Comparison of the shaping ability of Twisted Files with ProTaper and RevoS nickel-titanium instruments in simulated canals

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Abstract  Background/purpose: The manufacturer claims that Twisted Files (TFs) are superior to file systems made by the traditional grinding method due to their cyclic fatigue resistance, flexibility, and better cutting efficiency. The aim of this study was to compare the shaping ability of TFs with instruments produced by a traditional NiTi grinding process (RevoS and ProTaper).

Materials and methods: A total of 60 simulated resin blocks were divided into three experimental groups, each comprised of 20 resin blocks that were prepared with TFs, RevoS, and ProTaper using a crown-down technique. The preparation shape was assessed with a computer image analysis program on superimposed pre- and postoperative images. Material removal was measured at 10 points beginning 1 mm from the end-point of the canal. Mean total widths and outer and inner width measurements were determined on each central canal path, and the data were statistically analyzed using the Kruskal-Wallis and Mann-Whitney U-tests.

Results: The Revo-S and ProTaper instruments removed more material from the inner side of the curvature compared with the TF instruments. Differences among the three rotary NiTi systems were statistically significant (P < 0.05) except for the first 3 mm and the last 2 mm. On the outer side of the canal, both the ProTaper and Revo-S instruments removed more material than the TF instruments in the apical third (P < 0.05).

Conclusion: According to the results of this study, TFs respected the original canal curvature better than did ProTaper and RevoS rotary NiTi instruments. TF instruments also provided a more-centered apical preparation of the simulated canals at the apical third.

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Introduction

Success in root-canal treatment depends almost completely on how well the root canal is shaped and cleaned, and there have been many developments in recent years in this aspect of endodontic practice. Although many advances have been made in both scientific and technologic aspects of endodontics, the basic principles of root-canal preparation remain unchanged: removing all organic debris and microorganisms from the root-canal system and shaping the walls of the root canal to facilitate cleaning and obturation of the root-canal space.

Nickel-titanium (NiTi) rotary instruments have substantially reduced the incidence of several clinical problems such as blocks, ledges, transportation, and perforation. The shaping ability of rotary NiTi instruments was extensively studied in the endodontic literature. A number of studies reported the superiority of rotary NiTi instruments over stainless steel hand files, documenting that they were better at maintaining the original canal curvature. The shaping ability of different rotary NiTi instruments was also compared according to their design features such as taper (progressive vs. constant) and cross-sectional design.

Since the introduction of NiTi rotary instruments to endodontics, there have been many changes in instrument design to improve flexibility, cyclic fatigue resistance, and cutting and cleaning efficiencies. Recently, Twisted Files (TFs) manufactured by SybronEndo (Orange, CA, USA), were introduced and are produced using a new manufacturing process. TF instruments are manufactured using a raw NiTi wire in an austenite crystalline structure that transforms into a different phase (R-phase) by a process of heating and cooling. In the R-phase, NiTi can be twisted and converted back to an austenite structure by heating and cooling again. The manufacturer claims that TFs are superior to file systems manufactured by the traditional grinding method due to their cyclic fatigue resistance, flexibility, and better cutting efficiency, and the fact that they maintain the original canal shape with minimal transportation (TF Technical Bulletin, Sybron Endo).

Materials and methods

A total of 60 simulated root canal blocks (Endo Training Bloc-.02 Taper, Dentsply Maillefer) made of clear polyester resin were used in the present study. The diameter and taper of all simulated canals were equivalent to a size-15 root-canal instrument. The canals were 16 mm long, and the canal entrance was 13 mm from the apex. The canals had a straight part of 5 mm and a curved part of 8 mm.

The canals were randomly divided into three groups. The blocks were labeled 1–20 in each group, and a vertical and a horizontal line were prepared on the surface of each resin block, then the resin root canals were mounted in a setup and photographed with a digital camera (Pentax K200D with a 105-mm macro lens, Hoya, Tokyo, Japan) before preparation.

The simulated canals were prepared using TFs, ProTaper (Dentsply Maillefer), and Revo-S (Micro-Mega) with an X-Smart (Dentsply Maillefer) torque-limited electric motor and a 16:1 reduction rotary handpiece at the speed of rotation recommended by the manufacturers. All of the canals were enlarged by the same operator who was experienced with all three systems. The canals were prepared to a working length (WL) of 16 mm. Before use, each instrument was coated with a lubricant (Glyde, Dentsply), and distilled water was used for irrigation. Once the instrument reached the WL and rotated freely, it was removed. Each instrument was used to enlarge five canals and then discarded.

Group 1

TF instruments were used in a crown-down manner at a speed of 500 rpm as recommended by the manufacturer.
A small assorted pack (25.08, 25.06, and 25.04), which was recommended for shaping mesial roots of lower molars and buccal roots of upper molars, was used. The working sequence was as follows: a 10, K-File was used to create a guide path; an 8% taper, size-25 instrument was used at 2/3 of the WL (11 mm); a 6% taper, size-25 instrument was used at 13 mm; and a 4% taper, size-25 instrument was used at the full WL (16 mm).

**Group 2**

Revo-S instruments were used in a crown-down manner at a speed of 350 rpm. The operating sequence was as follows: a 10, K-File was used to create a guide path; a 6% taper, size-25 instrument (SC1) was used to 2/3 of the WL (11 mm); a 4% taper, size-25 instrument (SC2) was used to the full WL (16 mm); a 6% taper, size-25 instrument (SU) was used to the full WL (16 mm).

**Group 3**

ProTaper instruments were used in a crown-down manner at a speed of 350 rpm, and the sequence was as follows: a 10, K-File was used to create a guide path; an S1 file was used to 2/3 of the WL (11 mm); an SX file was used to 2/3 of the WL (11 mm); an S1 file was used to the full WL (16 mm); an S2 file was used to the full WL (16 mm); an F1 file was used to the full WL (16 mm); and an F2 file was used to the full WL (16 mm).

After instrumentation, a digital photograph was taken in the same orientation as the pre-instrumentation one (Fig. 2). The prepared canal shapes were assessed with the computer program, Image J 1.38 (National Institutes of Health, Washington, DC, USA). A composite image was produced from pre- and post-instrumentation images of each canal, and superimposed using Adobe Photoshop software (Adobe Systems, Inc., vers. 8.0, San Jose, CA, USA). Superimposition was aided by vertical and horizontal lines that were prepared on each block before preparation. The amounts of resin removed from both the inner and outer sides of the canal curvature were measured in 1-mm steps (Fig. 3). The first measuring point began 1 mm from the endpoint of the canal, and the last measuring point was 10 mm from the apical end, resulting in 10 measuring points on the outer and inner sides of the canal, for a total of 20 measuring points. The mean total width, and outer and inner width measurements were determined for each central canal path. The distance between the canal wall before and after instrumentation was measured to ±0.001 mm. All data were recorded, and the collected data were statistically analyzed with Kruskal-Wallis and Mann-Whitney U-tests using SPSS, version 15.0 (SPSS, Chicago, IL, USA). This was because the data did not show a normal distribution for some measuring points.

The centering ability was assessed by dividing the amounts of resin removed at the inner and outer walls from that removed on the opposite wall; a lower value was considered the numerator of the ratio. According to this, values closer to "1" indicate a better centering ability. A one-way analysis of variance (ANOVA) and Tukey’s honest significant difference tests were performed to find any significant differences between groups.

**Results**

Mean widths of the resin removed from the inner and outer sides of the canal are shown in Table 1. The Revo-S and ProTaper instruments removed more material from the inner side of the curvature than did TF instruments. Differences among the three rotary NiTi systems were statistically significant (P < 0.05) except for the first 3 mm and the last 2 mm.

On the outer side of the canal, both the ProTaper and Revo-S instruments removed more material than did TF instruments at the apical third, and the difference was statistically significant (P < 0.05). In the middle and coronal aspects of the canal, TF instruments removed less resin material than did the ProTaper and the Revo-S instruments, and the difference was statistically significant except for measuring points 6, 9, and 10 mm from the apex (P < 0.05).

![Figure 2](image_url)  
*Figure 2*  Postoperative images for the three experimental groups.
The ProTaper and Revo-S instruments removed similar amounts of resin material in the middle and coronal aspects of the canal wall with no significant difference.

Table 2 shows the mean centering ratios for the TF, Revo-S, and ProTaper rotary NiTi systems. TF instruments showed a better centering ability at the apical third and 4 mm from the apex, and the difference was statistically significant ($P < 0.05$). In the middle and coronal sections of the canals, there were no significant differences in the centering abilities among the three rotary NiTi systems ($P > 0.05$).

Discussion

NiTi rotary instruments are very important in endodontics because of their ability to shape root canals with fewer complications. After concluding that rotary NiTi instruments maintained the original canal curvature better than stainless steel hand instruments, particularly in the apical region of the root canal, studies compared the shaping ability of different rotary NiTi systems with different designs.

Table 1 shows the mean material removed (mm) and SD at different measuring points after instrumentation of simulated canals.

<table>
<thead>
<tr>
<th>Inner canal wall (mm from the apex)</th>
<th>Outer canal wall (mm from the apex)</th>
<th>TF Mean</th>
<th>TF SD</th>
<th>RevoS Mean</th>
<th>RevoS SD</th>
<th>ProTaper Mean</th>
<th>ProTaper SD</th>
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<td>0.152</td>
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<td>0.152</td>
<td>0.066</td>
<td>0.06</td>
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<td>0.058</td>
<td>0.153</td>
<td>0.075</td>
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<td>0.155</td>
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</table>

SD = standard deviation; TF = Twisted Files. a,b,c: There are no significant differences between the groups with the same letters.

![Figure 3](image.composite)
Shaping ability of rotary NiTi instruments

In previous studies, two experimental models were usually preferred: simulated canals vs. extracted teeth. Using extracted teeth has an advantage over resin blocks because they provide conditions closer to clinical situations. On the other hand, using simulated canals as an experimental model allows assessment of outcomes of canal shaping and instrument performance under standardized conditions. Simulated canals allow standardization of the root-canal diameter and length, and radius of the canal curvature. They also provide reproducible hardness and abrasion characteristics.

However, there are some drawbacks when using rotary NiTi instruments in resin blocks. The hardness and abrasion behavior of acrylic resin and root dentin are not identical, and the heat generated may soften the resin material. Although the hardness and abrasion behaviors of resin canals are a disadvantage, they allow standardization of the root-canal morphology and eliminate the great variability encountered in root-canal anatomy. Because the aim of this study was to compare the shaping ability of rotary NiTi instruments produced by different manufacturing methods, simulated canals in clear resin blocks were used to provide strictly controlled laboratory conditions.

Compared with TF instruments, ProTaper and Revo-S removed more material from the outer canal wall. This was also true for the inner side of the canal wall, except for the apical third and the last 2 mm of the coronal aspect. Previous studies also reported that varying degrees of canal straightening and transportation toward the outer aspect of the canal curvature occurred with ProTaper instruments. Canal transportation toward the outer aspect of the canal with ProTaper was related to their progressive tapers along the cutting surface of the instruments in combination with the sharp cutting edges of their cross-sectional design. Revo-S instruments also removed more resin material from the outside of the curvature than did TF instruments. These instruments have a constant taper with an asymmetrical cross-section. The canal axis has three cutting edges located on three different radii. TF instruments also have a triangular cross-section with a constant taper. While non-landed, ground-fluted instruments with aggressive cutting action have more difficulty negotiating a curvature and increase the risk of ledging or transportation, the manufacturer states that R-phase technology overcomes this by giving the instrument a much higher level of flexibility. The better results of TF instruments for shaping resin canals may be related to their different manufacturing methods. Our results were consistent with a recent report that found that TF instruments produced significantly less transportation and remained centered around the original canal.

When comparing the shaping ability of different root-canal instruments, it is important that they have similar apical preparation diameters. In the present study, the final apical preparation sizes were 25 for all groups, but the final apical taper differed for each group because we followed the sequences recommended by the manufacturers. The difference in the operation protocol may have introduced a significant bias. For TFs, the final apical size was 25.04, whereas the apical file was 25.06 for RevoS, and it was F2 for ProTaper. Thus, larger files with a significantly higher metal mass in the core reduce the flexibility and could explain the lower apical transportation witnessed with TFs. Furthermore, larger instruments predictably remove more dentin which could have affected the results.

Overinstrumentation of the curved section of a canal may leave infected dentin on canal walls while removing valuable dentin. Aydin and colleagues reported that preparation with an instrumentation technique designed to remove substantial amounts of dentin did not reduce intracanal bacteria more effectively than a conservative instrumentation technique. An irregular apical preparation may also negatively affect the apical sealing ability of the root filling.

In conclusion, ProTaper and RevoS instruments removed more resin material from the outside of the curvature than did TF instruments. On the inner canal wall, they also removed more material from the middle and coronal third, except for the last 2 mm from the apex. TF instruments provided a centered apical preparation of the simulated canals and maintained the original canal better. However, further studies using extracted teeth should be conducted to confirm the results of the present study.

Table 2 Centering ability (mean ± SD).

<table>
<thead>
<tr>
<th></th>
<th>Measuring point from the apex (mm)</th>
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</thead>
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<tr>
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<td>TF</td>
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<tr>
<td>Mean</td>
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<tr>
<td>SD</td>
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<tr>
<td>Revo-S</td>
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<td>Mean</td>
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</tr>
<tr>
<td>SD</td>
<td>0.25</td>
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<tr>
<td>ProTaper</td>
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<tr>
<td>Mean</td>
<td>0.61</td>
</tr>
<tr>
<td>SD</td>
<td>0.20</td>
</tr>
</tbody>
</table>

P value 0.05 0.05 0.05 0.05 0.48 0.08 0.97 0.92 0.86 0.99

Values closer to "1" indicates better centering ability.

SD = standard deviation; TF = Twisted Files.
References