In vitro study on the effectiveness of gutta-percha removal between the protaper retreatment system and r-endo system in endodontic retreatment

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Abstract

Background: During endodontic retreatment, complete removal of root canal filling material is essential for effective cleaning and disinfection of the root canal system. Various methods have been proposed for gutta-percha removal, including the rotary instruments, which is recommended because it is safe, effective, and less time-consuming. **Objective:** Comparison of gutta-percha removal efficiency in endodontic retreatment between the Protaper retreatment system (Dentsply Sirona) and R-Endo system (Micro Mega). **Methods:** The present in vitro study was conducted on 60 mandibular premolars extracted for orthodontic purposes; after initial endodontic treatment, root canal filling with gutta-percha and zinc oxide eugenol cement, the teeth were randomly divided into four groups, each group of 15 teeth. The groups were as follows: The group using the Protaper retreatment system, the group using the R-Endo system, the group using the Protaper retreatment system combined with the solvent, and the group using the R-Endo system combined with a solvent to remove gutta-percha. The time taken to remove gutta-percha was recorded. Roots were grooved into two halves, observed under a microscope, taken pictures, and evaluated with ImageJ 1.53v software, recording the amount of gutta-percha remaining on the root canal wall. **Results:** The study showed no significant difference in the effectiveness of gutta-percha removal between the Protaper retreatment system and the R-Endo system; all groups left gutta-percha on the canal wall. The Protaper retreatment system or R-Endo system combined with solvent left more gutta-percha on the canal wall than using only the Protaper retreatment system or R-Endo system. The amount of gutta-percha remaining on the canal wall at the cervical third, middle third, and apical third regions between the study groups did not have a statistically significant difference. The average time to remove gutta-percha showed a statistically significant difference between the study groups ($p < 0.05$). **Conclusion:** There was no difference in the efficiency of gutta-percha removal between the Protaper retreatment system and the R-Endo system in endodontic retreatment.

Keywords: *Protaper retreatment system, R-Endo system, endodontic retreatment, gutta-percha removal.*

1. BACKGROUND

Although endodontic treatment has a high success rate, it can lead to undesirable reactions and failure [1]. When endodontic treatment fails, treatment options include endodontic retreatment, apical surgery, or tooth extraction. Non surgical endodontic retreatment is indicated first to eliminate or significantly reduce the remaining microorganisms in the root canal. Endodontic retreatment aims to find a path to the apical foramen by completely removing the root canal filling material, thus facilitating cleaning and reshaping of the root canal system and, finally, proper obturation of the root canal [2]. Many materials are used to obturate root canals, of which gutta-percha with root canal sealer is the most common [3]. Many methods have been introduced to remove gutta-percha, such as using hand files, rotary files, ultrasonic endodontic instruments, or lasers, with or without solvents [4], [5, 6]. The use of rotary files is proposed because of their safety, efficiency, and low time consumption [4]. Some rotary systems with unique designs have been developed to optimize the ability to remove gutta-percha and filling materials, in which Protaper retreatment and R-Endo systems are prominent. Several studies have evaluated the effectiveness of the two rotary systems, Protaper retreatment and R-Endo in endodontic retreatment. Buranade et al. demonstrated no difference between the Protaper retreatment files and the R-Endo files in removing root canal filling material [7].

Meanwhile, the study of Tiwari et al. showed

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that the effectiveness of eliminating root canal filling material of the R-Endo system was superior to that of the Protaper retreatment system [8]. In Vietnam, up to now, there have been few studies on endodontic retreatment, mainly evaluating the retreatment effectiveness of Protaper retreatment files and Hedstrom files [9]; no studies have been conducted to evaluate the effectiveness of R-Endo files. Therefore, to thoroughly assess the effectiveness of different systems in endodontic retreatment, we performed the topic: "In vitro study on the effectiveness of gutta-percha removal between the Protaper retreatment system and R-endo system in endodontic retreatment."

Research objectives:

1. Comparison of the amount of gutta-percha remaining on the root canal wall between Protaper retreatment and R-endo.

2. Comparison of the time to remove gutta-percha during retreatment between the two systems.

2. MATERIALS AND METHODS

The study sample included 60 mandibular premolars extracted for orthodontic treatment and stored in 0.9% NaCl solution at room temperature until use. The teeth were intact, had completely closed roots, had type I root canals according to the Vertucci classification, and had straight root canals with curvature not exceeding 10° according to Schneider's measurement method on the radiograph. Teeth with internal resorption, external resorption, calcified root canals, root caries, root fractures, and obturated teeth were excluded from the study sample. The teeth were sectioned with a diamond cutting disc so that the remaining length of the tooth from the section to the apex was 15 mm. The working length of the teeth was determined, prepared with K files using the step-back method to K40 file, with the master apical file K25, and obturated by the lateral condensation technique with 2% tapered gutta-percha and zinc oxide eugenol cement. The tooth samples were then divided into groups of 15 each and stored for two weeks to allow the sealer to set. Endodontic retreatment was performed for each group using specific instruments. Groups 1 and 2 used rotary file system with the crown-down technique to remove gutta-percha in the coronal third, middle third, and apical third of the root canal. Groups 3 and 4 employed rotary file system with the crown-down technique in the cervical third, middle third, and apical third after placing 2–3 drops of orange oil—Carvene GP solvent (Prevest, India) into the canal for 3 minutes.

- Group 1: using the Protaper retreatment system
- Group 2: using R-Endo system
- Group 3: using Protaper retreatment system combined with solvent (Orange oil)
- Group 4: using R-Endo system combined with solvent (Orange oil)

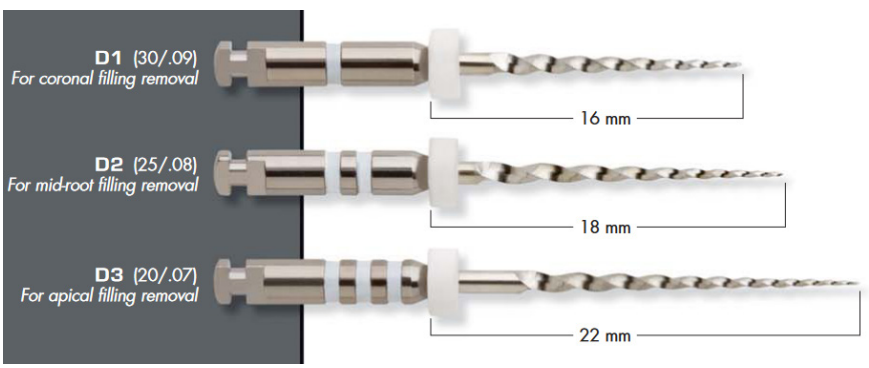

Figure 1. Protaper retreatment rotary file system [10]

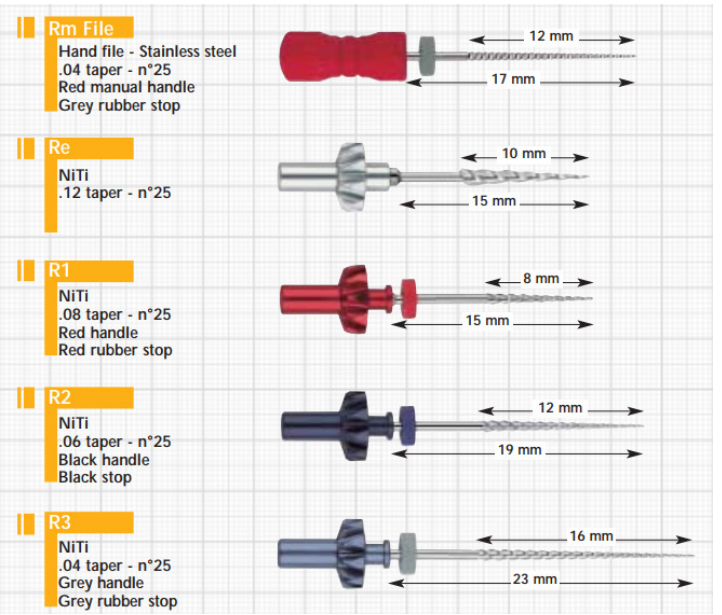

Figure 2. R-Endo file system [11]

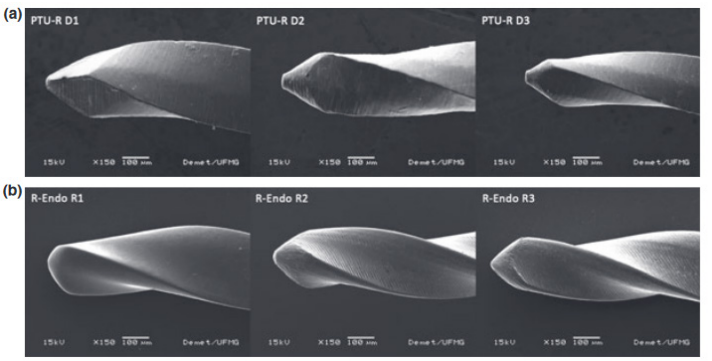

Figure 3. Scanning electron microscope images of the Protaper retreatment file tip (a) and the R-Endo file tip (b). [12]

The file was inserted into the root canal with very light apical pressure, using a filing motion against the canal wall. The file was frequently withdrawn to check and clean filling material and dentin debris from the cutting blades with a moist cotton pellet before proceeding.

The Protaper retreatment rotary file was used at a constant speed of 400 rpm with a torque of 3 N/cm, according to the manufacturer's instructions.

The R-Endo rotary file was used at a constant speed of 350 rpm with a torque of 1.2 N/cm, according to the manufacturer's instructions.

During endodontic retreatment, after each file change, the canal was irrigated with 1 ml of 2.5% NaOCl for 10 seconds.

The gutta-percha (GP) removal process was completed when the gutta-percha was no longer visible on the file and the root canal wall was smooth. The teeth were sectioned longitudinally in the mesiodistal direction, parallel to the tooth axis, and through the apical foramen. The two halves of the roots were photographed using a camera attached to a stereo microscope with a magnification of 50X; the distance between the microscope lens and the tooth samples was constant, with the same magnification. Then, the images were processed using ImageJ 1.53v software (National Institutes of Health, USA) to determine the area of gutta-percha remaining on the root canal wall. The gutta-percha area was measured at the corresponding region of the cervical third, middle third, and apical third for each position three times, and the average value was taken; the half of the root with the higher percentage of remaining gutta-percha area was selected as the representative of the amount of gutta-percha remaining on the root canal wall

after retreatment. The samples were evaluated for the amount of gutta-percha remaining on the root canal wall by percentage according to the formula of Kasam et al. (2016) [5]

$$\% \text{ Remaining gutta-percha area} = \frac{\text{Remaining gutta-percha area}}{\text{Root canal area}} \times 100\ (\%)$$

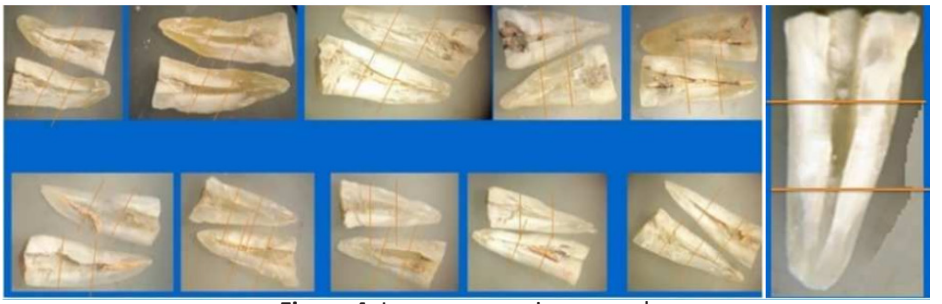

Figure 4. Image processing procedure
A. Longitudinal sectioning and splitting of the root;
B. Division of the root canal into three parts (cervical third, middle third, apical third);

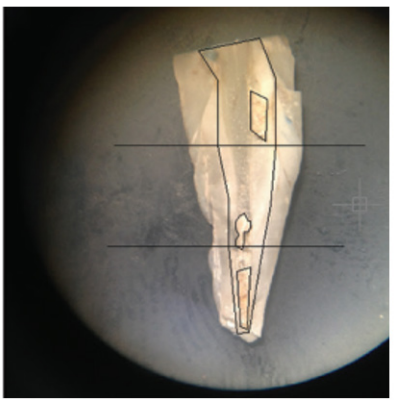

Figure 5. Identification and measurement of the root canal outline area and the remaining gutta-percha outline area.

According to Kasam et al. (2016), the retreatment time took to completely remove gutta-percha from the root canal wall was calculated in seconds from the time the first instrument was inserted into the root canal until the gutta-percha was completely removed. [5]

The data were processed and analyzed using SPSS 20 software. The Kruskal-Wallis test was used to compare mean values between groups, and the Mann-Whitney U test was used to compare mean values between two independent groups. The values were evaluated with a significance level of $p < 0.05$.

3. RESULTS

3.1. Comparison of the amount of gutta-percha remaining on the root canal wall between Protaper retreatment system and R-endo system

Table 1. Comparison of mean % remaining gutta-percha area on the entire root canal wall between study groups

Group	Quantity (n)	Mean ± SD	p value
PTR	15	3.96 ± 3.33	0.787
R-Endo	15	4.21 ± 4.45	
PTR + solvent	15	7.39 ± 8.87	
R-Endo + solvent	15	7.00 ± 7.78	

**Using test Kruskal-Wallis*

There was no statistically significant difference between the study groups when comparing the mean % of remaining GP area on the entire canal wall (p >0.05). Using Protaper retreatment files or R-Endo files combined with solvent left more GP on the canal wall than using Protaper retreatment files or R-Endo files alone.

Table 2. Comparison of the average percentage of remaining gutta-percha area on the root canal wall at the cervical third, middle third, and apical third between the study groups

Group	Quantity (n)	The cervical 1/3 (%)	The middle 1/3 (%)	The apical 1/3 (%)
PTR	15	1.02 ± 1.99	5.38 ± 9.80	12.39 ± 12.11
R-Endo	15	2.22 ± 3.79	3.50 ± 7.17	12.60 ± 19.02
PTR + solvent	15	1.03 ± 1.74	14.33 ± 22.09	16.56 ± 20.90
R-Endo + solvent	15	2.13 ± 5.66	12.12 ± 12.82	8.61 ± 13.58
P value		0.911	0.108	0.519

**Using test Kruskal-Wallis*

At the cervical third, middle third, and apical third, the average % of remaining GP area on the root canal wall in the groups using Protaper retreatment, R-Endo, Protaper retreatment combined with solvent, R-Endo combined with solvent was not statistically different (p > 0.05).

3.2. *Comparison of gutta-percha removal time in endodontic retreatment between two systems*

Table 3. Comparison of mean gutta-percha removal time in endodontic retreatment between study groups

Group	Quantity (n)	Mean ± SD (seconds)	p-value
PTR	15	398.40 ± 167.69	0.015
R-Endo	15	527.20 ± 219.59	
PTR + solvent	15	315.20 ± 144.51	
R-Endo + solvent	15	348.60 ± 167.17	

**Using test Kruskal-Wallis*

The mean time for gutta-percha removal was statistically significantly different between the study groups (p < 0.05). The group using Protaper retreatment files combined with solvent took the least time to remove gutta-percha (315.20 ± 144.51 seconds). In contrast, the group using R-Endo files took the longest time to do this (527.20 ± 219.59 seconds).

Table 4. Comparison of mean gutta-percha removal time in endodontic retreatment between each pair of study groups

Group	Quantity (n)	Mean ± SD (seconds)	p value
PTR	15	398.40 ± 167.69	0.120
R-Endo	15	527.20 ± 219.59	
PTR	15	398.40 ± 167.69	0.106
PTR + solvent	15	315.20 ± 144.51	
R-Endo	15	527.20 ± 219.59	0.014
R-Endo + solvent	15	348.60 ± 167.17	
PTR + solvent	15	315.20 ± 144.51	0.431
R-Endo + solvent	15	348.60 ± 167.17	

**Using test Mann-Whitney U*

The mean gutta-percha removal time was shorter in the Protaper retreatment group compared to the R-Endo group. However, it was longer compared to the Protaper retreatment group combined with solvent. The mean gutta-percha removal time was shorter in the Protaper retreatment group combined with solvent compared to the R-Endo combined with solvent group. These differences were not statistically significant. In contrast, the mean gutta-percha removal time was significantly longer in the R-Endo group compared to the R-Endo group combined with solvent (p < 0.05).

4. DISCUSSION

4.1. Comparison of the amount of gutta-percha remaining on the root canal wall between Protaper retreatment and R-endo files

The use of Protaper retreatment and R-Endo files in endodontic retreatment, in both cases using only rotary files and using rotary files combined with solvent, showed that there was no statistically significant difference in the percentage of remaining GP area on the entire root canal wall between these two types of files. Our results are similar to the research results of Al-Haddad et al. [13], Amal et al. [14], Buranade et al. [7]. The Protaper retreatment and R-Endo files have similar designs and similar rotational movements, leading to no difference in GP removal efficiency between the two systems. The Protaper retreatment files have a convex triangular cross-section; the D1, D2, and D3 files with tip diameters of 0.3mm, 0.25mm, and 0.2mm were used in each third of the root. R-Endo files have a triangular cross-section with three equally spaced cutting edges; R1, R2, and R3 files have a tip diameter of 0.25mm. Both types of files operate with continuous rotation. In endodontic retreatment, using Protaper retreatment files or R-Endo files combined with solvent left more GP on the root canal wall than using only Protaper retreatment files or R-Endo files ($p>0.05$). Our study results are similar to those of Bhagavaldas et al. [4] and Subbiya et al. [15], showing that the group using rotary files combined with solvent was less effective in removing GP than the group using rotary files alone. As many authors explain, the above result is due to the formation of a thin layer of GP adherent to the root canal wall when using solvent, which hinders cleaning of the root canal system [2], [16].

At the cervical third, in both cases of using only the rotary files and using the rotary files combined with the solvent, there was no difference in the percentage of GP area remaining on the canal wall at the cervical third between the group using the Protaper retreatment files and the group using the R-Endo files. This may be due to the similar tip diameters of the D1 (0.3mm) and R1 (0.25mm) files used to remove GP at the cervical third. This similarity likely resulted in comparable effectiveness in eliminating GP at this region for both systems. The research results of Gokturk et al. [17], Nasiri, and Wrbas [18] also showed no statistically significant difference in the amount of GP remaining on the canal wall at this region between the two instruments. However, unlike the above studies, the study of Aly et al. [19] showed that the R-Endo files were more effective than the Protaper retreatment files in removing GP at the cervical third.

In the middle third, in both cases, using only the rotary files and using the rotary files combined with the solvent, there was no difference in the percentage of GP area remaining on the canal wall at this region between the Protaper retreatment files and the R-Endo files. Our results are similar to the results of the studies of Al-Haddad et al. [13], Aly et al. [19], Gokturk et al. [17], and Nasiri and Wrbas [18]. The D2 and R2 files used for removing GP at the middle third have the same tip diameter, 0.25mm. Hence, the effectiveness of eliminating GP in this region is almost equivalent for both systems.

At the apical third, in the group using only the rotary files, the percentage of GP remaining on the canal wall at the apical third between the two instruments was similar. While in the group using the rotary files combined with the solvent, the group using the R-Endo files had a lower amount of GP remaining on the canal wall at this region than the group using the Protaper retreatment files. However, this difference was not statistically significant. Similar studies by Al-Haddad et al. [13], Aly et al. [19], Gokturk et al. [17], and Nasiri and Wrbas [18] also showed no difference in the amount of GP remaining on the canal wall at this region between the two instruments. In the study conducted by Beshr et al. [20] to compare the effectiveness of endodontic retreatment between three file systems, K3, Protaper retreatment, and R-Endo, the results showed that at the apical third, the K3 files left less GP than Protaper retreatment and R-Endo files. The authors believed that the difference in file tip diameter was the cause of this difference; Protaper retreatment and R-Endo files used at the apical third had almost the same file tip diameter (D3 was 0.2mm and R3 was 0.25mm), while K3 file used for this region had a more extensive file tip diameter than the two files above (0.4mm). In our study, a D3 file with a tip diameter of 0.2mm and an R3 file with a tip diameter of 0.25mm was used to remove GP at the apical third, so the ability to remove GP is similar between the two types of files, which is appropriate.

4.2. Comparison of gutta-percha removal time in endodontic retreatment

In our study, the time for gutta-percha removal in endodontic retreatment was calculated from the time the first instrument was inserted into the root canal (D1 in the Protaper retreatment system, R1 in the R-Endo system) until the completion of

gutta-percha removal from the root canal. This time did not include the time for irrigation of the root canal and the time for changing the files. Our results showed that in both cases of using only the files and the files combined with the solvent, the average time for GP removal when using the Protaper retreatment files was shorter than when using the R-Endo files. However, the difference was not statistically significant. In this study, we used the Protaper retreatment files and the R-Endo files with the same number of files, both three files. However, the D1 file with a cutting tip helps to remove GP faster, facilitating the penetration of the following files.

Meanwhile, the tip of the R-Endo files does not have a cutting effect. In addition, the spiral groove design of the Protaper retreatment files and the continuous rotational motion help to cut a large amount of GP around the instrument and pull it toward the canal entrance, which helps to remove GP faster [1]. Furthermore, with the Protaper retreatment files, we used a rotation speed of 400 rpm, while with the R-Endo files, we used a lower rotation speed of 350 rpm. The above differences may make the Protaper retreatment files more effective than the R-Endo files when comparing the time to remove GP, although the difference is not statistically significant.

When using Protaper retreatment files in combination with solvent, the time to remove GP was not different from when using Protaper retreatment files alone ($p = 0.106$). Our results are similar to the results of studies conducted by Colombo et al. [21] and Kfir et al. [22]. This can be explained by the ability of Protaper retreatment files to remove the filling material, making GP softening solvent unnecessary [21]. In addition, we believe that D1 files with a cutting tip help penetrate and remove GP at the cervical third quickly; the following files will penetrate the filling material more quickly, so the solvent effect, in this case, is insignificant. Takahashi et al. [23] evaluated the effectiveness of Protaper retreatment files in removing GP when combined with solvent, which gave different results from our study. The study results showed that using Protaper retreatment files combined with solvent took more time to remove GP than using Protaper retreatment files alone. This difference is because, in the study by Takahashi et al. [23], endodontic treatment was considered complete when no filling material was observed on the instruments, and no filling material was detected on the canal wall when observed with a surgical microscope. According to the author, using a surgical microscope to evaluate the filling material on the canal wall is time-consuming.

Furthermore, the author also believes that using solvent makes it challenging to remove the filling material due to forming a thin layer of GP adhering to the canal wall. When using R-Endo files in combination with solvent, the time to remove GP was significantly lower than when using R-Endo files alone ($p = 0.014$). The R-Endo file tip does not have a cutting effect. Therefore, when combined with solvent, the effectiveness is enhanced as the solvent softens the GP, making it easier for the file to penetrate and remove GP than when not using solvent. Purba et al.'s study [1] gave different results from our research; the time to remove GP when using R-Endo files in combination with solvent was not different from that of using R-Endo files alone ($p = 1.000$). In Purba et al.'s study [1], the author used an additional ultrasonic endodontic instrument to activate the solvent, increasing the treatment time compared to using solvent alone. This may be the reason for the difference in results between the two studies.

5. CONCLUSION

1. There was no difference in the effectiveness of gutta-percha removal between Protaper retreatment and R-endo systems. Using Protaper retreatment or R-Endo files combined with solvent left more gutta-percha on the canal wall than using Protaper retreatment or R-Endo files alone.

2. The average time for gutta-percha removal in the Protaper retreatment group was shorter than in the R-Endo group, although the difference was not statistically significant ($p > 0.05$). The average time for gutta-percha removal was significantly longer in the R-Endo group compared to the R-Endo group combined with solvent ($p < 0.05$).

Our study was conducted on a limited number of teeth with straight root canals. Therefore, we recommend further studies on a larger sample size, including teeth with curved and narrow root canals, to better reflect the diversity encountered in clinical practice. Moreover, to obtain a more comprehensive understanding of the outcomes of endodontic retreatment, more extensive research is needed on various rotary instrument systems, different root canal filling materials, and diverse techniques for removing root canal filling materials. This will help determine whether a single approach is clinically effective or whether a combination of different

methods is required to enhance the success of endodontic retreatment.

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