




# Comparison of the Time Required by Six Different Retreatment Techniques for Retrieval of Gutta-Percha: An In Vitro Study

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## Abstract

**Objective** A retreatment is a conservative approach than periapical surgery in case of failed root canal treatment. Retreatment techniques that are efficient and faster should be the main concern to treat endodontic failure. This study aimed to compare the time required by various hand and rotary retreatment systems for the retrieval of gutta-percha (GP) from root canals.

**Materials and Methods** A total of 120 extracted single-rooted premolar teeth with straight canals were chosen. Biomechanical preparation was completed using the Step-Back approach keeping the master apical file size 35. Then, teeth were down-packed and back-filled with System B device, along with AH Plus sealer. The teeth were categorized into six groups ( $n = 20$ ) at random as per techniques applied for retrieval of GP: group I hand instrumentation (Hedstrom files and Gates-Glidden drills); group II ProTaper Universal Retreatment (PTUR) system; group III Mtwo Retreatment (Mtwo R) system; group IV D-RaCe; group V R-Endo; and group VI Mani Gutta Percha Remover (NRT-GPR). A chronometer was used to measure the time required for retrieval of GP. Data were examined by comparative evaluation of one-way analysis of variance and chi-square test.

**Results** Among all the retreatment techniques used, D-RaCe was faster in GP retrieval than other groups. NRT-GPR system also took less time than other groups except for the D-RaCe system. The Mtwo R system was the slowest among all groups.

**Conclusion** D-RaCe retreatment instruments required extensively less time for retrieval of GP than other groups ( $p < 0.001$ ).

## Keywords

- gutta-percha
- retreatment
- time
- D-RaCe
- NRT-GPR

## Introduction

The success of endodontic treatment emphasizes shaping, chemo-mechanical debridement, and a three-dimensional hermetic seal. Despite a high degree of success (97%), failure may occur in root canal therapy.<sup>1</sup>

Inadequate chemo-mechanical preparation, iatrogenic mishaps, hermetic obturation, or reinfection by loss of coronal seal are credible grounds for endodontic failure. Residual microorganisms in unapproachable areas of root space and leakage of endotoxin may propagate periapical infection.<sup>2-4</sup>

Conventional retreatment, periradicular surgery, or extractions are the different treatment modalities for endodontic failure. Nonsurgical retreatment being the most conservative method reduces the microbial load substantially. Treatment of persistent endodontic infections is a crucial task convoluted by the complex anatomy of the root canal system.<sup>5</sup>

Many of the studies dictate a higher success rate of nonsurgical retreatment over endodontic surgery in a long term.<sup>6</sup> Considering the advantages of nonsurgical treatment, it should be done on a primary basis. All possible measures should be done to reduce pathogens in and around the apical third of the root, rather than removing the apical third of the root in periapical surgery. Reduction in root length and loss of periapical tissues may weaken the tooth for a masticatory load.

*Enterococcus faecalis* is the most prevalent species associated with persistent endodontic infections. It is a non-fastidious, therapy-resistant bacteria in infected root canals. Tackling of these microorganisms with irrigation regimens, and further removal of infected radicular dentin by instrumentation and intracanal medicaments is only possible after immediate and complete retrieval of gutta-percha (GP).<sup>7,8</sup>

Retreatment's primary objective is to restore access to the apical foramen by retrieving all of the GP. GP retrieval can be accomplished by hand files, ultrasonic aids, or rotary instruments. Slower techniques in retrieval of GP may lead to operator and patient fatigue. In such instances, apical pressure is exerted by rigid instruments, which may be harmful. Many complications may also be painstaking during retrieval of GP like ledge formation, canal transportation, and instrument separation.<sup>9</sup>

Hand files (K-type or Hedstrom files [H files]), Gates-Glidden (GG), or Peezo burs were initially used for GP retrieval, later replaced by rotary nickel-titanium (NiTi) instruments. Over time various retreatment NiTi systems distinctively designed for GP retrieval were designed with different cross-sections and working tips.<sup>10</sup> Rotary NiTi files are preferred over hand files because of their safety, efficiency, and faster GP retrieval. Rotary NiTi retreatment files with continuous or reciprocating motion as well as various heat treatments (M-wire, CM-wire, or blue technology) have been explored for efficacy in GP retrieval.<sup>11</sup> One must select a retreatment system that has absolute GP retrieval efficiency, does not damage root canal space, as well as quick in action.<sup>9</sup>

Along with efficacy, the time required for retrieval of GP is an essential factor to reach working length (WL). The lesser

the time is taken for retrieval of GP more instantly periapical infection can be attained. Efficiency and time taken to retrieve GP are two imperative factors for any retreatment technique. Many of the studies have proven the efficacy of retreatment systems over one another. In studies performed by Garg et al<sup>4</sup> and Alakabani et al<sup>12</sup> few retreatment systems were assessed for faster GP retrieval. Our study was planned to involve many retreatment systems specially designed for it, nonreciprocating and having multiple files system.

The rationale of the present work was to estimate and compare the time required to retrieve GP using various hand and rotary retreatment techniques.

## Materials and Methods

### Sample Preparation

A total of 120 freshly extracted premolar teeth with a single root were preferred. After radiographic evaluation, teeth with root curvature and calcification were excluded. All the samples were decoronated at 16 mm from the apex for better access and standardization. The patency of all teeth was examined with the #15 K-file (Mani Inc., Tochigi, Japan). WL was established by subtracting 1 mm at which a #15-K-file was detected at the apical foramen. Biomechanical preparation was done by the Step-Back approach, keeping master apical file size #35 K-file. Note that 3% sodium hypochlorite (NaOCl; Vishal Dentocare Pvt., Ltd., Ahmedabad, Gujarat, India) was used in-between the sequential filling of instruments.<sup>13</sup>

The final irrigation protocol was followed using 3% NaOCl and 17% ethylenediaminetetraacetic acid to remove the smear layer. Paper points were used to dry the canals. Tug-back of master cone GP was assured for WL. AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) was coated on root canals. Apical 5 mm of root canal space was down-packed with continuous wave compaction and the rest of the root canal was back-filled using System B (Analytic Sybron Dental Specialties, Orange, California, United States). Then, we restored the access cavity with Cavit and the samples were placed in an incubator at 37°C and 100% humidity to enable the sealer to be fully set.

### Retreatment Procedure

One hundred and twenty teeth were randomly separated into six groups and GP was retrieved by six different techniques.<sup>4,14</sup>

#### Group I: Hand Instrumentation

GP from coronal one-third was removed using GG drill (Dentsply Maillefer, Ballaigues, Switzerland) size 3 and subsequently size 2. GP was retrieved with H file size #30 to the WL using a circumferential filing motion.

#### Group II: ProTaper Universal Retreatment System (Dentsply Maillefer, Ballaigues, Switzerland)

In the ProTaper Universal Retreatment (PTUR) group, coronal one-third of GP was retrieved using the ProTaper D1 file (size 30, 0.09 taper). The middle portion of GP was retrieved with

ProTaper D2 (size 25, 0.08 taper) and the apical portion of GP was retrieved with ProTaper D3 (size 20, 0.07 taper). All of them were utilized with brushing action and lateral pressing movements (500 revolutions per minute [rpm] and  $3 \text{ Ncm}^{-1}$  torque).

#### Group III: Mtwo Retreatment System (VDW, Munich, Germany)

As per the manufacturer's specifications, the GP was retrieved to the WL by Mtwo Retreatment (Mtwo R) 15/0.05 and Mtwo R 25/0.05 retreatment instruments in a brushing action at a torque of  $1.2 \text{ Ncm}^{-1}$  and a speed of 300 rpm.

#### Group IV: D-RaCe System (FKG Dentaire Sa, La Chaux-de-Fonds- Switzerland)

As per the user manual DR1 (size 30, 0.10 taper) file is used for GP retrieval from the cervical third and commencement of the middle third at a torque of  $1.5 \text{ Ncm}^{-1}$  and speed of 1,000 rpm. The rest of the canal GP was retrieved with DR2 (size 25, 0.04 taper) at a torque of  $1 \text{ Ncm}^{-1}$  and speed of 600 rpm.

#### Group V: R-Endo System (Micro-Mega, Besançon, France)

The hand file of Rm stainless (size 25, 0.04 taper) was employed with one-quarter turn apically directed pressure for initial entry into GP. The Re instrument (size 25, 0.12 taper) was employed for the initial 2 to 3 mm of the canal, and R1 (size 25, 0.08 taper) was used to retrieve GP from the coronal third. R2 (size 25, 0.06 taper) was utilized to retrieve GP till the middle third. R3 (size 25, 0.04 taper) was used till WL with a circumferential filing motion from the apical third to the coronal third. A torque of  $1.2 \text{ Ncm}^{-1}$  and a speed of 350 rpm was used for rotary files.

#### Group VI: Mani Gutta Percha Remover (Gutta-Percha Remover) System (MANI, Utsunomiya, Japan)

2S file size 50 (taper 0.04) was used to remove GP till the middle of a root canal, and 4N file size 30 (taper 0.04) was used to remove GP till WL. Both files were used in the pull-stroke motion. According to the user manual, instruments were run at 1,000 rpm, and no torque control.

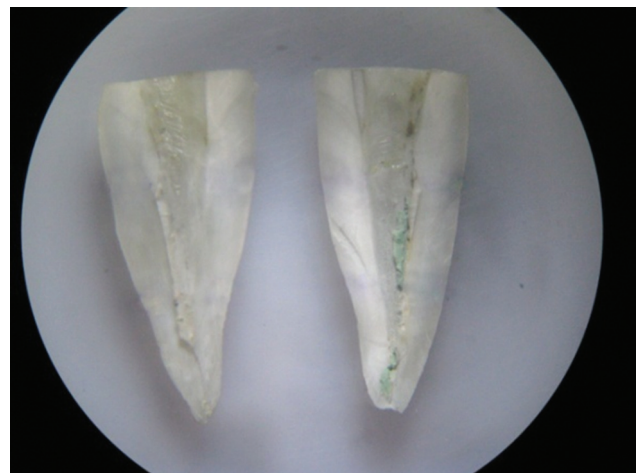
At every change of instrument, copious irrigation was done using 3% NaOCl. GP retrieval was assumed completed when the WL was achieved, and no remnants of GP can be observed on the final instrument utilized in each group. The GP retrieval time was registered from the beginning of GP retrieval to the point where retreatment was declared completed.<sup>4</sup> All the specimens were sectioned bucco-lingually and remnants of GP were analyzed under stereomicroscope (→Figs. 1–6). All the actions were done by an experienced single operator to exclude bias.

### Statistical Analysis

The time taken for retrieval of GP by each group was documented on a master chart. SPSS 16 software (Windows, Version 16.0, SPSS Inc, Chicago, Illinois, United States) was used to conduct the analysis of the collected data. To assess the significance of variation between variables, one-way

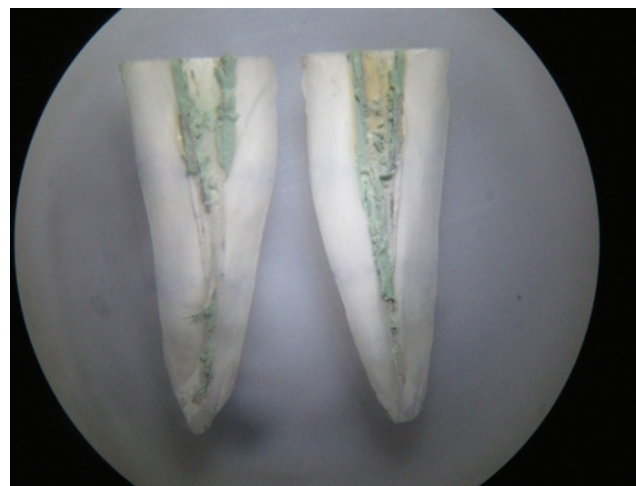


**Fig. 1** Hand instrumentation sample.



**Fig. 2** ProTaper Universal Retreatment (PTUR) sample.

analysis of variance tests for raw data and the “chi-square” test for consolidated data were employed with this software to consider mean, standard deviation (SD), and probability (p) values. A significant link was described by a p-value

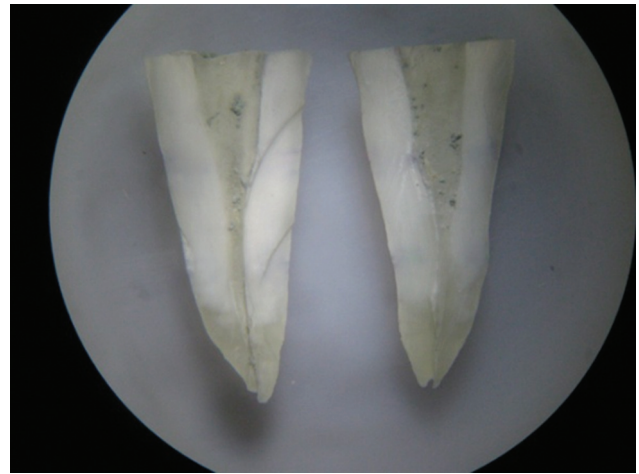


**Fig. 3** Mtwo Retreatment (Mtwo R) sample.





**Fig. 4** D-RaCe sample.



**Fig. 6** Mani Gutta Percha Remover (NRT-GPR) sample.



**Fig. 5** R-Endo sample.

of  $< 0.05$ . A total of 85% was the power of the study, and the significance level was 95% at 0.05 levels.

## Results

Mean  $\pm$  SD, maximum, and minimum values of the time required to retrieve GP (in seconds) using the six retreatment

techniques are shown in **Table 1**. Among all groups, the least mean time taken for GP retrieval was by the D-RaCe system and the highest time taken was by the Mtwo R system.

D-RaCe was significantly faster than all other retreatment groups ( $p$ -value  $< 0.001$ ) indicating the least time taken for GP retrieval as shown in **Table 2**. It can be noted in **Table 2** that Mani Gutta Percha Remover (NRT-GPR) was also considerably faster than other groups except for the D-RaCe system ( $p$ -value  $< 0.001$ ). In comparison to hand and rotary techniques, hand instruments were slower than the D-RaCe system and NRT-GPR system, but the hand instrumentation technique took less time than the R-Endo, PTUR system, and Mtwo R system.

**Tables 3–7** depict an intergroup comparison of the D-RaCe system with the PTUR system, Mtwo R file system, R-Endo file system, and NRT-GPR system, showing the D-RaCe system to be significantly faster in GP retrieval than other groups. The Mtwo R system took the highest time for GP retrieval than other groups ( $p$ -value  $< 0.001$ ).

Among hand instrumentation techniques, PTUR system, and R-Endo retreatment system, there was no statistically significant result in GP retrieval time ( $p$ -value 0.266) as shown in **Table 8**. In this study, these GP retrieval systems are comparatively slower.

**Table 1** Mean  $\pm$  SD, maximum, and minimum values of the time required to retrieve GP (in seconds) using six retreatment techniques

Groups	No. of samples	Mean	SD	Standard error	Max	Min	Median
Hand instrumentation	20	337.7	44.891	10.038	408	248	336
ProTaper Retreatment file system	20	370.7	52.584	11.758	445	293	375
Mtwo Retreatment system	20	578.9	56.303	12.59	708	515	560
D-RaCe file system	20	140	19.767	4.42	170	113	137
R-Endo file system	20	355.3	85.341	19.083	472	232	351.5
NRT-GPR system	20	220.7	68.973	15.423	358	126	218

Abbreviations: GP, gutta-percha; NRT-GPR, Mani Gutta Percha Remover; SD, standard deviation.

**Table 2** Comparison of mean time required for retrieval of GP (seconds) using six retreatment techniques

Overall, six groups	Hand instrumentation	ProTaper Retreatment file system	Mtwo Retreatment system	D-RaCe file system	R-Endo file system	NRT-GPR system
Mean	337.7	370.7	578.9	140	355.3	220.7
SD	44.89	52.58	56.3	19.77	85.34	68.97
p-Value	Less than 0.001 significant					

Abbreviations: GP, gutta-percha; NRT-GPR, mani gutta percha remover; SD, standard deviation.

**Table 3** Intergroup comparison between group IV and group I

Group IV vs. Group I	D-RaCe file system	Hand instrumentation
Mean	140	337.7
SD	19.77	44.89
p-Value	Less than 0.001 significant	

Abbreviation: SD, standard deviation.

**Table 4** Intergroup comparison between group IV and group II

Group IV vs. Group II	D-RaCe file system	ProTaper Retreatment file system
Mean	140	370.7
SD	19.77	52.58
p-Value	Less than 0.001 significant	

Abbreviation: SD, standard deviation.

**Table 5** Intergroup comparison between group IV and group III

Group IV vs. Group III	D-RaCe file system	Mtwo R system
Mean	140	578.9
SD	19.77	56.3
p-Value	Less than 0.001 significant	

Abbreviations: Mtwo R, Mtwo retreatment; SD, standard deviation.

The rank of retreatment systems considering the mean time taken to complete retreatment was D-RaCe system < NRT-GPR system < H file < R-Endo system < PTUR system < Mtwo R system as shown in **Graph 1**.

**Table 8** Intergroup comparison between group I, group II, and group V

Group I, II, and V	Hand instrumentation	ProTaper Retreatment file system	R-Endo file system
Mean	337.7	370.7	355.3
SD	44.89	52.58	85.34
p-Value	0.266 not significant		

Abbreviation: SD, standard deviation.

**Table 6** Intergroup comparison between group IV and group V

Group IV vs. Group V	D-RaCe file system	R-Endo file system
Mean	140	355.3
SD	19.77	85.34
p-Value	Less than 0.001 significant	

Abbreviation: SD, standard deviation.

**Table 7** Intergroup comparison between group IV and group VI

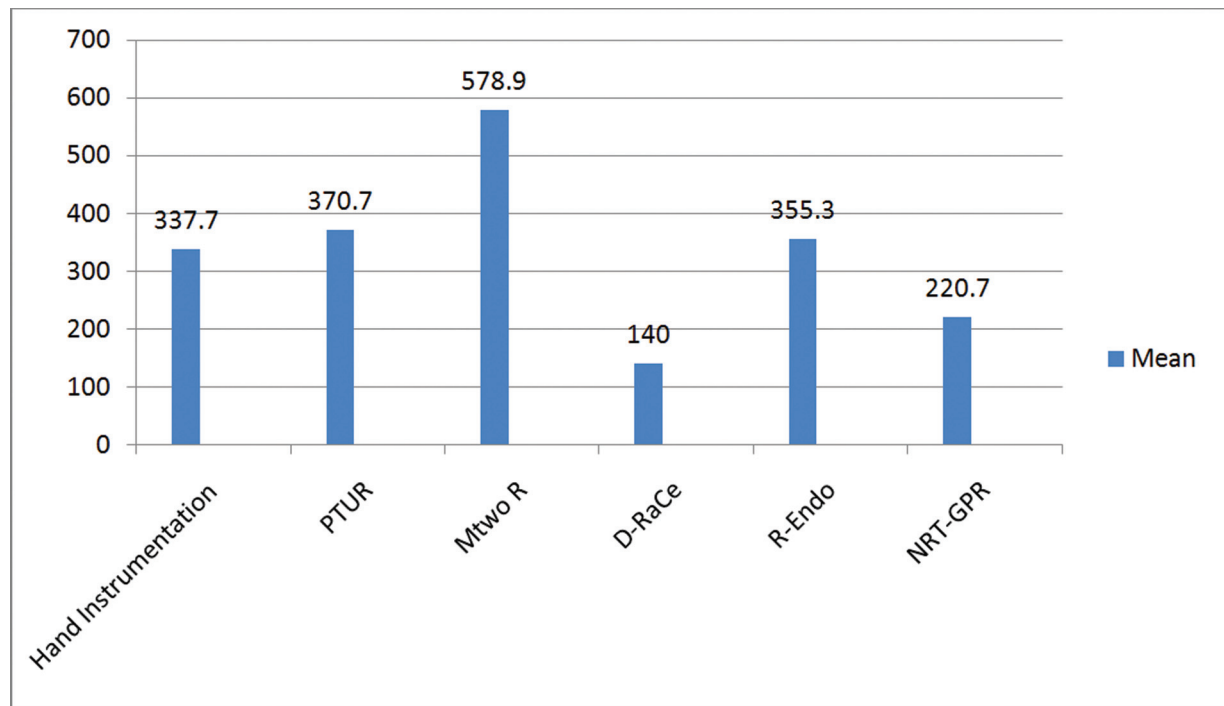
Group IV vs. Group VI	D-RaCe file system	NRT-GPR system
Mean	140	220.7
SD	19.77	68.97
p-Value	Less than 0.001 significant	

Abbreviations: NRT-GPR, mani gutta percha remover; SD, standard deviation.

## Discussion

Endodontic retreatment has chiefly replaced endodontic surgery for the elimination of persisting periapical infection. In way to that, complete retrieval of GP and sealer is essential for exposure of remnants of necrotic tissue or viable pathogens.<sup>15</sup>

Many retreatment systems are available at present which put the operator in dilemma to choose. Irrespective of which retreatment system was used, all were not significant incomplete retrieval of GP from the apical one-third of the root. The intention of this research was to focus on the capability of retreatment systems to reach WL as early as possible,



Graph 1 Comparison of mean time for all six groups in seconds.

which is very essential to elevate underlying periapical infection.

Reduced working time, operator fatigue, and maintenance of canal shape are the supremacy of rotary files over hand files. At the same time, extrusion of debris through the apex, higher incidence of file separation, and alterations of root canal morphology are limitations of rotary systems.<sup>16,17</sup>

Decoronation of teeth was done to standardize WL, which facilitates easy root canal access. Radiographs, longitudinal sectioning, cone-beam computed tomography, and micro-computed tomography are methods to evaluate the complete removal of GP. Longitudinal sectioning was used in this study, in sight of the fact that radiographs are not a suitable method to assess complete retrieval of GP from root canal space.<sup>13</sup>

Solvents were not used in this present study in view of time consumption and insignificant results of many studies done with or without using solvents. In fact, many studies concluded with more remnants of GP and sealer on root canal walls when the solvent was used in the retreatment procedure.<sup>18</sup> Rotary instruments plasticize the GP due to friction, enabling easy removal and elevating the necessity of using solvents. Due to the uncertainty of WL in endodontic retreatment, the use of solvents may further irritate periapical tissue.

D-RaCe retreatment system consisting of DR1 and DR2 files was most efficient in faster retrieval of GP. These files have triangular cross-sections and alternating cutting edges which avoid undesirable screwing effects, making them more effective. DR1 has an active tip that assists in easy and rapid penetration in the GP. The special electrochemical treatment creates a smooth instrument surface, which might be a con-

tributing factor to the superior sharpness of these instruments. Enhanced cutting efficiency may be due to less adherence of the GP.<sup>4,16</sup> D-RaCe system was related to extensively less residual obturation material.<sup>14,19</sup> The results of the present research are in line with Garg et al<sup>4</sup> and state that the D-RaCe system is most efficient in faster retrieval of GP.

NRT-GPR system consists of four files 1S, 2S, 3N, and 4N of 0.04 taper. 1S (size #70, length 16 mm) and 2S (size #50, length 18 mm) are made of stainless steel, used to retrieve GP till middle section of the root. 3N (size #40, length 21 mm) and 4N (size #30, length 21 mm) are made of NiTi alloy used to retrieve GP till apical section of the root. They possess only one cutting edge and one groove. NRT-GPR has R-Phase NiTi cutting edge. They have a broad radial land and a neutral cutting angle, which decreases cutting capacity and screw impact while increasing abrasion, supporting the manufacturer's instructions to use without torque control. Alberto Rubino et al reports PTUR system is more efficient in GP retrieval than NRT-GPR but none of the studies have compared the GP retrieval time.<sup>20</sup> In the present study, the NRT-GPR system is faster in GP retrieval than many retreatment systems except D-RaCe.

Among all the rotary retreatment techniques, R-Endo consists of the highest number of rotary files set for retrieval of GP. In the current research, R-Endo is faster than Mtwo R files but slower than all other groups, this observation is in accordance with Garg et al study. R-Endo was slower than the D-RaCe system which accounts for the lack of active tip and radial land making it difficult for initial penetration and progression into GP.<sup>4,15</sup>

In this study, the PTUR system is slower in GP retrieval than all groups except the Mtwo R system. PTUR files have a

progressive taper and convex triangular cross-section. Among D1, D2, and D3 only D1 has an active cutting tip, which assists in better initial penetration into GP. D2 and D3 have lesser tip size, and perhaps do not connect with the root canal walls inside the apical region. Uezu et al concluded in their research that ProTaper universal treatment files are faster than PTUR files due to progressive taper and increased tip size of shaping and finishing files.<sup>21</sup> The outcome of our study is in contrast with Purba et al, where the authors advise that the specific flute design of PTUR files cuts both GP and the “superficial layer” of dentin in GP retrieval.<sup>22</sup>

The cross-sectional design of the instrument has a significant characteristic role in the capability of the NiTi rotary file for retrieval of GP. Mtwo R instruments have a positive rake angle, two cutting edges, and an S-shaped cross-section to cut dentine efficiently. In spite of having a cutting tip and a constant helical angle for unforced progression into GP, many studies conclude insignificant complete removal of GP.<sup>15</sup> Iribos and Sazak Öveçoğlu report PTUR system is more competent in faster retrieval of GP than the Mtwo R system.<sup>23</sup> Kumar et al compared the Mtwo R system with the hand file and HyFlex NT file and concluded that the Mtwo R system is quicker than the other two groups.<sup>24</sup> Indeed in our study, its performance was much slower than all other groups. Small instrument core and high flexibility may be contributing factors to poor performance.

Many studies put forward that hand instrument technique is slower in the retrieval of GP than the rotary technique.<sup>25,26</sup> Rotary instruments generally plasticize GP by generating heat via friction, thus rapidly and easily enabling them to achieve the WL. It was estimated in the present study that the hand instrument technique was quicker in the retrieval of GP than PTUR, R-Endo, and Mtwo R systems. This finding is congruent with Imura et al and Schirrmeister et al which may be explained by the fact that faster rotation of GG drill plasticizes GP in the coronal third of the root canal and larger pieces of GP were removed by H files.<sup>27,28</sup>

All the standard protocols were followed in this study like apical preparation size of #35 which facilitates irrigation (30 gauge) near WL, continuous wave of compaction and backfill which reduces the amount of sealer volume, periodic change of instrument after every 3 to 5 teeth sample, and operation by a single experienced operator to avoid bias.

It can be suggested from this study that the D-RaCe system made of NiTi alloy is a faster method of GP retrieval due to its superior sharpness, triangular cross-section, and alternative cutting edges. NRT-GPR system made of stainless steel and NiTi alloy files is a good alternative to the D-RaCe system. Although files of the Mtwo R system have active tips, their effectiveness in rapid GP retrieval is uncertain.

## Conclusion

Within the confines of the present research, it may be concluded that the D-RaCe system was faster than all other groups in the retrieval of GP. NRT-GPR group was also faster

than other groups except for the D-RaCe system. Mtwo R system was comparatively slower in GP retrieval than all other groups.

## Conflict of Interest

None declared.

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