Efficacy of Two Rotary NiTi Instruments in the Removal of Gutta-Percha During Root Canal Retreatment

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Abstract
The aim of this study was to evaluate the efficacy of ProTaper and K3 in the removal of gutta-percha during root canal retreatment in comparison with hand Hedstrom files. Time of gutta-percha removal and amount of apically extruded debris were also evaluated. Sixty extracted single-rooted anterior teeth and premolars were instrumented and obturated with laterally condensed gutta-percha technique. The teeth were cleared and randomly divided into three groups of 20 teeth each. The roots were split longitudinally, digital images were created using a scanner, and the areas of remaining filling material were traced using Ulead Photoimpact7 then calculated using SigmaScan software. The results indicated that the two rotary nickel-titanium instruments left significantly less remaining filling material than hand instruments (p < 0.001). The ProTaper and K3 required significantly less time for filling material removal than hand instruments (p < 0.001). There was no statistically significant difference among the three techniques regarding the amount of apically extruded debris (p = 0.159). In conclusion, ProTaper and K3 were found to be effective and faster in removing gutta-percha. (J Endod 2007;33:38–41)

Key Words
Gutta-percha, hand Hedstrom files, K3, ProTaper, root canal treatment, rotary NiTi instruments

Root canal therapy, despite having a high degree of success, may not lead to the desired response, and failure may occur (1–5). When root canal therapy fails, treatment options include conventional retreatment, peri-radicular surgery, or extraction. Whenever possible, the retreatment option is preferred because it is the most conservative method to solve the problem (6). The main goal of retreatment is to regain access to the apical foramen by complete removal of the root canal filling material, thereby facilitating sufficient cleaning and shaping of the root canal system and final proper obturation (7, 8). Prognostic studies have indicated that endodontic surgery or extraction could be avoided by conventional retreatment (1, 5). Gutta-percha removal can be achieved by several methods. One of these methods is the chemical technique, using different types of solvents, such as chloroform, eucalyptol, xylene, halothane, turpentine, or orange solvent, in combination with K-type or Hedstrom files (5, 9–14). Care should be taken to avoid forcing the softened gutta-percha or solvent through the apical foramen to avoid peri-radicular tissue irritation (11, 15–17). Other methods of gutta-percha removal include removing the coronal portion of gutta-percha using Gates Glidden or heat pluggers (4, 18), then the rest can be removed by an ultrasonic technique (19, 20). Additionally, rotary instruments can also be used, such as the inflexible GPX burs (18, 21), the canal finder (22–24), or one of the recent flexible rotary nickel-titanium (NiTi) files in a slow-speed handpiece (25, 26).

Two new designs of flexible rotary NiTi instruments were recently introduced, the ProTaper and K3. These instruments are commonly used in endodontic treatment for cleaning and shaping of root canals. ProTaper files are characterized by progressively increasing tapers, a convex triangular cross-section, and a modified guiding tip. On the other hand, K3 is a triple-fluted file with asymmetrical cross-section in combination with radial land relief, negative rake angle, and constant taper (26, 27). Review of the literature revealed that only a few studies investigated the effectiveness of these new files in the removal of gutta-percha during endodontic retreatment. Hulsmann and Bluhm (25) demonstrated that ProTaper proved to be efficient and time saving for the removal of gutta-percha compared with Hedstrom. On the other hand, Masierno and Barletta (26) evaluated various techniques for removing gutta-percha from root canals using K-type files, M4 system with K-type files, and Endo-gripper with K-type files in comparison with K3, and they concluded that there were no significant differences between these methods of removal when the entire canal was evaluated. Furthermore, Schirmeister et al. (28, 29) showed no difference between the ProTaper and hand instrumentation in gutta-percha removal in straight and curved root canals.

The aim of this in vitro investigation was to evaluate the efficacy of two rotary NiTi instruments, the ProTaper and the K3, in the removal of gutta-percha during root canal retreatment in comparison with hand instruments using Hedstrom files. The time of gutta-percha removal and the amount of apically extruded debris were also recorded and evaluated.

Materials and Methods
Sixty extracted single-rooted anterior teeth and premolars were selected for this study. After access cavity preparation, apical patency was confirmed with a size 15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) extending 1 mm beyond the point at which it was first visible. Working length was established 1 mm shorter than the length at which a size 15 K-file was visualized at the apical foramen. The cervical and middle thirds of all teeth were enlarged with size 1, 2, and 3 Gates Glidden (Dentsply Maillefer). The apical
thirds were prepared in a modified step-back technique using ProFile 0.04 taper (Dentsply Maillefer). The master apical file was size 40 at the working length for all teeth.

The root canals were dried with paper points (Meta Dental Co. Ltd., Korea) and obturated with laterally compacted gutta-percha (Sure-Endo, Sure Dent Corp., Seoul, Korea) and AH-26 (Dentsply, Germany) sealer cement that was mixed according to the manufacturer’s instructions. Regardless of the working length of each tooth, the extension of the root canal filling was uniformly limited to 15 mm from the apical extension of the filling so that the volume of the gutta-percha was as equal as possible for all teeth. The teeth were sealed with a cotton pellet and Cavit (ESPE, Germany). The teeth were then stored in 100% humidity at 37°C for 7 days to allow the sealer to set.

The teeth were secured for retreatment and debris collection using a modification of the technique described by Hulsmann and Stotz (21). The teeth were mounted using an orthodontic resin (DeguDent, Germany) in a standardized method in which the coronal and apical 6 mm were not covered by the resin; the part of the tooth covered with the resin was 10 mm for all specimens. During retreatment, the mounted tooth was placed on a round copper base having a groove (24 mm in diameter and 1 mm in depth) allowing the seating of the specimen. When the specimen was seated on the copper base, the apical 6 mm of the root fit into a specially designed hole in the center of the base (10 mm in diameter and 9 mm deep) in which an aluminum crown, preweighted using a digital scale (Precisa 180A, PAG Oerlikon AG, Zurich, Switzerland), was placed to collect the apically extruded materials.

The teeth were then coded and randomly divided for retreatment into three groups of 20 specimens each. Cavit and cotton pellets were removed to open the root canals. Gutta-percha was then removed using size 25 to 40 Hedstrom files in a reaming motion. These specimens served as the control group.

Group 2: ProTaper NiTi rotary instruments (Dentsply Maillefer) in an electric motor (TCM Endo; Nouvag, Goldach, Switzerland), with a constant speed of 300 r.p.m. As suggested by the manufacturer, the gutta-percha was removed by the following sequence using light apical pressure: Finishing files #3 (ISO size 30, taper 0.09-0.05), #2 (ISO size 25, taper 0.08-0.055), and #1 (ISO size 20, taper 0.07-0.055) were used in a crown-down technique to remove the gutta-percha until the working length was reached. Finishing files #2 and #3 were used again to the working length to complete gutta-percha removal and cleaning of the canal walls.

Group 3: K3 NiTi rotary instruments (SybronEndo, West Collins, CA) with the electric motor (TCM Endo; Nouvag, Goldach, Switzerland) at a constant speed of 300 r.p.m. K3 instruments were used with a light apical pressure using the following sequence: Size 25 (taper 0.10), size 25 (0.08 taper), and size 20 (0.06 taper) in a crown-down technique to remove the gutta-percha until the working length was reached. Completion of gutta-percha removal and cleaning of canal walls was done using size 25 (0.06 taper) followed by size 30 (0.06 taper) to the working length.

Gutta-percha removal was judged complete when the working length was reached and no more gutta-percha could be seen on the last instrument used in each group. The time of gutta-percha removal was recorded to the nearest second, from the start of gutta-percha removal to the point where retreatment was considered complete.

At the end of the experiment, the mounted teeth were taken out of the copper base. Subsequently, the aluminum crowns were taken out and reweighed using the digital scale to calculate the amount of apically extruded material if present. This calculation was achieved by subtracting the weight of the aluminum crown from the combined weight of the aluminum crown and debris. The coronal parts were cut at their junction with the mounting resin blocks to have root sections of equal length (16 mm each).

The orthodontic resin block was removed using diamond disks and forcesps. The roots were grooved longitudinally, into two halves with a diamond disk and then split with a chisel. Each half was divided into coronal, middle, and apical thirds. Each half of the root was photographed using a flat-bed scanner (Hewlett Packard, ScanJet 3970) with a standardized brightness and contrast at a resolution of 2400 DPI. The scanned images were evaluated using the SigmaScan software (Jandel Scientific, San Rafael, CA).

By using the trace feature of the Ulead Photoimpact7 software (Ulead Systems, Inc.), the area of the whole canal, the area of each third, and the remaining filling materials in the whole canal and in each third were traced. No attempt was made to distinguish between the gutta-percha and sealer. The images of traced canal area and the remaining filling material were overlaid and transferred to SigmaScan software to calculate the area of the canal and the remaining filling material (in millimeters). The ratio of the remaining filling materials to the whole canal and to each third was calculated.

**Statistical Analysis**

The percentage of remaining filling material, the mean time of gutta-percha removal, and the weight of apically extruded debris were statistically evaluated for all groups. Parametric one-way analysis of variance (ANOVA) test was used to identify significant differences among the three techniques. Tukey’s post hoc multiple range test was used to determine which groups were significantly different. The significance level was set at $p < 0.05$.

**Results**

All retreatment techniques used in this study left some filling material inside the root canal. When the whole root canal was considered, the two rotary NiTi instruments performed better than hand instruments. The mean ratio of remaining filling material (mean ± SD) in the whole canal was less with the ProTaper (5.07 ± 3.77) and K3 (3.56 ± 3.49) compared with hand instruments (10.24 ± 4.87); the difference was statistically significant ($p < 0.001$). The difference between the ProTaper and K3 was not statistically significant ($p = 0.97$).

Descriptive analyses of the three techniques showing the mean values for each third are presented in Table 1. In the hand-instrument technique, the remaining filling material was significantly less in the apical third than in the middle and coronal thirds.

<table>
<thead>
<tr>
<th>Technique</th>
<th>N</th>
<th>Region</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand</td>
<td>20</td>
<td>Apical</td>
<td>15.89 ± 10.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle</td>
<td>11.32 ± 5.94</td>
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<tr>
<td></td>
<td></td>
<td>Coronal</td>
<td>4.50 ± 3.51</td>
</tr>
<tr>
<td>ProTaper</td>
<td>20</td>
<td>Apical</td>
<td>7.81 ± 5.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle</td>
<td>5.53 ± 3.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coronal</td>
<td>2.78 ± 1.79</td>
</tr>
<tr>
<td>K3</td>
<td>20</td>
<td>Apical</td>
<td>8.07 ± 5.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle</td>
<td>5.73 ± 3.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coronal</td>
<td>3.10 ± 2.24</td>
</tr>
</tbody>
</table>

By using the trace feature of the Ulead Photoimpact7 software (Ulead Systems, Inc.), the area of the whole canal, the area of each third, and the remaining filling materials in the whole canal and in each third were traced. No attempt was made to distinguish between the gutta-percha and sealer. The images of traced canal area and the remaining filling material were overlaid and transferred to SigmaScan software to calculate the area of the canal and the remaining filling material (in millimeters). The ratio of the remaining filling materials to the whole canal and to each third was calculated.

**Table 1. Remaining filling material in each third of the canal (expressed as percentage of area of each third) for each technique**
coronal third than in the apical third (p < 0.001) and also the middle third (p < 0.01). In the ProTaper technique, the coronal third showed significantly less remaining filling material than the apical third (p < 0.001). Furthermore, in the K3 technique, the analysis showed that the remaining filling material was significantly less in the coronal third than in the apical third (p < 0.001).

Regarding differences in the mean ratio values between the three techniques in each third, there was a significant difference among techniques in the apical third (p < 0.001) and in the middle third (p < 0.001). In the apical and middle thirds, ProTaper and K3 left significantly less remaining filling material compared with the hand instruments (p = 0.005). However, in the coronal third, there was no significant difference (p = 0.08) among the three groups.

Table 2 shows the mean time needed to remove the filling material using each of the three different retreatment techniques. Parametric one-way ANOVA test showed that there was a significant difference (p < 0.001) among groups. ProTaper and K3 required significantly less time for filling material removal than hand instruments. On the other hand, there was no significant difference in the mean time of gutta-percha removal between the groups retreated with K3 or retreated with ProTaper (p = 0.9).

All the retreatment techniques caused extrusion of apical debris. The mean weight of apically extruded debris in grams caused by each of the three retreatment techniques is presented in Table 3. One-way ANOVA analysis showed no significant difference (p = 0.159) in the amount of apically extruded debris among the three retreatment techniques.

Discussion

Endodontic retreatment has largely replaced periradicular surgery for the management of failed root canal treatment (6, 8). It is important to remove as much sealer and gutta-percha as possible during retreatment to uncover remnants of necrotic tissues or bacteria that might be responsible for endodontic failure (1, 4, 15). In the current study, all retreatment techniques left remaining filling material inside the canal. This finding confirms previous results reported by numerous investigators using different retreatment instruments, techniques, and solvents (9–14, 18–25, 29). Furthermore, the findings of the present investigation showed the two rotary NiTi instruments, the ProTaper and K3, to be significantly more effective in removing gutta-percha from root canals compared to Hedstrom files. Similar results were reported by a previous study that demonstrated the efficacy of ProTaper in retreatment, especially in the coronal and middle thirds, compared with Hedstrom files (25). However, in that study Hedstrom files showed better performance than ProTaper in the apical third, whereas in our study the ProTaper performed better than Hedstrom files in the apical third. This disagreement may be attributed to the fact that in that study, the Hedstrom files that were used to remove the gutta-percha were two sizes larger than the master apical file and were used with an uncontrolled amount of solvent, compared to using the same final retreatment Hedstrom file size as the master apical file size and using a definite amount of solvent in the present study. Whereas K3 was found in one study to be fast and efficient in removing root canal filling materials (30), other investigators reported different findings in which there was no significant difference between either K3 or ProTaper and a number of other instruments, including K-type files (26, 28, 29). This discrepancy with the latter studies could be attributed to differences in obturation technique, difference in retreatment methods, and limitations of the evaluation protocol used in their work.

In the current study, retreatment was performed in significantly less time using the two rotary instruments compared to Hedstrom files. This result was in accordance with a previous study comparing the ProTaper with Hedstrom files (25). Moreover, in the present investigation the amount of apically extruded debris was less when compared with that of the Hedstrom files; however, this difference was not statistically significant. This finding was similar to that reported by many investigators regardless of the method used for evaluation and indicating that rotary instruments tend to direct the debris coronally rather than apically (31, 32). In addition, the apically directed pressure used to facilitate file and solvent penetration may have contributed to the amount of apically extruded debris. This debris may cause irritation to the periradicular tissues and disturb healing (11, 15–17). In addition, chloroform was used to assist, with files, in the removal of gutta-percha from the root canals. Chloroform has been shown to be the most effective solvent when compared with other solvents. However, it causes damage to the periradicular tissues if it leaks out of the root canal system (9, 12–14). In the current study, the use of chloroform was controlled to simulate the clinical situation. Finally, the evaluation of remaining filling material was performed by calculating the percentage of debris in the whole canal and in each third relative to the total canal area and to the area of each third. This method appears to be effective and supports previous studies performed by numerous investigators who demonstrated its efficacy in evaluating the amount of remaining filling materials (23, 32). This procedure was undertaken to minimize the subjectivity that may be seen in evaluation methods using radiographs or photographs that are evaluated on a scoring system based on scales (21, 33, 34).

This study was performed on teeth with straight root canals. Therefore, the conclusions of this study could not be directly extended to teeth with curved root canals. In two studies by the same group of investigators, the ProTaper has been shown to have similar performance in removing root canal filling material relative to three other techniques in both straight and curved root canals; however, more ProTaper files fractured during retreatment of curved canals compared with straight canals (28, 29). Clearly, more studies are needed to evaluate the efficacy, maintenance of original canal morphology, and safety of rotary NiTi instruments during retreatment of teeth with complicated root canal anatomy.

The current findings indicate that all instruments used in retreatment, rotary or hand, left some filling material inside the root canal. The two types of rotary NiTi instruments were significantly more effective and faster than Hedstrom files in removing gutta-percha during retreatment. There was no significant difference between the two rotary instruments. Furthermore, there was no significant difference among the three techniques regarding the amount of apically extruded debris.

References