Shaping Ability of Reciproc, WaveOne GOLD, and HyFlex EDM Single-file Systems in Simulated S-shaped Canals

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Abstract

Introduction: The aim of the present study was to compare the shaping ability of Reciproc (RPC; VDW, Munich, Germany), HyFlex EDM (HEDM; Coltene/Whaledent AG, Altstätten, Switzerland), and WaveOne GOLD (WOG; Dentsply Maillefer, Ballaigues, Switzerland) nickel-titanium (NiTi) files made of different NiTi alloys in S-shaped simulated canals. **Methods:** Sixty S-shaped canals in resin blocks were prepared to an apical size of 0.25 mm using RPC R25, WOG Primary, and HEDM One-File (n = 20 canal/per group) systems. Composite images were made from the superimposition of pre- and postinstrumentation images. The amount of resin removed by each system was measured using a digital template and image analysis software in 22 different points. Canal aberrations were also recorded. Data were statistically analyzed using the Kruskal-Wallis and post hoc Dunn tests at the 5% level. **Results:** NiTi file fracture was not observed during shaping of the simulated canals although a danger zone formation in 1 sample and a ledge in 1 sample were observed in the RPC group. There was no statistically significant difference between the WOG and HEDM groups' apical, medial, and coronal regions ($P > .05$). However, it was determined that the RPC group removed a statistically significantly higher amount of resin from all the canal regions when compared with the WOG and HEDM groups ($P < .05$). **Conclusions:** Within the limitation of the present study, it was determined that all of the tested NiTi files caused various levels of resin removal. However, WOG and HEDM NiTi files were found to cause a lower level of resin removal than RPC NiTi files. *(J Endod 2017;43:805–809)*

Key Words

Canal irregularity, controlled memory, endodontics, GOLD wire, nickel-titanium, shaping ability

Significance

There are several NiTi instruments on the dental market. General dentists and endodontists should know the shaping performances of novel NiTi files.

In root canal shaping, from the aspect of the success of endodontic treatment, it is very important to maintain the original form of the canal as far as possible while the root canal is being gradually enlarged from the apical to the coronal region (1). Because of their super flexibility, nickel-titanium (NiTi) files, which are used for enlarging root canals, are useful in minimizing canal irregularities such as danger zone formation, ledges, zips, and perforations that may occur during shaping, especially narrow and curved root canals (2, 3). Danger zone refers to the distal area in the mesial root in mandibular molars. Usually a straight layer of dentin, it becomes a preferable site for strip perforation during instrumentation. Nowadays, the use of NiTi rotary file systems made of various alloys (conventional, R-phase, M-Wire, and GOLD Wire NiTi) and the use of various kinematics (continuous rotation, reciprocation, and adaptive motion) are recommended for maintaining the original form of the canal while shaping the root canal (4, 5). Besides the advantages of NiTi alloys, they also have certain disadvantages, such as high fracture incidence depending on the cyclic fatigue in narrow and curved root canals. To prevent fracture in NiTi files caused by cyclic fatigue, single-file reciprocation motion systems are recommended (6). Among these systems, the most widely known systems are WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) and Reciproc (RPC; VDW, Munich, Germany) NiTi file systems, which are made of M-Wire alloy (7). RPC files have an S-shaped cross section with 2 cutting edges, and a file taper is fixed 3 mm from the apex of the files and decreases in the middle and coronal thirds. WaveOne was recently modified to WaveOne GOLD (WOG, Dentsply Maillefer). The movement kinematics of the file has not been changed, but the cross section of the file has been modified to the parallelogram structure with 2 cutting edges in order to make the file more flexible. Furthermore, the off-center design that is seen in ProTaper Next (PTN) files (Dentsply Maillefer) is also used in WOG files. The most important modification is the alteration of alloy from M-Wire to GOLD alloy (8). The GOLD alloy technology is based on heating the file and then slowly cooling it, rather than the M-Wire technology involving heat treatment before the production. The manufacturer claims that the flexibility of files is improved through this new heat treatment method (9).

Another single-file system recently introduced to the market is HyFlex EDM (HEDM; Coltene/Whaledent AG, Altstätten, Switzerland). HEDM is manufactured using the technique of electrical discharge machining. Electrical discharge machining can be used in manufacturing all types of conductive materials (ie, metals, alloys, graphite, ceramics, and so on) of any hardness at high precision levels (10). This manufacturing

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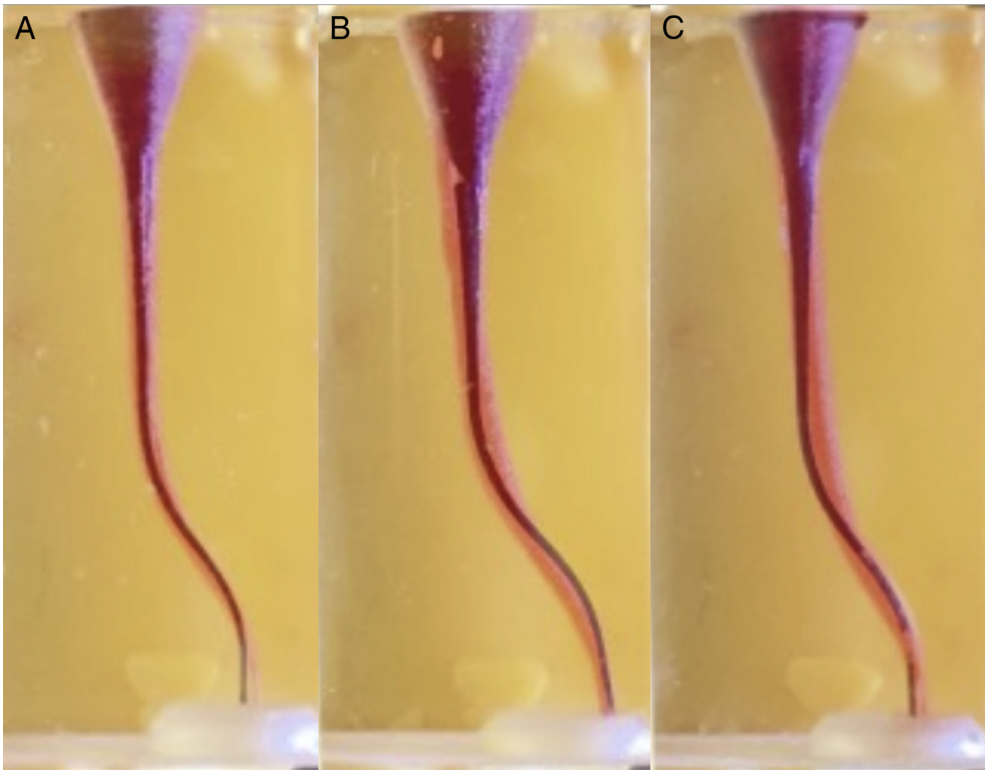

Figure 1. Representative images of simulated canals instrumented using (*A*) HEDM, (*B*) WOG, and (*C*) RPC.

process uses spark erosion to harden the surface of the NiTi file, resulting in superior fracture resistance and improved cutting efficiency. HEDM NiTi files are manufactured using Controlled Memory alloy technology like the HyFlex CM (Coltene/Whaledent AG) NiTi files. HEDM has the taper changing throughout the file shaft and a 0.25-mm apical diameter. Throughout the file shaft, HEDM uses 3 different cross sections: quadratic in the apical third, trapezoidal in the middle third, and almost triangular in the coronal third (11).

A comprehensive literature review indicated that there was no study examining the shaping ability of WOG and HEDM NiTi files in shaping the extracted teeth or in simulated canals. For this reason, the aim of this study was to compare the shaping ability of RPC, HEDM, and WOG NiTi files made of different NiTi alloys in S-shaped simulated canals. The null hypothesis of the present study was that there would be no difference between the tested NiTi files in terms of the shaping abilities.

Materials and Methods

Sixty S-shaped simulated canals having a 0.02 taper, a 0.15-mm apical diameter, and a 16-mm working length (Endo Training Block-S, Dentsply Maillefer) were involved in this study. The coronal curvature angle of the simulated canals was 30°, the coronal canal radius was 5 mm, the apical curvature angle was 20°, and the apical canal radius was 4.5 mm. After checking the canal openings of the simulated canals using a #10 K-file (Dentsply Maillefer), blocks were randomly divided into 3 groups (n = 20), and the following procedures were initiated.

Group 1: RPC

The RPC R25 (25/.08) instrument was used with the VDW Silver Reciproc (VDW) endodontic motor using an in-and-out pecking motion in the "RECIPROC ALL" mode until reaching the working length. According to the manufacturer's instructions, gentle apical pressure was applied to the file.

Group 2: WOG

The canals in this group were shaped using a torque-controlled endodontic motor (VDW Silver Reciproc) with the WOG Primary (25/.07) NiTi file in the "WAVEONE ALL" mode until reaching the working length. According to the manufacturer's instructions, gentle apical pressure was applied to the file.

Group 3: HEDM

The canals in this group were shaped using a torque-controlled endodontic motor (VDW Silver Reciproc) with the HEDM OneFile (25/.∼) NiTi file at 500 rpm and 2.5 Ncm torque in accordance with the manufacturer's instructions.

All of the operations were executed by an endodontist experienced in using NiTi files. A new file was used for shaping each of the canals. During the use of the files, the canals were irrigated using total 20 mL distilled water. In total, 60 S-Shaped simulated canals were shaped.

Assessment of Canal Preparation

Before starting the shaping process, all of the canals were stained using black ink (Pelikan, Istanbul, Turkey). Then, a photo camera (EOS 500D; Canon, Tokyo, Japan) adapted to standard setup was used for taking images of the canals. The artificial canals were stained using red ink (Pelikan) after the preparation, and their photographs were taken again.

The composite images of canals were obtained from pre- and posttreatment photographs using computer software (Pages; Apple

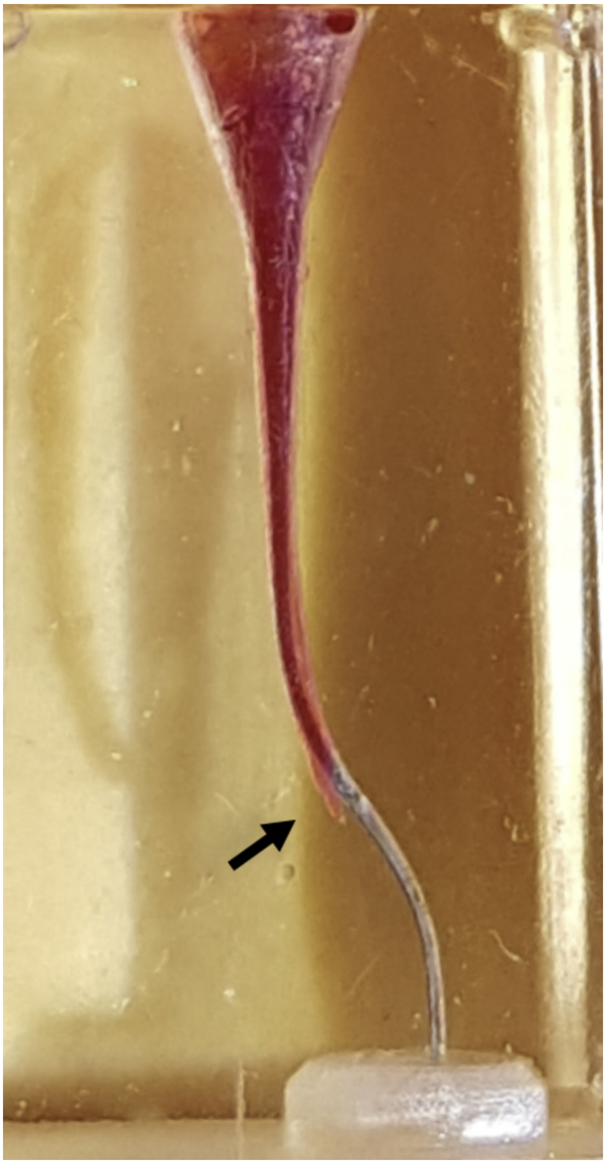

Figure 2. The ledge formation in the RPC group (*arrow*).

Inc, Cupertino, CA) for combining the images (Fig. 1*A–C*). Using the same software, a measurement scale was also prepared. Then, these images were transferred to AutoCAD (Autodesk, San Rafael, CA) software, and the levels of resin removed were calculated at 22 points (11 internal points and 11 external points). The points of measurement were determined in 1-mm intervals; points 0 to 3 constituted the apical curvature, points 4 to 7 constituted the coronal curvature, and points 8 to 10 constituted the coronal plane portion of the canal (12).

Statistical Analysis

Statistical analyses of data obtained in this study were performed using SPSS 21 (IBM SPSS Inc, Chicago, IL) software. Using the Shapiro-Wilk test, it was determined that the obtained data did not show normal distribution. The differences between the groups were determined using the Kruskal-Wallis and post hoc Dunn tests. The level of statistical significance was set to 5%.

Results

NiTi file fracture was not observed during shaping of the simulated canals in any group. Canal irregularity was not observed in the WOG and HEDM groups, whereas a danger zone formation in 1 sample and a ledge in 1 sample were observed in the RPC group (Fig. 2).

In terms of the mean amount of resin removed by the files, there was no statistically significant difference among the WOG and HEDM groups' apical (points 0–3), middle (points 4–7), or coronal (points 8–10) regions ($P > .05$) (Fig. 3). However, it was determined that the RPC group removed a statistically significantly higher amount of resin from all canal regions when compared with the WOG and HEDM groups ($P < .05$).

Mean values and standard deviations of width values of canals shaped using RPC, WOG, and HEDM file systems are presented in Table 1. The RPC group was found to create statistically significantly higher enlargement values at all measurement points when compared with the other groups ($P < .05$).

Discussion

The various thermomechanic procedures and the improvement of composition of the alloy that is used in manufacturing NiTi files are aimed to improve the flexibility of NiTi files (13–15). Improved flexibility of NiTi files would minimize the intracanal irregularities such as canal transportation and would ensure an increase in the success of root canal therapy (16).

Natural teeth and simulated resin canals are used to compare the shaping abilities of NiTi files. However, in studies using natural teeth, it is very difficult to maintain standardization because of the anatomic variations of the teeth. Peters et al (17) argued that when natural teeth are used, the anatomic variations of these teeth affect the results more than NiTi files. In studies using S-shaped simulated canals, by easily comparing the pre- and postshaping images of roots via various computer programs, it is possible to compare the shaping abilities of NiTi files (18). For this reason and considering these conditions, the S-shaped simulated canals were used to eliminate the anatomic variations that natural teeth have. The most significant disadvantages of this technique are the hardness level of resin and the dentin is not the same. For these reasons, it is very important to pay attention to the evaluation of study results in terms of the clinical conditions (19).

Increasing the apical diameter ensures the penetration of irrigation solution into the apical region and effective cleaning in this region. However, it may cause undesired canal irregularity in narrow and curved root canals (20). For this reason, in the present study, NiTi files having an apical diameter of 0.25 mm were used in shaping the S-shaped simulated canals according to previous studies (20).

In the present study, file fracture was not observed in any of the groups during root canal shaping, whereas danger zone formation in 1 sample and ledge formation in another sample were noted in the RPC group. We believe that the canal irregularities in the RPC group are caused by the fact that RPC files tend to retain their original form within the canal because of the file's manufacturing method with conventional NiTi alloy.

According to the results of the present study, the RPC group was found to remove statistically significantly more resin at all of the measurement points when compared with the WOG and HEDM groups ($P < .05$). Moreover, the RPC group created statistically significantly higher levels of enlargement at all of the measurement points than all other groups ($P < .05$). For this reason, the null hypothesis of the present study was rejected. Because no study examining the shaping ability of WOG and HEDM NiTi files could be found in our comprehensive literature review, it is not possible to directly compare our results with

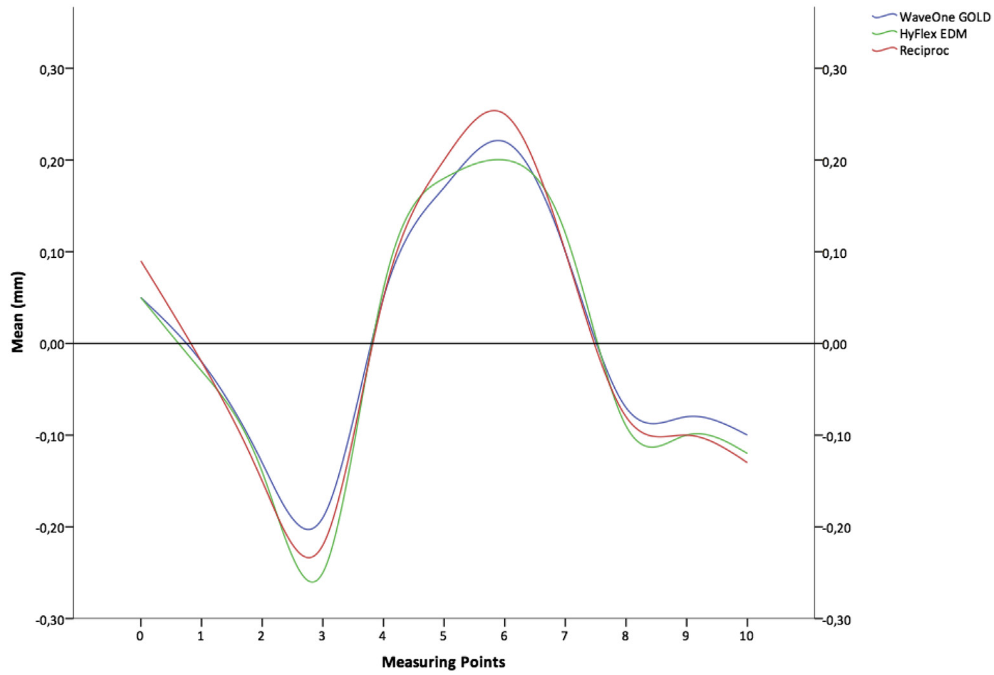

Figure 3. The direction and amount of canal transportation (mm) at the different measurement points. Values were calculated by subtracting the amount of resin removed at the inner side (concavity of the apical curvature) of the simulated canal from the amount of resin removed at the outer side.

others. The fact that RPC has a higher taper than WOG (25/.07) and HEDM (25/.~) files may have allowed the RPC group to remove more resin and to create a larger canal width than other groups.

Similar to the present study results, Gergi et al (21) compared the Twisted File (TF; SybronEndo, Orange, CA), WO, and RPC NiTi files' shaping ability, and they reported that the RPC group removed a statistically significantly higher amount of dentin than the other groups.

Gagliardi et al (22) compared the ProTaper Universal (Dentsply Maillefer), PTN, and ProTaper GOLD (PTG, Dentsply Maillefer) NiTi files' shaping ability and reported that PTN and PTG files performed less canal transportation and argued that this was because of the flexible alloy of PTG files. Zhao et al (23) compared the shaping abilities of TF, HyFlex CM, and K3 (SybronEndo) NiTi files and reported that TF and HyFlex CM caused less apical transportation than K3. In another study, Saber et al (24) concluded that HyFlex CM files caused less transportation than PTN files made of M-Wire alloy and iRaCe (FKG, La Chaux-de-Fonds, Switzerland) files made of a conventional alloy. Similarly, Bürklein et al (25) also reported that HyFlex CM files led to less transportation than Revo-S files (Micro Mega, Besancon, France) made of a conventional alloy. Authors have attributed the less transportation of HyFlex CM files to their flexibility and elastic structure. As the reason for the lower amount of canal transportation performed by HEDM files compared with RPC files, we believe that, under favor of the alloy that HEDM files are mad of, HyFlex CM files are more flexible, and consequently they are capable of better adapting to the original shape of the canal. The design features such as taper, tip, and cross section of the NiTi files that were tested in the present study were different. RPC files have an S-shaped cross section, but WOG and HEDM files have an almost rectangular cross section. The results of the present study showed that the almost rectangular cross section provides better management of a curved canal than the S-shaped cross section. Also, we think that the higher enlargement values at all measurement points created by the RPC group were because of the high taper (.08) of RPC files.

TABLE 1. Means (mm) and Standard Deviations at the Different Measurement Points of Canal Width after Preparation with the Different Instruments

	WaveOne GOLD	HyFlex EDM	Reciproc
0	0.30 ± 0.03^a	0.30 ± 0.03^a	0.35 ± 0.05^b
1	0.33 ± 0.02^a	0.32 ± 0.02^a	0.41 ± 0.05^b
2	0.39 ± 0.02^a	0.37 ± 0.02^a	0.52 ± 0.05^b
3	0.44 ± 0.02^a	0.42 ± 0.03^a	0.57 ± 0.03^b
4	0.48 ± 0.03^a	0.48 ± 0.02^a	0.64 ± 0.03^b
5	0.58 ± 0.03^a	0.57 ± 0.02^a	0.75 ± 0.03^b
6	0.64 ± 0.02^a	0.62 ± 0.02^a	0.79 ± 0.03^b
7	0.74 ± 0.02^a	0.71 ± 0.03^a	0.81 ± 0.02^b
8	0.74 ± 0.03^a	0.71 ± 0.03^a	0.83 ± 0.02^b
9	0.74 ± 0.03^a	0.74 ± 0.04^a	0.87 ± 0.02^b
10	0.83 ± 0.03^a	0.82 ± 0.04^a	0.98 ± 0.03^b

Values with different superscript letters were statistically different ($P < .05$).

Even though there were statistically significant differences between the tested NiTi files in terms of the amount of resin removed and the total width of the canal, the results of this study are disputable from a clinical aspect, and the shaping efficiencies on natural teeth may differ (26). However, these results are important for clinicians to have knowledge about the RPC, WOG, and HEDM NiTi files' shaping efficiencies and to be capable of dealing with the anatomic difficulties experienced during root canal shaping in a clinic medium.

Conclusion

Within the limitations of the present study, it was determined that all of the tested NiTi files caused various levels of resin removal. However, the WOG and HEDM NiTi files were found to cause a lower level of resin removal than the RPC NiTi files did.

Acknowledgments

The authors deny any conflicts of interest related to this study.

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