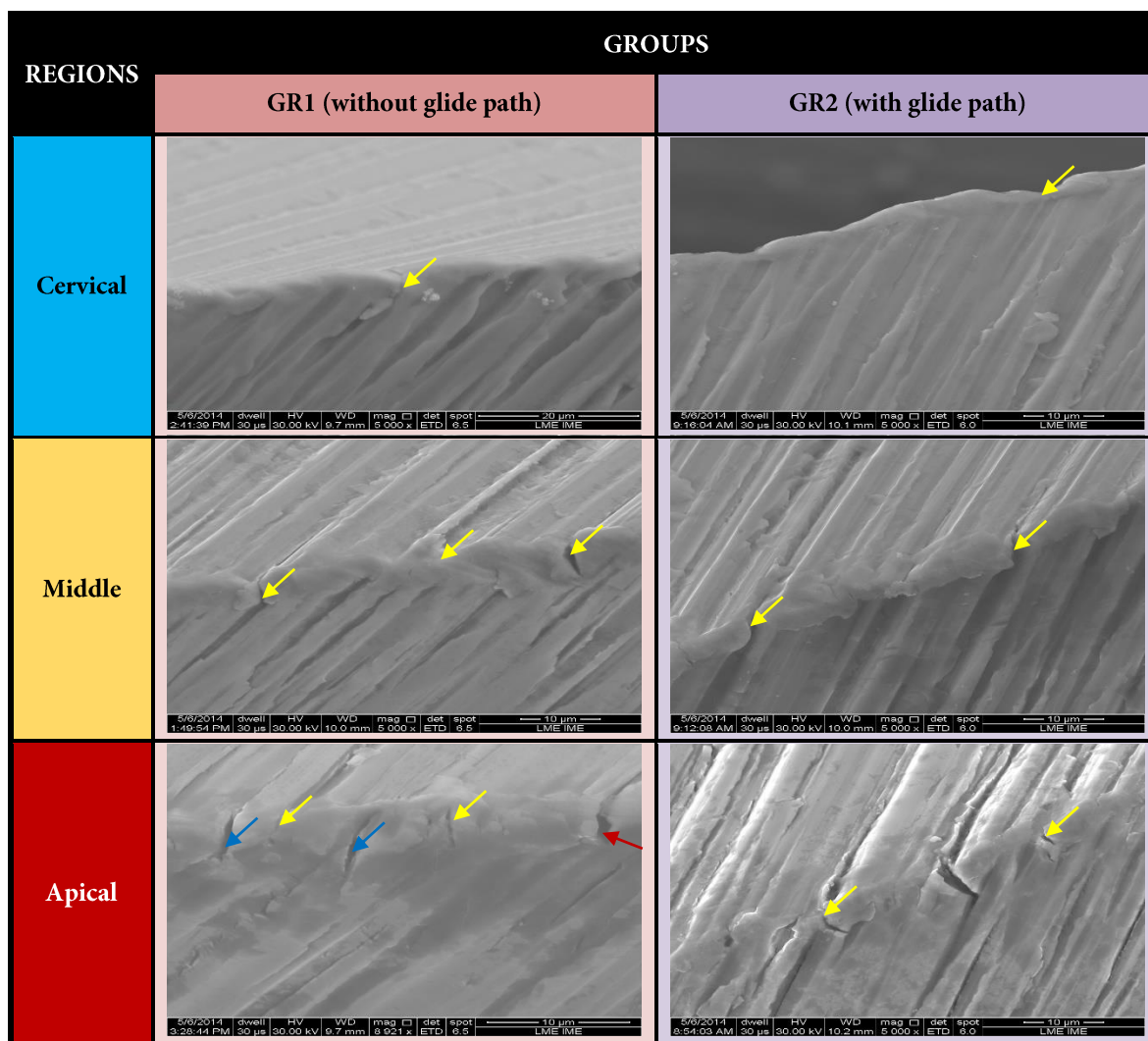


Figure 2: Micrographs of the GR1 and GR2 files surfaces after their third use (red arrow=fracture; blue arrow=torsion; yellow arrow=crack. Increase of 5,000×)

root canal simulators (Endo-Training-Bloc, Dentsply IND., RJ, Brazil), with 0.02 taper, angle of 40°, with working length of 20 mm.

Endodontic instruments studied were divided into groups, according to the manufacturer: GW-WaveOne (Dentsply Maillefer, Ballaigues, Switzerland; lot 1079258) and GR-Reciproc (VDW, Munich, Germany; lot 071857); and according to the conditions of simulated canal preparation (GW1 and GW2; GR1 and GR2). Four instruments were selected to be analyzed intact and four instruments to be tested in each subgroup [24, 32], according to the number of uses evaluated (one, two and three), resulting in a total of 16 units for each group. The canals of GW1 and GR1 groups were instrumented in accordance with manufacturer's recommendations: WaveOne™ (Primary, 25/0.08) and Reciproc® (R25, 25/0.08), respectively. In GW2 and GR2

groups, the canals were instrumented in accordance with the glide path generated by PathFile system (Dentsply Maillefer, Ballaigues, Switzerland; lot 1306000884) using the #013, 016, and 019 instruments with 25 mm length.

All simulated canals were prepared by the same operator. Each block of simulated root canals was irrigated with 1.5 mL of NaOCl 1% (Medicamenta, Juiz de Fora/MG, Brazil); a #10 manual K-File instrument (VDW, Munich, Germany; lot 056080) with gentle watch-winding and pull motion was carried to the patent length. The test files of groups GW1 and GR1 were then applied in reciprocating motion in three different times with irrigation as previously described. Recapitulation was done with #10 K-file up to the patent length followed by final irrigation.

In GW2 and GR2 groups, the rotational instruments PathFile™ was used for the glide path of simulated canals with the following

procedure: irrigation was performed with 1.5 mL of NaOCl 1%, combined with manual #10 K-file used in watch-winding motion until the patency was gained; the instrument glide path of the rotational system PathFile™ was followed in the order recommended by the manufacturer (013, 016, 019), alternating with NaOCl irrigation in cervical, middle, and apical thirds. The PathFile™ instruments were used until they were loose inside the canal, and used one kit for each reciprocal specimen analyzed. After this procedure, test instruments (GW2 and GR2) were used in the same manner as in GW1 and GR1 groups.

Each instrument was analyzed via scanning electron microscopy (SEM) to observe surface changes on the basis of the methodology used. Intact tools (controls) were also observed, in isolation. All instruments were analyzed by SEM (FEI Quanta apparatus in EGF Bruker and 250-1000 Flash, Centaurus Detector, Berlin, Germany) with a magnification of 5000×. Readings were performed for the cervical (9 mm), middle (6 mm), and apical (3 mm) thirds of each instrument.

Statistical analysis

Data were described using means and standard deviations. We used generalized linear models (GLM) to compare differences between factors (region, manufacturer, glide path, and number of uses) [5]. This model is able to identify the net effect of each independent variable, as well as its various interactions. SPSS software (SPSS, Version 15, Chicago, IL, USA) was used, with a significance level of 5%.

Results

Table 1 demonstrate the total surface changes (fractures, twists, and cracks) on cervical (9 mm), middle (6 mm), and apical (3 mm) regions in the instruments used, as observed in SEM (Figures 1 and 2).

Comparison of fracture in the WaveOne™ group on the third use with the glide path, the number of fractures in the cervical region was maintained, while in middle and apical regions there were reductions in the number of fractures from "8" to "0" and "12" to "2", respectively. Conversely, instruments in Reciproc group, did not show concurrent glide path fractures on the surfaces of the same regions. Without using the glide path (GR1), the number of fractures remained minimal for Reciproc.

Regarding twisting in the WaveOne™ group on the third use, there was a large reduction in the cervical region from "21" twists in GW1 to "0" in GW2. Conversely, in the Reciproc group, the occurrence of twists was solely observed in the apical region, with a reduction of seven twists at GR2.

Cracking was most commonly observed on the surfaces of both instruments tested. Regarding the third use of both instruments, cracks occurred most frequently in conditions without the glide path, with the largest numbers in GW1 for all regions (cervical=24, middle=29, and apical=25). However, when using the glide path, this number was considerably reduced in most regions tested, for both instruments.

When applying the GLM, it was noted that: 1) without the glide path there were interactions between manufacturers with respect to the number of uses. WaveOne™ instruments tended to fracture more frequently ($P=0.003$), twist more frequently ($P=0.05$), and crack more frequently ($P=0.022$) with increasing use. In the cervical region, WaveOne™ instruments tended to twist ($P=0.039$) with increasing use; WaveOne™ instruments cracked more with increasing use ($P=0.024$). Also with the glide path there were interactions between manufacturers with respect to the number of uses; WaveOne™ instruments and Reciproc® cracked less ($P=0.001$). And Reciproc® instruments did not suffer superficial changes, such as fractures and/or twists.

Table 1. Superficial changes found in the instruments after the use (n=12)

Amendment	Region	GW1			GW2			GR1			GR2		
		1U	2U	3U	1U	2U	3U	1U	2U	3U	1U	2U	3U
Fracture	Cervical	1	1	3	3	2	3	0	0	1	0	0	0
	Middle	4	4	8	5	5	0	0	0	2	0	0	0
	Apical	3	2	12	3	9	2	1	1	2	0	0	0
Twist	Cervical	1	2	21	1	12	0	0	0	0	0	0	0
	Middle	2	2	0	5	0	0	0	0	0	0	1	0
	Apical	2	11	2	11	0	0	1	0	8	1	4	1
Crack	Cervical	6	7	24	6	17	17	10	17	16	5	8	8
	Middle	11	12	29	10	16	16	11	19	22	3	9	14
	Apical	18	11	25	9	17	28	9	21	22	3	9	13

1U=after first use; 2U=after 2nd use; 3U=after 3rd use; GW1=WaveOne™ without glide path; GW2=WaveOne™ with glide path; GR1=Reciproc® without glide path; GR2=Reciproc® with glide path

Discussion

In this study, analyses were conducted for up to three uses [5, 14], with readings before and after each use of the reciprocating instruments, following the approach of Bueno *et al.* [14]. Evaluating the reuse of single-use instruments has shown considerable variance in the number of uses: three [5, 14], ten [30, 31], or 12 [15] uses, or until the instrument was fractured [16]. In addition, the studies have also varied with respect to time of evaluation. Park *et al.* [31] analyzed instruments before and after the instrumentation of one, five, and 10 canals; Pires [30] analyzed before use, and after two, six, eight, and 10 uses; Caballero *et al.* [15] evaluated before use, and after three, six, nine, and 12 uses; and Maniglia-Ferreira *et al.* [16] evaluated after each use.

The study by Pires [30], which compared WaveOne[®] and OneShape[®] systems, showed that the OneShape[®] system can be used a maximum of 10 times, while WaveOne[™] exhibits more limited performance, and should be used a maximum of six times. Caballero *et al.* [15], when assessing Reciproc[®] and Twisted[®] systems, found that Reciproc[®] demonstrated superior performance and may be used for maximum of nine times, while Twisted[®] File can be used a maximum of six times.

Park *et al.* [31], when analyzing the same systems assessed in this study WaveOne[™] and Reciproc[®] concluded that both can be used to prepare a maximum of five curved root canals. The current study confirms those findings, which indicate that the alternate handling instruments are not limited to a single use; notably, both systems tested in the present study can be used safely and effectively a maximum of three times. Moreover, the present study showed better performance for Reciproc[®] instruments, and corroborated the findings of Bueno *et al.* [14].

However, in the study by Caballero *et al.* [15] craters and blunt tips were predominantly observed in the Reciproc[®] group. In the present study, there was a predominance of cracks for all groups tested, and these occurred more often in WaveOne[™] groups.

Importantly, the present study was not limited to examination of the number of uses for each instrument; it also assessed the influence of the use of glide path with the PathFile[™] system, with respect to superficial changes that occurred on the Reciproc[®] and WaveOne[™] instruments. This analysis was performed because, according to some authors [2, 13, 20, 23, 26, 28, 29, 33], the glide path is considerably effective in removing much of the cervical interference that can provide resistance during the introduction of an instrument until it

reaches the apex. Nevertheless, NiTi instruments developed for this purpose facilitate more rapid root canal shaping, resulting in a lower rate of accidents and complications; moreover, they contribute to the maintenance of the original canal anatomy [13, 20, 23, 28, 29]. PathFile[™] rotational instruments, for example, were developed specifically for the glide path of the root canal [2, 13, 27, 29, 33] and allow its extension with minimal deviation, compared with manual K-Files [13, 27].

These statements have been proven by studies such as that of Berutti *et al.* [13], which found that the *glide path* with the PathFile[™] system, appears suitable for root canal shaping irrespective of any rotary or alternative motion of NiTi instrumentation. Additionally, Kubde *et al.* [27] found that the PathFile[™] system provided a fast and secure glide path of the root canal, without the occurrence of apical foramen shuttle or formation of steps; Ajuz *et al.* [25] concluded that NiTi instruments are best suited to the glide path because they promote fewer deviations in the original anatomy of the canal. Dhingra *et al.* [20] concluded that the glide path improved the performance of WaveOne[™] instruments; it was beneficial for the following parameters: canal curvature, cross-sectional area, centering capacity, residual dentin thickness, and extent of the transport channel. Similarly, Yilmaz *et al.* [33] concluded that instrumentation with WaveOne[™] in curved canals was improved after the use of glide path with PathFile[™].

In this study, when comparing superficial changes in reciprocating instruments with and without the use of glide path (generated by PathFile[™]), realization of the glide path provided a significant reduction in the occurrence of fractures, twists, and cracks for both instruments tested. Importantly, Reciproc[®] instruments exhibited fewer surface changes, compared with WaveOne[™] instruments.

The use of irrigant solutions simulates the effect of chemical disinfection on the NiTi surface [4]. However, the effect on dentinal surface cannot be replicated as in the study of Cassimiro *et al.* [6], since a limitation of the study is the use of resin blocks, this situation is far from clinical conditions.

Conclusion

Reciproc[®] instruments exhibited better performance than WaveOne[™] instruments, particularly when using the glide path generated by the PathFile[™] system; both reciprocating instruments can be safely used in the preparation of curved canals.

Conflict of Interest: 'None declared'.

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Please cite this paper as: Barbosa Machado AL, Machado AG, Silveira Bueno CE. Surface Changes Of WaveOne™ and Reciproc® Instruments after Using Three Times for Preparation of Simulated Curved Canals with and without Glide Path. *Iran Endod J*. 2019;14(2): 133-8. Doi: 10.22037/iej.v14i2.22758.