

## Efficacy of Pro-taper Universal Rotary Re-treatment System, H-file and K-flex File in Gutta-Percha Removal from Root Canal: A Comparative *In-Vitro* Study

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### Abstract:

**Background:** The purpose of this study was to evaluate and compare the efficacy of Pro-taper Universal Rotary re-treatment system; H-file and K-flex file in removing gutta-percha (GP) from root canal during re-treatment.

**Materials and Methods:** A total of 54 permanent single-rooted maxillary and mandibular premolars enlarged up to master apical file size 30 and obturated with GP and AH-Plus sealer. Teeth were randomly divided into three groups ( $n = 18$ ). Re-treatment was carried out using three techniques. Group A: Pro-taper Universal Rotary re-treatment system followed by Pro-taper finishing files, Group B: H-files followed by Pro-taper finishing files, and Group C: H-files followed by K-flex files. Stereomicroscopic images of the area of root canal filling were assessed and evaluated in mm<sup>2</sup> using an image analyzer software.

Data were analyzed statistically using one-way analysis of variance and Newman-Keuls multiple *post-hoc* procedure.

**Results:** Remaining filling material was observed in all specimens. However, Pro-taper was significantly more effective than H-files and K-flex files.

**Conclusion:** All techniques left GP/sealer remnants within the root canal. Pro-taper Universal Rotary re-treatment system proved to be an efficient method of removing GP/sealer from the root

canal and resulted in a smaller percentage of canal area covered with GP/sealer when compared with H-files and K-flex files.

**Key Words:** Endodontic re-treatment, gutta-percha removal, Pro-taper Universal Rotary re-treatment system

### Introduction

The success of root canal treatment is based on the triad of debridement, sterilization, and obturation. The complexity of the cases being treated is increasing. With advances in techniques and technology such difficult cases are treated successfully. However, despite of having a high degree of success root canal treatment may not lead to the desired response and failure may occur. When root canal treatment fails other options are namely re-treatment, periradicular surgery/extraction.<sup>1</sup> Non-surgical re-treatment is the most conservative attempt to reestablish healthy periapical tissues.<sup>1,2</sup> It aims to thoroughly remove the obturated material so as to enable effective cleaning, shaping and filling.<sup>3</sup> Various methods used to remove gutta-percha (GP) from canals include hand instruments, ultrasonics, lasers, heat carrying instruments, and NiTi rotary instruments.<sup>3-5</sup> Pro-taper Universal Rotary re-treatment system consists of three re-treatment instruments (D1, D2, D3) designed for removing filling materials from the canals. Hence, this study was aimed to evaluate and compare the efficacy of H-file, K-flex file, and Pro-taper Universal Rotary re-treatment system in removal of GP from root canals.

### Materials and Methods

A total of 54 single-rooted permanent premolars, with single patent canal and fully formed apices, were selected for the study. It was ensured that teeth with fractures, calcifications and internal resorption were excluded from the study. Soft tissue and calculus were mechanically removed from the external root surface.

### Sample preparation

Access opening was performed with high-speed handpiece No. 2 round diamond bur, and working length (WL) was determined by passing a No. 10-K file into the canal until the tip was just visible at the apical foramen and 1 mm was subtracted from the length. Teeth were then sectioned with a diamond disc at the level of the cemento-enamel junction to get a uniform WL of 14-15 mm in each tooth. Canal orifice was enlarged using Gates Glidden 1, 2, and 3. Canals were enlarged to a master apical file size 30 using K-files in a step back technique up to ISO size 50 K-file. Upon withdrawal of each instrument,

canals were irrigated with 5.25% NaOCl with a final flush of 17% ethylenediaminetetraacetic (EDTA). Canals were dried and obturated using AH-Plus sealer and GP cones using cold lateral condensation technique. Orifices were sealed with the cavity. Teeth were radiographed to confirm the adequacy of obturation. All teeth were stored in a humidifier at 37°C for 30 days to allow complete setting of the sealer. Samples were randomly divided into three groups with 10 specimens each. The temporary material used for the seal was removed using a round bur, thus forming a reservoir for eucalyptol that was used as a solvent.

**Procedure for re-treatment**

Re-treatment was carried out using the following method:

Group A: Re-treatment was carried out using: Pro-taper Universal Rotary re-treatment instruments with further canal preparation using Pro-taper Universal shaping and finishing instruments.

In this group, the obturated material was removed using Pro-taper Universal Rotary re-treatment instruments following the manufacturer’s instruction. The re-treatment rotary files namely D1 (9% taper, size 30) file, D2 (8% taper, size 25) file, and D3 (7% taper, size 20) file were sequentially used in a crown-down manner, using light apical pressure to reach the pre-established WL, they were manipulated in a brushing action with rotational speed set at 500 rpm.

In teeth samples where the rotary instruments did not advance in the canal prior to reaching the designated depth (i.e. pre-established WL), K-files (hand instruments) were used to establish the glide path before reintroducing the rotary instruments.

Root canal refinement was accomplished using Pro-taper Rotary shaping - S1 (2-11% taper, size 17), S2 (4-11.5% taper, size 20), and finishing F1 (5.5-7% taper, size 20), F2 (5.5-8% taper, size 25), and F3 (5-9% taper, size 30) instruments, which were used in a gentle brushing action at a speed of 300 rpm, as per the manufacturer’s instructions.

Group B: Re-treatment was carried out using: Hedstrom hand files with further canal preparation using Pro-taper Universal Rotary shaping and finishing instruments.

In this group, the removal of obturated material was initiated with the use of ISO size 15 and 20 Hedstrom hand files which were used for deep penetration within the obturated material until they reached the pre-established WL. The removal of GP was completed using H-files ISO sizes 30, 25, 20 (hand instruments) in a circumferential quarter-turn push-pull filing motion. Once the bulk of the obturated material was removed, canal refinement was accomplished using Pro-taper Universal Rotary shaping (S1, S2) and finishing (F1, F2, F3) instruments.

Which were used in a gentle brushing action at a speed of 300 rpm, as per the manufacturer’s instructions.

Group C: Re-treatment was carried out using: Hedstrom hand files, with further canal preparation using K-flex hand files.

In this group, the method of removing obturated material was the same as in Group B. Further root canal refinement was accomplished using K-flex hand files with apical enlargement to ISO size 35 and step-back in 1 mm increments to ISO size 50. The files were used with push and pull motion in a circumferential manner.

All the 54 teeth were then rendered transparent by first decalcifying them in 5% nitric acid then dehydrating them in 80% alcohol for 12 h, 90% alcohol for 1 h, and 100% alcohol for 3 h. The teeth were then cleared using methylsalicylate. To reduce interoperator variability, each root canal was prepared, obturated and retreated by the same operator.

One set of instruments were used for re-treatment of five root canals. Files were wiped regularly using gauze to remove obturated material and debris. The preparation was deemed to be complete when there was no more GP/sealer covering the instruments and canal walls were smooth.

**Evaluation**

For all roots, the following data were recorded.

**Canal wall cleanliness**

The amount of GP/sealer remnants on the canal walls was imaged using a stereomicroscope with ×8 magnification. The area of GP/sealer remnants, as well as the canal wall, was measured in mm<sup>2</sup> using the image analyzer software.

**Results**

Table 1 shows descriptive statistics in the form of a mean and standard deviation of Pro-taper Universal Rotary re-treatment system + Pro-taper Universal shaping and finishing files (27.6278 ± 7.4095), H-files + Pro-taper Universal shaping and finishing files (52.3100 ± 8.5264), and H-files + K-flex files (58.4083 ± 9.7444).

On one-way analysis of variance (Kruskal–Wallis ANOVA) (Table 2): The mean percentage of area covered by the GP/sealer remnants after treatment by the investigated techniques (Group A: Pro-taper Universal Rotary re-treatment system + Pro-taper Universal shaping and finishing files;

**Table 1: Summary of statistics.**

Groups	Mean	Standard deviation	Standard error	Coefficient of variation
Group A	27.6278	7.4095	1.7464	26.8189
Group B	52.3100	8.5264	2.0097	16.2997
Group C	58.4083	9.7444	2.2968	16.6833

**Table 2: Comparison of three groups with percentage of GP/Sealer remaining on the root canal wall by one-way ANOVA test.**

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F value	P value
Between groups	2	9563.07	4781.5331	64.4546	<0.001
Within groups	51	3783.41	74.1845		
Total	53	13346.48			

\*Significant at 1% level of significance (P<0.001)

Group B: H-files + Pro-taper Universal shaping, and finishing files; Group C: H-Files + K-Files) in the three groups were 27.6278, 52.3100, and 58.4083, respectively.

With the degree of freedom and critical F-probability value determined ( $F = 64.4546$ ), the homogeneity of variance test-Levine statistic suggested that the variance among the groups is not significantly different from each other. Hence, the robust test of equality of means - Welch statistic inferred that there is a statistically significant difference between the efficacy of the techniques in removing GP/sealer from root canal during re-treatment ( $P < 0.001$ ).

On pair wise comparison of the three groups by Newman-Keuls multiple *post-hoc* test (Table 3) a statistically significant difference was recorded among Group A, Group B, and Group C.

Hence, pertaining to techniques used to remove GP/sealer in re-treatment cases, Pro-taper Universal Rotary re-treatment system + Pro-taper Universal shaping and finishing files was found to be the most efficient (Figure 1), followed by Group B: H-files + Pro-taper Universal shaping and finishing files (Figure 2). Those treated with H-files + K-flex files (Figure 3) showed almost 59% of the mean percentage of area covered by the GP/sealer remnants.

**Discussion**

The success rate for root canal treatment is between 80% and 95%. Studies vary, with reported success rates ranging from a high of 95% to a low of 53%. Unfortunately, not all root canal treatments are successful.<sup>6</sup>

Major factors associated with endodontic failure are the persistence of microbial infection in the root canal system and or the periradicular area. Nevertheless, there are some cases in which the treatment has followed the highest technical standards, and yet failure results.<sup>7</sup>

A growing interest in endodontic re-treatment has been seen recently, caused by increasing demand to preserve teeth, including those cases where endodontic therapy has failed.<sup>2</sup> Many causes of failure of initial endodontic therapy include iatrogenic procedural errors, such as poor access cavity design, untreated canals (both major and accessory), canals that are poorly cleaned and obturated, complications of instrumentation (ledges, perforations or separated instruments), blamed for the post-treatment disease.<sup>8</sup> The main causes of endodontic

**Table 3: Pair wise comparison of three groups by Newman-Keuls multiple *post-hoc* procedure.**

Groups	Group A	Group B	Group C
Means	27.6280	52.3100	58.4080
Group A	-	-	
Group B	0.0001*		
Group C	0.0001*	0.0386**	-

\*Significant at 1% level of significance (P<0.001). \*\*Significant at 5% level of significance (P<0.05)

failure making re-treatment necessary are insufficient cleaning and inadequate obturation.<sup>9</sup> The primary difference between nonsurgical management of primary endodontic disease versus post-treatment disease is the need to regain access to the apical foramen of the root canal space in the previously treated tooth.<sup>8</sup>

Non-surgical endodontic re-treatment, when indicated, requires regaining of access to the entire root canal system through complete removal of the pre-existent endodontic obturating material. This enables thorough chemomechanical instrumentation and disinfection of the entire root canal system, which are prerequisites for successful re-treatment.<sup>10</sup> Only if the filling material can be removed completely and the root canal negotiated to the apical foramen, thus allowing thorough debridement, will the prerequisites for successful re-treatment be fulfilled. In these cases, the success rates for re-treatment range from about 65% to more than 80%.<sup>9</sup>

Possibility of re-treatment depends on the feasibility of completely removing the original obturated material.<sup>11</sup>

Removing as much sealer and filling material as possible from inadequately prepared and filled root canal is critical to uncover remnants of necrotic tissue or bacteria that maybe responsible for periapical inflammation and failure.<sup>12</sup>

Several techniques, employing various instruments have been proposed for removing root filling materials.<sup>4</sup> The techniques used to remove GP from root canals include manual endodontic hand instruments, ultrasonics, lasers, heat carrying instruments, as well as NiTi rotary instruments.<sup>5</sup> In many cases, the combined use of different techniques maybe the most efficient and time-saving method. Nevertheless, removal in many cases is a tedious and time-consuming procedure, especially in narrow and curved canals or when the filling material is well-condensed.<sup>13</sup>

Conventionally, the removal of GP using hand files with or without solvents can be tedious, time-consuming process, especially when the root filling material is well condensed.<sup>14</sup>

A new generation of endodontic instruments made of nickel-titanium has been developed. These were investigated initially by Walia *et al.*, who assessed their bending and torsional properties compared to K-type files. The nickel-titanium files showed two to three times more elastic flexibility than stainless steel files due to the very low values of modulus of elasticity. They also showed superior resistance to torsional fracture, because of the ductility of nickel-titanium. Use of rotary NiTi instruments in root canal re-treatment may decrease patient and operator fatigue.<sup>14</sup>

Premolar teeth were selected in this study. Although their canals are often straight, they are often flattened mesio-distally (M-D), an important anatomic variation during their treatment. All root canals in this study were prepared initially to size 35 with a 2% taper. This was assumed to represent rather narrow and often underprepared root canals, which frequently are found in re-treatment cases. Probably, preparation to sizes of 30 or even 25 may have been more appropriate from a clinical prerogative, but this would have resulted in some of the instruments used for GP removal cutting not only GP but also dentine.<sup>13</sup> Upon withdrawal of each instrument, canals were irrigated alternatively with 5.25% NaOCl and 17% EDTA.<sup>3</sup>

The root canals were filled using GP and AH-Plus sealer using lateral condensation technique. This obturation technique was used in many retreatment studies.<sup>2</sup> AH-Plus is an epoxy resin based sealer, adds to difficulty during re-treatment since it has better adhesion to root canal wall and hence it was used in the present study. Access cavities were sealed with cavity. The quality of the root fillings was confirmed using post-operative radiographs in bucco-lingual and M-D views. All teeth were stored at 37°C in a humidifier for 30 days to allow complete setting of the sealer.<sup>1</sup>

The temporary filling material was removed with a round bur, thus forming a reservoir for eucalyptol oil that was used to soften the GP. In the present study, eucalyptol was used as a solvent. Although chloroform is known to be more efficient in dissolving GP, it has been reported to be locally toxic in contact with periradicular tissues and has been classified as a carcinogen.<sup>13</sup> Eucalyptol has been reported to be a safe and efficient alternative to chloroform. Eucalyptol was also used in previous re-treatment studies comparing rotary instruments.<sup>2</sup>

All samples were randomly divided into three groups of 18 teeth each and re-treatment was performed using the following test instruments:

1. Group A: Pro-taper Universal Rotary re-treatment files + Pro-Taper shaping and finishing files
2. Group B: Hedstrom hand files + Pro-taper shaping and finishing files
3. Group C: Hedstrom hand files + K-flex hand files.

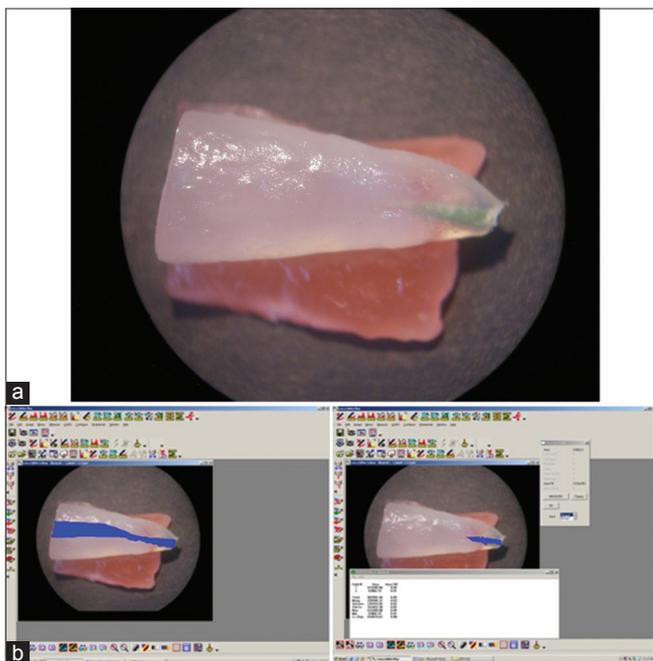
In the present study, the Pro-taper Universal Rotary instruments left a smaller percentage of area covered by GP/sealer remnants than those treated with other techniques. The better performance of Pro-taper Universal re-treatment instruments in the present study maybe attributable to their design. Moreover, the specific flute design and rotary motion of the Pro-taper Universal re-treatment instruments tend to pull GP into the file flutes and direct it toward the orifice. Engine-driven files produce a certain degree of frictional heat which might plasticize GP. The plasticized GP would thus present less resistance and be easier to remove. Prior to the introduction of Pro-taper Universal re-treatment files, Pro-taper rotary finishing files had been used for GP removal. This technique yielded a high fracture incidence of 22.7%. Procedural errors including instrument fracture were not noted in the present study, demonstrating the safety of Pro-taper Universal re-treatment instruments in endodontic re-treatment.<sup>3</sup>

H-files were used for hand instrumentation as in many previous studies.<sup>15</sup> Furthermore, a combination of H-files and K-files were used for re-treatment.<sup>5</sup> Studies have shown that the use of Hedstrom files without a solvent is more time consuming but results in better canal cleanliness. It is difficult to direct NiTi instruments in the apical region. Manually operated Hedstrom files allowed better preparation of isolated root canal wall areas.

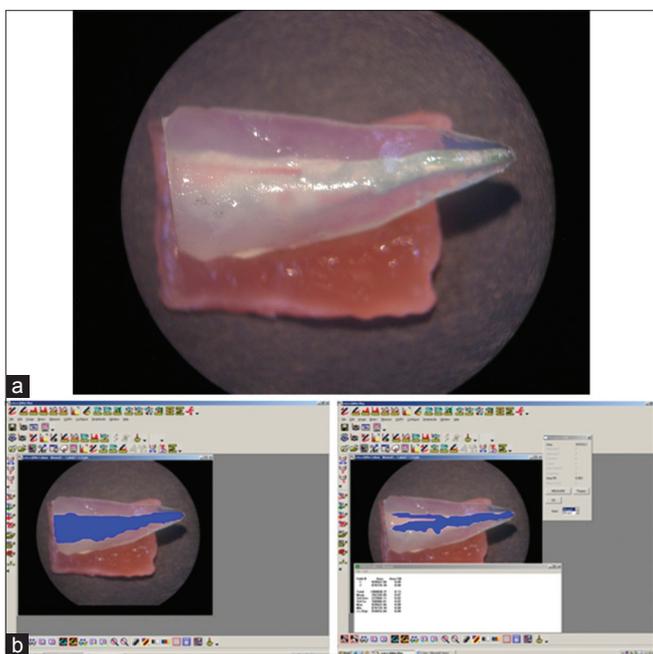
Different techniques have been used to evaluate remaining filling material namely radiography, splitting teeth longitudinally, or making the teeth transparent.<sup>3</sup> Schirrmeister *et al.* reported that residual material might be lost by splitting the roots longitudinally. In the present study, the roots were cleared to allow measurement of the area of the residual filling material.<sup>14</sup> The transparent (clearing) teeth method appears to be cost effective and sensitive enough to identify a small area of residual GP/sealer on the canal wall.<sup>3</sup> In this study, the residual GP/sealer on the root canals was imaged using stereomicroscope as it was considered a simple and efficient assessment method.<sup>4</sup> The area of GP/sealer remnants, as well as the canal wall, was measured in mm<sup>2</sup> using the image analyzer software.<sup>3</sup> This software aids in standardization, is reproducible, repeatable, automatic, and gives quick results. On the other hand, it is expensive.

It is impossible to remove all traces of GP/sealer from root canals with any re-treatment technique, regardless of single or combined action. This was also demonstrated in the present study, as none of the specimens was free of GP/sealer remnants under stereomicroscopic examination.<sup>3</sup> The results were then analyzed statistically using one-way ANOVA test and Newman-Keuls multiple *post-hoc* procedure.

Results showed that in the present study, Group 1 removed GP/sealer from root canals more efficiently compared with



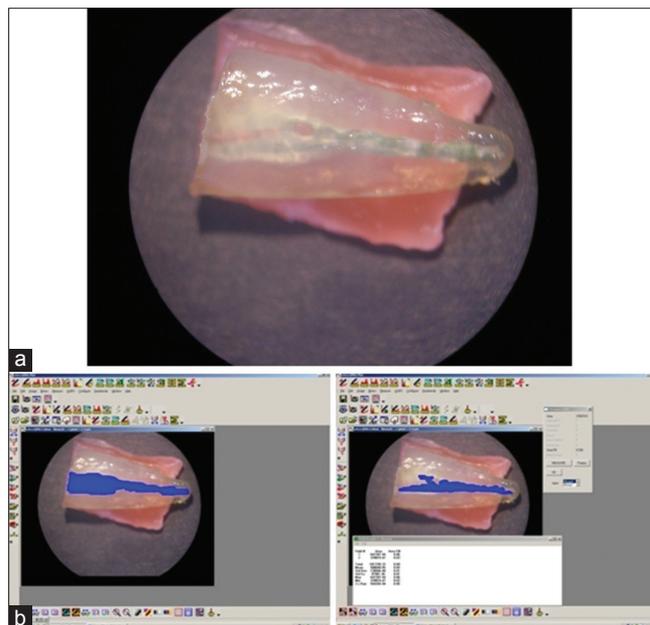
**Figure 1:** Sample in Group A, (a) Stereomicroscopic image of remaining gutta-percha (GP)/Sealer, (b) GP/Sealer remnant area analyzed with image analyzer software.



**Figure 2:** Sample in Group B, (a) Stereomicroscopic image of remaining gutta-percha (GP)/Sealer, (b) GP/Sealer remnant area analyzed with image analyzer software.

Group 2 and Group 3. On the other hand, Group 2 was more efficient than Group 3. Hence, it was concluded that there was statistically significant difference in GP/sealer remnants between all the three groups.

Our results are in accordance with the following studies conducted by Gu *et al.*,<sup>3</sup> Sandhya *et al.*,<sup>16</sup> Somma *et al.*,<sup>17</sup>



**Figure 3:** Sample in Group C, (a) Stereomicroscopic image of remaining gutta-percha (GP)/Sealer, (b) GP/Sealer remnant area analyzed with image analyzer software.

de Carvalho Maciel and Zaccaro Scelza,<sup>18</sup> Giuliani *et al.*,<sup>19</sup> Shivanand *et al.*<sup>20</sup>

The results of our study demonstrate that Pro-taper Universal Rotary instruments left a smaller percentage of area covered by GP/sealer remnants than those treated with other techniques. Further studies are required to assess the efficiency of both hand and rotary instruments for re-treatment in a clinical scenario.

**Conclusion**

Completely clean root canal walls were not achieved with any of the techniques investigated in this re-treatment study. It can be graded as Pro-taper Universal Rotary re-treatment system + Pro-taper Universal shaping and finishing files > H-files + Pro-taper Universal Shaping and finishing files > H-files+ K-flex files. However, additional *in-vivo* and *in-vitro* studies are necessary to the findings of our study.

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