

# Gentlefile Versus Protaper in the Shaping Ability in Simulated J-shaped Root Canals

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## Research article

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# Abstract

**Background:** The aim of this study was to compare the shaping ability of Gentlefile (GF), a unique stainless-steel (SS) rotary system, and ProTaper (PT), a popular mechanical nickel-titanium (NiTi) system, in J-shaped simulated canals.

**Methods:** Thirty-three resin blocks with a J-shaped canal were selected and randomly divided into 3 groups according to tip diameters: *GF red* (#23); PT F2(#25); *GF blue* (#26). They were prepared in one training model which imitated human dentition. Specimens were photographed by a *dental* operating *microscope* before and after preparation. The images were processed and measured using professional software. Centering ability and canal transportation were calculated, canal aberration and instrument separation were also recorded.

**Results:** The GF system was significantly less transported than PT F2 in the apical and middle section. What's more, better centering ability of GF was shown in all sections, including the coronal level. However, there was no difference between *GF red* and *GF blue* based on above criteria. Two cases of instrument separation of GF were noted.

**Conclusion:** Under the conditions of this study, the two GF files showed better shaping ability, but were more easily separated than PT F2. As a novel SS rotary system, Gentlefile is more flexible to prepare narrow and curved root canals by scraping dentin with high-speed rotation, which might help remove smear layer much thoroughly and cause less dentin microcracks.

## Background

Root canal preparation is one of the most important steps in root canal therapy. The ultimate goal of root canal preparation is to clean and shape the root canal system while maintaining the original configuration [1]. NiTi instruments with good flexibility, super-elasticity, and shape-memory, have gradually become the mainstream in endodontic treatment [2]. However, it is often reported that the preparation of NiTi instruments may produce microcracks in dentin [3–5] and the fracture of instruments caused by torsion and cyclic fatigue seems to be inevitable during preparation.

ProTaper (PT, Dentsply Maillefer, Ballaigues, Switzerland), as a traditional NiTi rotary system, is still widely applied in clinical practice due to its great cyclic fatigue resistance and shaping ability [6–8]. It is generally accepted that NiTi mechanical instruments are more suitable for root canal preparation than SS ones, which caused the rare number of SS mechanical instruments.

Gentlefile (GF, MedicNRG, Kibbutz Afikim, Israel), a unique SS rotary system with limited studies, has been proved to be more flexible than NiTi instruments [9]. The system consists of six files: one 18 mm coronal file (*GF gray*) and five 25 mm final files (*GF yellow*, *GF red*, *GF blue*, *GF green*, *GF black*). Each file is composed of three SS wires, which divide the file into a bi-layer-structure apical section and a three-layer-structure upper section, the taper of which varies between 3% and 4% [10], and its apical 0.5 mm edge

sharpened at a 45° angle results in a non-cutting passive tip. These instruments are connected by friction to a dedicated motor (Gentlefile Drive, Medic NRG) that automatically adjusts to load, operating at a maximum speed of 6500 rpm. High-speed rotation influences the intracanal fluid dynamics and increases effective irrigation [11]. GF instruments have been reported [12] to have great shaping and cleaning ability in oval canals, but that in the severely curved simulated canals is still lacking.

This study aimed to compare the shaping ability of PT F2, *GF red*, and *GF blue* in simulated curved canals. The null hypothesis was that there is no difference in the shaping ability of these instruments.

## Materials And Methods

### Selection of Samples

A total of 33 J-shaped simulated root canals in clear resin blocks were included. Each one had an initial 0.02 taper, 0.10 mm diameter at the apex, 17 mm working length, and 30° curvature angle. Given the fact that special apical sizes of Gentlefile, these root canals were divided equally into three different experimental groups to get comprehensive results: a basic preparation was performed up to *GF red* (#23) □ PT F2 (#25) □ *GF blue* (#26), respectively.

### Canal Instrumentation

All the root canals were prepared in one training model (Endo Training Model Castillo, VDW, Munich, Germany) which imitated human dentition to simulate the clinical environment. The curved part of each root canal was towards the mesial of the artificial dentition.

#### Group 1: *GF red*

According to the latest manufacturer's instructions [10], after instrumentation with a manual #10 K file (Dentsply Maillefer, Ballaigues, Switzerland), *GF grey* was inserted into the canals and activated using the Gentlefile Drive, applying inward action (pecking) [13] 5 times with very slight apical pressure for 5 seconds. Repeat the motions until the instrument reached 1 mm less than the working length. Then, *GF red* was chosen to proceed towards the working length (WL). Once *GF red* had prepared to the WL and rotated freely, it was removed from the canal.

#### Group 2: PT F2

Files were used with a 16:1 gear reduction handpiece powered by an electric and torque-controlled endodontic motor (X-Smart, Dentsply Maillefer, Ballaigues, Switzerland). According to the manufacturer's recommendations, S1, S2 were sequentially used at 300 rpm/3.0 N.cm and 300 rpm/1.0 N.cm until the instrument reached 1 mm less than the working length. Then, F1, F2 were rotated at 300 rpm/1.6 N.cm, 300 rpm/2.0 N.cm to the full WL, respectively. Outward action (brushing) [13] was performed 5 times for 5 seconds throughout the whole preparation. Once the instrument had prepared to the WL and rotated freely, it was removed from the canal.

Group 3:GF *blue*

We repeated the same conduction as in the Group 1. Then, *GF red* and *GF blue* were chosen to proceed towards the working length. Once *GF blue* had prepared to the WL and rotated freely, it was removed from the canal.

During canal preparation, irrigation was performed using 3 ml 0.9% NaCl solution before and after using each instrument. EDTA (GLYDE™ FILE PREP, Dentsply Maillefer, Ballaigues, Switzerland) was used as a lubricating agent.

## Image Processing and Data Collection

All the root canals were injected by black ink before and after preparation. The dental operating microscope (Leica m525 F20, Leica Camera AG, Solms, Germany) was used to capture the pre- and post-instrumentation images under the same parameters and positions. The two images of each root canal were superimposed into a composite image using a computer software program (Adobe Photoshop CC2018, Adobe Systems, San Jose, CA, USA). Layers of post-instrumentation were treated by using the “find edges” filter.

After calibration with the scale in the pictures, ten circles were drawn on the composite images by AutoCAD2010 (Autodesk, San Rafael, CA). Twenty points were chosen for analysis. The first two points were 1 mm away from the apical ending, and following points were located at 1-mm intervals. The last two were 10 mm from the apical stop, then connected the two points in each level and generated ten lines (Fig. 1). 0–3 mm from the apical foramen consisted the apical part, 4–6 mm represented the middle part, and 7–10 mm were the coronal part of the canal. Image J (National Institutes of Health, Bethesda, MD; public domain) was used to measure the amount of resin removed in the mesial and distal direction.

Transportation and Centering ratio, according to the following formulas, were considered as two important criteria of shaping ability. X1 and X2 were the resin removed from mesial and distal section during preparation, respectively. In the first formula, “0” indicated no transportation. whereas positive and negative values showed mesial and distal transportation, respectively. In the second formula, “1” indicated complete centering. The closer to the value 1, the stronger the centering ability. Canal aberration and instrument separation were also recorded.

Transportation =  $X1 - X2$

Centering ratio =  $X1/X2$  ( $X2 > X1$ ) OR  $X2/X1$  ( $X1 > X2$ )

## Data Analysis

Variables were expressed as the mean  $\pm$  standard deviation. Statistical analysis was performed with SPSS software 22.0 (SPSS Inc, Chicago, IL). Data were analyzed using Shapiro–Wilk test, Levene test, and one-way multivariate analysis of variance (ANOVA). The level of significance was set at 0.05.

## Results

### Aberration and instrument separation

The three groups were able to prepare continuous taper without aberration, but two cases of instrument separation occurred in GF *red* and GF *blue* groups (Table 1).

Table 1  
The frequency of each file used, the number of aberration and instrument separation occurred

	<b>ProTaper</b>	<b>Gentlefile Red</b>	<b>Gentlefile Blue</b>
Files	S1 S2 F1 F2	Grey Red	Grey Red Blue
Number of times used	11 11 11 11	11 11	11 11 11
Instrument separation	0 0 0 0	0 1	0 0 1
Aberration	0	0	0

### Transportation

The GF system caused significantly less transportation than PT F2 in the apical ( $P < 0.001$ ) and middle section ( $P < 0.001$ ). However, in the coronal preparation, there was no significant difference in transportation between the two systems ( $P = 0.057$ ). As for GF *red* and GF *blue*, no difference was found in root canal transportation at all three levels above ( $P > 0.05$ ) (Table 2).

Table 2  
Means and standard deviations of root canal transportation at different levels among the three instruments

Distance from apical stop(mm)	GF Red(mm)	PT F2(mm)	GF Blue(mm)
1	-0.013 ± 0.041 <sup>b</sup>	-0.059 ± 0.032 <sup>a</sup>	-0.013 ± 0.034 <sup>b</sup>
2	-0.006 ± 0.048 <sup>b</sup>	-0.087 ± 0.039 <sup>a</sup>	-0.020 ± 0.042 <sup>b</sup>
3	-0.005 ± 0.042 <sup>b</sup>	-0.106 ± 0.042 <sup>a</sup>	-0.015 ± 0.028 <sup>b</sup>
4	0.015 ± 0.036 <sup>a</sup>	-0.041 ± 0.077 <sup>a</sup>	0.018 ± 0.021 <sup>a</sup>
5	-0.034 ± 0.064 <sup>b</sup>	0.174 ± 0.094 <sup>a</sup>	0.034 ± 0.036 <sup>b</sup>
6	-0.001 ± 0.071 <sup>b</sup>	0.305 ± 0.101 <sup>a</sup>	-0.025 ± 0.056 <sup>b</sup>
7	-0.002 ± 0.077 <sup>b</sup>	0.224 ± 0.127 <sup>a</sup>	-0.012 ± 0.070 <sup>b</sup>
8	-0.026 ± 0.055 <sup>a</sup>	0.068 ± 0.132 <sup>a</sup>	-0.013 ± 0.037 <sup>a</sup>
9	-0.011 ± 0.046 <sup>a</sup>	-0.041 ± 0.112 <sup>a</sup>	0.007 ± 0.036 <sup>a</sup>
10	-0.002 ± 0.099 <sup>a</sup>	-0.075 ± 0.095 <sup>a</sup>	0.028 ± 0.08 <sup>a</sup>
Apical	-0.008 ± 0.042 <sup>b</sup>	-0.084 ± 0.042 <sup>a</sup>	-0.016 ± 0.034 <sup>b</sup>
Middle	-0.016 ± 0.059 <sup>b</sup>	0.146 ± 0.170 <sup>a</sup>	-0.026 ± 0.040 <sup>b</sup>
Coronal	-0.010 ± 0.070 <sup>a</sup>	0.044 ± 0.163 <sup>a</sup>	0.001 ± 0.060 <sup>a</sup>

Positive values represented canal transportation toward the mesial side and negative values toward the distal side of the canals. Values with the same superscript letters were not statistically different at  $P = 0.05$  (multivariate analysis of variance).

## Centering ratio

Better centering ability of GF system was shown in all three sections of the root canal, but there was no difference between GF *red* and GF *blue* ( $P > 0.05$ ) (Table 3).

Table 3  
Means and standard deviations of centering ratio at different levels among the three instruments

Distance from apical stop(mm)	GF Red	PT F2	GF Blue
1	0.672 ± 0.211 <sup>a</sup>	0.612 ± 0.196 <sup>a</sup>	0.705 ± 0.155 <sup>a</sup>
2	0.687 ± 0.173 <sup>a</sup>	0.564 ± 0.164 <sup>a</sup>	0.650 ± 0.162 <sup>a</sup>
3	0.731 ± 0.112 <sup>b</sup>	0.567 ± 0.145 <sup>a</sup>	0.744 ± 0.083 <sup>b</sup>
4	0.776 ± 0.156 <sup>a</sup>	0.721 ± 0.133 <sup>a</sup>	0.792 ± 0.074 <sup>a</sup>
5	0.706 ± 0.209 <sup>a</sup>	0.556 ± 0.189 <sup>a</sup>	0.725 ± 0.201 <sup>a</sup>
6	0.706 ± 0.105 <sup>b</sup>	0.359 ± 0.155 <sup>a</sup>	0.744 ± 0.192 <sup>b</sup>
7	0.728 ± 0.112 <sup>b</sup>	0.493 ± 0.233 <sup>a</sup>	0.710 ± 0.126 <sup>b</sup>
8	0.852 ± 0.115 <sup>a</sup>	0.717 ± 0.215 <sup>a</sup>	0.858 ± 0.104 <sup>a</sup>
9	0.887 ± 0.115 <sup>b</sup>	0.734 ± 0.116 <sup>a</sup>	0.916 ± 0.106 <sup>b</sup>
10	0.700 ± 0.262 <sup>a</sup>	0.758 ± 0.130 <sup>a</sup>	0.784 ± 0.179 <sup>a</sup>
Apical	0.697 ± 0.166 <sup>b</sup>	0.582 ± 0.170 <sup>a</sup>	0.697 ± 0.140 <sup>b</sup>
Middle	0.729 ± 0.160 <sup>b</sup>	0.545 ± 0.216 <sup>a</sup>	0.754 ± 0.163 <sup>b</sup>
Coronal	0.792 ± 0.177 <sup>b</sup>	0.676 ± 0.205 <sup>a</sup>	0.817 ± 0.136 <sup>b</sup>

## Discussion

The preparation of curved root canals has always been a challenge. Many studies [14–16] have showed that canal curvature results in an increased risk of canal transportation and instrument fracture, which leads to the failure of root canal therapy. Unfortunately, around 84% human teeth have clinically noticeable root canal curvatures [17]. It is well-known that NiTi instruments are superior to SS ones in shaping the narrow and curved canals.

However, several of the recent studies [9, 12] indicated that, as a unique rotary system made from SS, GF was more flexible and prepared better for oval root canals than some of the NiTi instruments, and our study showed the GF system was also more centered and less transported than PT in the middle and apical sections of the narrow and curved root canals. This finding is consistent with that of Moreinos [9] who reported that GF files created less vertical force on bent canals.

There is a large volume of published studies [18, 19] describing the threat of root canal transportation. Once canal transportation scores exceed 0.15 mm, the possibility of preparation failure will increase. Excessive transportation results in unreliable canal walls—one side of canals could not be completely cleaned, while the other side remains thin dentin, which will lead to a series of complications such as perforation, root fracture, periapical periodontitis, and so on [20, 21]. The instrumentation of PT F2 in 5–7 mm in our study seemed to be riskier than GF on account of their excessive results at these levels (average transportation value is 0.174, 0.305, 0.224, respectively), obvious transportation even can be observed in the middle section (Fig. 2).

The results seemed that PT is not suitable for narrow and severely curved canals. In addition to the curvature mentioned above, two other possible reasons are the big taper and brushing movement of PT system. PT F2 is a multi-taper instrument, the maximum taper can reach 0.08, which means that, compared with GF system, more dentin needs to be removed to achieve the same shaping effect and several reports [22, 23] have shown that 0.06 or smaller taper is enough for mechanical debridement. Furthermore, brushing motion [24] has been proved to be more aggressive but safer than pecking. Multiplying the number of unidirectional brushing strokes will lead to significant cutting of the canal wall and result in unnecessary root canal enlargement in one direction [24].

However, in the present study, two cases of instrument separation occurred in GF groups. This outcome was contrary to that of Moreinos [9] who found GF files have greater resistance to cyclic fatigue than NiTi files. It is worth mentioning that resin materials have some limitations in simulating human teeth preparation, especially under high rotation speed. Although plastic blocks make it possible to standardize and visualize samples and the credibility of resin blocks as an experimental model for the analysis of preparation effect has been proved [25], due to the difference of hardness, preparation in simulated root canals would generate much heat, which might soften the resin material and increase the risk of fracture, especially at a speed of nearly 6500 rpm in GF groups. Thus, it is necessary to take further studies in extracted teeth with curved root canals.

Interestingly, there occurred a new mode of instrument separation in the present study. The separated file was just like a ring in the canal, thus it was hollow so that other instruments can insert into the canal and take it out easily (Fig. 3). The reason for this is not clear but it may have something to do with its coiling method of the three SS wires.

## Conclusions

Under the limitations of this study, GF files, with the new concept of preparation, showed better shaping ability than PT F2, except the centering ability in the coronal section of simulated curved root canals. However, because of the different hardness of resin and dentin, further studies should be undertaken in extracted teeth.

## Abbreviations

ANOVA

Analysis of variance; EDTA:Ethylene di-amin tetra-acetic acid; GF:Gentlefile; NiTi:Nickel-titanium; PT:ProTaper; SS:Stainless-steel; WL:Working length.

## Declarations

### Ethics approval and consent to participate

Not applicable

### Consent for publication

Not applicable

### Availability of data and materials

The data supporting the results reported in this manuscript can be provided upon request to the journal by the authors.

### Competing interests

The authors declare that they have no competing interests.

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### Authors' contributions

XX and JY participated in the design of this study, and they both collected important background information. XX performed the study and statistical analysis, he also drafted the manuscript. And JY revised the manuscript. They both approved the final manuscript.

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Not applicable

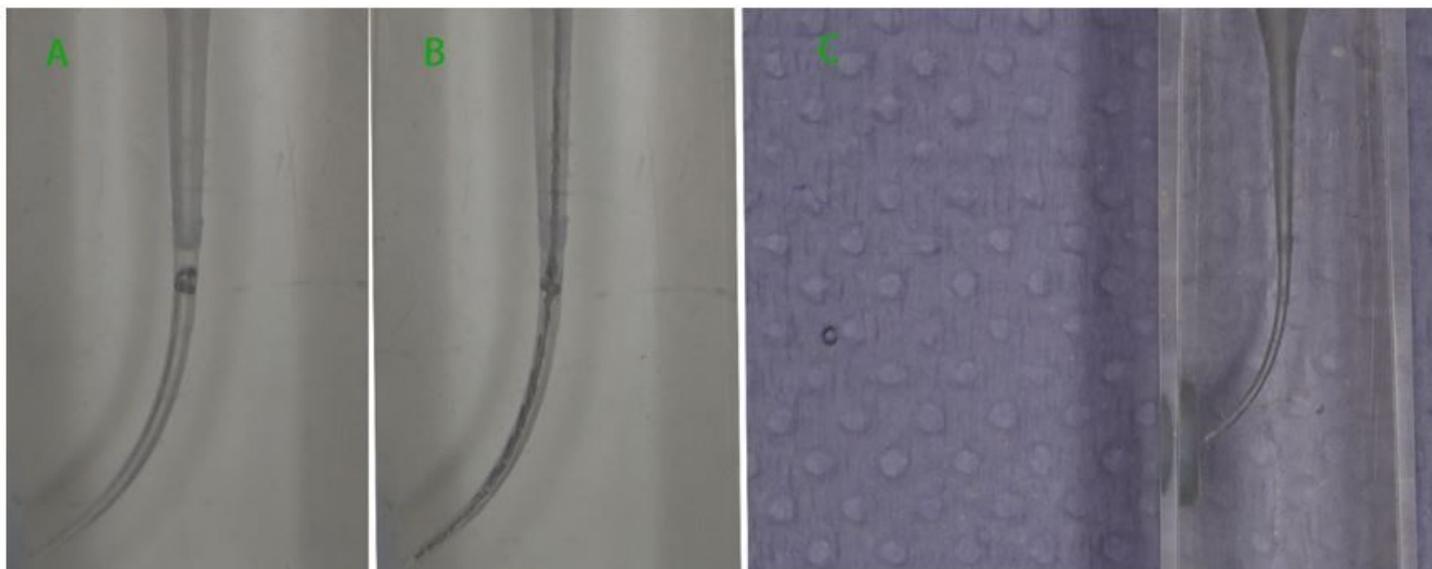
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## Figures



### Figure 3

Instrument separation of Gentlefile. A. Part of GF Red in simulated root canal; B. #15 H file inserted into the root canal; C. Separated part of Gentlefile and the root canal after taking out the separated part.