

Article

Two Nickel-Titanium Retreatment Tools, Respectively, Cleaning Effects on Root Canal Filling Materials Are Compared

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Abstract: objective : To compare the effectiveness of the ProTaper Universal, R-Endo retreatment files, and a Hedstrom manual technique in the removal of gutta—percha during retreatment. Methods: 60 single-rooted straight mandibular premolars were selected. The root canals of all suitcases were formed by Nickel-Titanium revolving apparatuses Hero 642, and obturated with the lateral strengthening technique. Then all cases were randomly divided into 3 groups(n=20) and prepared with a Hedstrom manual technique. ProTaper Universal and R—Endo retreatment files, respectively. Eucalyptol was used as a solvent in the treatment. For all roots, the subsequent data were documented : practical mistakes and time of retreatment. Bucco-lingual and proximal radiographs of the roots were taken, and the percentage area was calculated. The remaining material was premeditated by separating the area of the outstanding filling substantial by the area of the canal partition. Information was statistically analyzed with Kruskal-Wallis and Mann-Whitney U tests ($P=0.05$) . Results : None of the techniques completely removed the root filling materials. The remaining filling material was meaningfully less after physical instrumentation than R-Endo or ProTaper composition ($P<0.05$) . The ProTaper and R-Endo retreatment documentations had a positive influence, in dropping the time for retreatment ($P<0.05$) . Conclusion : All tested instruments cannot completely remove the filling material inside the root canal. ProTaper, and R-Endo rotary instruments work faster than manual instruments

Keywords: Root canal retreatment ; Nickel-titanium rotary instrumentation ; Root canal preparation

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1. Introduction

Elimination of the original filling from the root canal is the most critical step in root canal retreatment. Removal of gutta-percha, which is tightly bound to the root canal, is time-consuming and laborious, and is primarily accomplished using manual instruments, mechanical nickel-titanium instruments, thermal transfer devices, and ultrasonic methods [1]. Studies have found that the efficiency of gutta-percha removal varies among various nickel-titanium instruments, and complications such as step-downs and fractures are also high. The ProTaper Universal and R-Endo instruments are two new nickel-titanium retreatment instruments specifically designed for gutta-percha removal and access. Currently, comparative evaluations of these two instruments are limited [2]. This study established a retreatment root canal model and, using radiographic analysis combined with imaging software, compared the efficiency of the ProTaper Universal, R-Endo, and manual H-files in eliminating filling material from the root canal. The characteristics of each instrument were analyzed for clinical application [3].

2. Materials and Methods

1.1 Sample Tooth Preparation

Excised mandibular premolars were collected. Inclusion criteria for excised teeth included: intact teeth with fully developed root apex, no fillings or restorations, no resorption, no fractures or longitudinal cracks, no prior endodontic treatment, a single round root canal with a curvature of $<5^\circ$, and a root length of approximately 18–20 mm. The teeth were ultrasonically cleaned of soft tissue and calculus and then immersed in a 4% formaldehyde solution. The teeth were opened, and a No. 10 K file was inserted into the root canal until the file tip was visible at the apical pore. Root canal preparation was terminated by subtracting 0.5 mm. To maintain uniform tooth length, the crown was removed with an abrasive disc, resulting in a working length of 15 mm for each root [4].

1.2 Root Canal Preparation and Filling

To standardize apical diameters, excised teeth with apical apertures larger than ISO 20# were discarded. Root canals were prepared crown-down using a Hero 642 nickel-titanium rotary instrument to a diameter of 30# and a taper of 0.4. This standardized the final number of apical preparations, resulting in all canals having a diameter of 30# and a taper of 0.4. During preparation, 5 ml of 5.25% sodium hypochlorite was used for irrigation with each change of the enlarging file. After preparation, the root canals were soaked in 1 ml of 17% EDTA for 30 seconds to remove the smear layer, and finally rinsed with 5 ml of normal saline. The root canals were dried with paper points and filled with conventional (2% taper) gutta-percha points and bilan paste using lateral pressure. The canal orifices were temporarily sealed with glass ionomer [5]. All procedures were performed by the same operator using standard techniques.

All teeth were stored at 37°C at 100% humidity for 7 days to allow the sealant to set.

1.3 Root Canal Retreatment

Teeth were randomly divided into three groups, 20 in each. Temporary sealing was removed, and 1 mm of filling material was removed using a G drill. 0.1 ml of eucalyptol dissolving agent was placed in the gutta-percha at the root canal orifice for 3 minutes. The order of instrument use and working lengths are shown in Table 1.

Table 1. sequence procedure with instrument and working length (WL)

Hand Instruments	Group M WL (mm)	Group P Protaper Universal	Group P WL (mm)	Group R R- Endo	Group R WL (mm)
#3 GG Diamond	2	D1 (30#, 9%)	5	Rm (25#, 4%)	3
#2 GG Diamond	5	D2 (30#, 8%)	10	Re (25#, 12%)	3
#1 GG Diamond	8	D3 (30#, 7%)	15	R1 (25#, 8%)	5
#25K File	10			R2 (25#, 6%)	10
#20K File	15			R3 (25#, 4%)	15
#25K File	15			Rs (30#, 4%)	15
#30H File	15				
#35H File	14				
#40K File	13				
#45K File	12				
#50K File	11				

Group M (Manuel Instruments) used hand-held H files. First, a G drill was used to remove 3–5 mm of filling material from the root canal orifice. H files #30, #25, and #20 were then used to remove filling material from the root canal. Once the working length was

reached, the root apex was prepared to #30. Finally, a stepwise retraction technique was used, increasing the instrument size by one per mm, until the root canal was prepared to #50. The final apical diameter was 0.30 mm, with a taper of 0.05.

Group P used the Protaper Universal. D1 was used to prepare the coronal portion of the root canal, D2 and D3 to prepare the mid-root and apical portions, respectively. During preparation, a "brushing" motion was applied with gentle lateral pressure to clean the root canal walls. Finally, D3 was used to reach the working length. The final apical diameter was 0.30 mm, with a taper of 0.07.

Group R used the R. Endo. Manual pressure was applied to the root apex with the Rm, breaking the hard surface of the filling to create access for the next instrument. The Re then enlarged the root canal orifice. R1, R2, and R3 were used to sequentially prepare the coronal, mid-root, and apical segments. Finally, the Rs (30#, 0.04 taper) was used to prepare the root canal to working length. All instruments, except the Rm, used a circumferential widening maneuver for root canal cleaning. The final apical diameter was 0.30 mm, and the taper was 0.04. Groups P and R used mechanical retreatment instruments. Driven by the endodontic treatment motor, the root canal filling material was removed using a crown-down approach at a constant speed (400 r/min in group P, 300 r/min in group R) with gentle apical force. After preparation reached a certain depth, the instrument blade was inspected, and debris was cleaned from the instrument groove. Only 10 root canals were treated with each instrument. During the preparation process in all three groups, the eucalyptol dissolving agent was continuously updated (approximately 0.5 ml per root canal). Each time an enlarging file was changed during preparation, 5 mL of 5.25% sodium hypochlorite was used for irrigation. After preparation, the root canal was soaked in 1 ml of 17% EDTA for 30 seconds to remove the smear layer, followed by a final irrigation with 5 ml of normal saline. Retreatments: Complete completion criteria included:

- ① The last instrument reached its working length, no filling material remained on the instrument surface, and no filling material debris was observed in the irrigation solution;
- ② The root canal wall was smooth and free of visible debris. Finally, a temporary sealing material was used to seal the root canal orifice.

1.4 Evaluation of Retreatments Outcomes

1.4.1 Evaluation of Root Canal Cleanliness: Digital radiographs of the three groups of specimens were taken from two angles: buccal-lingual and mesio-distal. Using AUTO-CAD 2000 image analysis software, the root canal was divided into three sections: coronal, mid-radial, and apical. The percentage of root canal wall area covered by filling material and the original root canal wall area in each section was analyzed [6]. The analysis did not distinguish between root filling material and root canal paste covering the root surface.

1.4.2 Operational Safety and Efficiency: The occurrence of blockages, steps, and perforations during retreatment was recorded. The operation time required for the complete cleaning of each root canal was recorded.

1.4.3 Instrument Evaluation: A physician blinded to the significance of the experiment performed 10 root canals with each instrument. After use, the instrument was placed under a 10x microscope and observed for deformation and separation.

1.5 Statistical Analysis: Data are expressed as $\pm s$. Operation time was analyzed using a one-way analysis of variance. The root canal cleanliness index, i.e., the filling material covering the root canal, was significantly different from the root canal cleanliness index. The percentage of the root canal wall area of the modified material and the original root canal wall area was analyzed using analysis of variance [7].

2. results

2.1 Evaluation of residual filling material

The results of the filling materials and residues of each group are shown in Figure 1. The percentage of the residual filling material on the tube wall to the total filling material is shown in Table 2. The residual amount of filling material in group P was significantly lower than that in group P and group R ($P < 0.05$). The residual amount of filling material

in group P was lower than that in group R, but there was no significant difference between the two groups. The residual fillings in the root canals of each group were mostly located in the middle and lower parts of the root canals.

Table 2. the area of percent (%) reming filling material in each third rootcannels

Group	Buccal & Lingual - Root and Crown	Buccal & Lingual - Middle Part of Root	Buccal & Lingual - Apex	Mediolateral - Root and Crown	Mediolateral - Middle Part of Root	Mediolateral - Apex
Group M	2 ± 7	12 ± 5	29 ± 13	4 ± 7	11 ± 6	28 ± 16
Group P	12 ± 16	32 ± 17	37 ± 15	9 ± 7	23 ± 15	36 ± 19
Group R	14 ± 15	31 ± 17	42 ± 19	9 ± 8	25 ± 21	40 ± 23

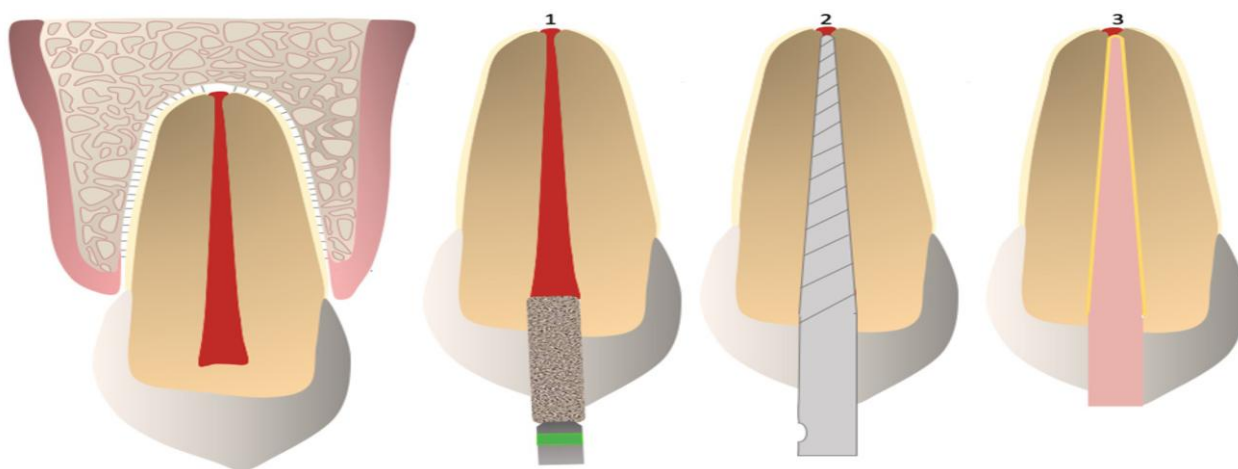


Figure 1. Images of gutta-percha and sealer remaining on the root canal walls in different groups

2.2 Time to remove filling material (Table 3)

The average operation time of group M was significantly higher than that of group P and group R ($P < 0.05$), and the average operation time of group P was lower than that of group R, but there was no statistical significance. During the operation, D1 in group P caused a step on the upper part of the tube. It was formed and then eliminated by hand using instruments to pass over it without perforation.

Table 3. Time required for removal of filling materials in different groups

Group	Time(s)
Group M	532 ± 24
Group P	327 ± 33
R group	343 ± 25

2.3 Instrument deformation and fracture

In group M, no instruments were broken or deformed. In group P, two D2 instruments were deformed, and one D3 instrument was broken. In group R, one R3 instrument was deformed.

3. discussions

During retreatment, it is important to completely remove gutta-percha from improperly prepared or filled root canal systems, as these may contain necrotic tissue. Necrotic tissue or bacteria can become the source of future periapical disease. Many methods have

been reported for evaluating residual root filling material, including longitudinal splitting, transparent specimen analysis, and CT scanning. This study used radiographs combined with imaging software analysis, which does not damage tooth tissue and is more reliable than longitudinal splitting, which can lose residual gutta-percha and sealant during root splitting. Radiographic evaluation is a semiquantitative method and has limitations. X-ray images only provide two-dimensional information within a three-dimensional structure, which can result in magnification or distortion. Small amounts of residual material may be lost, and it is also impossible to distinguish between gutta-percha and sealant. To improve the accuracy of this method, this study observed the teeth from two angles, and a skilled operator, unaware of the experimental groupings, marked the outline of the residual material on the radiographs. Currently, most international studies focus on the removal of root canal material using nickel-titanium root canal preparation instruments. However, differences in the nickel-titanium systems used, evaluation methods, and canal morphology of the samples result in significant discrepancies in the results (16). Many studies report that machine-applied nickel-titanium instruments are more effective than hand instruments in cleaning. For example, in straight root canal retreatment, Giuliani et al. found that the Protaper Universal cleaned more thoroughly than hand instruments. For curved root canals, Unal et al. found that hand instruments cleaned more thoroughly than the Protaper Universal and R-Endo. Gergi et al. found no difference in the percentage of residual material in root canals after preparation using hand, Protaper Universal, and R-Endo. Tong Fangli et al. experimented comparing Protaper Universal, Mtwo, and hand instruments in oval root canals and found that the percentage of residual filling material in the hand instrument group was significantly lower than that in the Protaper Universal group. The results of this learning showed that while none of the instruments could entirely remove residual material from the root canal, the amount of residual filling material in the canal wall was significantly lower in the hand instrument group than in the ProTaper and R-Endo groups, and similar to the results of Unal and Tong Fangli. This may be due to the following reasons: While other studies have primarily used straight root canals of maxillary anterior teeth, this study used mandibular premolars, which have straighter middle and upper root canals. The G drill in the hand instrument group was able to clean the middle and upper root canal more thoroughly. The root canal shape is oval, and the H file has a smaller taper than the nickel-titanium instrument, making it easier to approach the lateral wall of the oval root canal. Furthermore, the combination of the H file and the K file can remove large pieces of gutta-percha. The residual filling material in the three groups in this study was significantly reduced. The fillings were concentrated in the middle and lower third of the root canal, consistent with the findings of most other studies. This is primarily due to the better functional difference in the apical third, making cleaning more challenging. The ProTaper Universal group had less residual filling than the R-Endo group, but the difference was not statistically significant. The Protaper Universal instruments, D1 and D3, feature a gradual taper and sharp cutting edges, providing strong cutting force, capable of removing not only gutta-percha but also some dentin. Their groove design allows for the insertion of gutta-percha into the groove and its removal from the root canal. While the D1 has a cutting tip that can penetrate gutta-percha, it can also easily cause steps and lateral penetration. In contrast, the R-Endo, with its non-cutting tip and three equally sized cutting edges, is relatively safe, but its smaller taper (0.04) after preparation compromises its cleaning effectiveness. Factors influencing instrument operation time include instrument removal efficiency and the number of instruments used. Given the same cleaning efficiency, too many instruments can reduce the speed. In this study, although the use of H files in the hand group accelerated the removal of large pieces of gutta-percha, frequent instrument changes in the hand group reduced the speed. Similarly, the Protaper Universal (3 instruments) had similar cutting efficiency to the R-Endo, but with fewer instruments than the R-Endo (5 instruments), the operation was faster. Domestic and international studies also suggest that

machine instruments are faster than hand instruments. Taper design is a key factor affecting fracture resistance.

4. Conclusions

The Protaper Universal's increased tendency to fracture may be related to its large taper. In this study, one Protaper Universal instrument fractured and two deformed, while only one R-Endo instrument (R3) was found to deform. Given the same number of root canals, the R-Endo instrument has greater durability. Both Protaper Universal and R-Endo retreatment instruments effectively and quickly remove gutta-percha. Each has its own unique characteristics, requiring selection based on the specific characteristics and root canal morphology. For example, the R-Endo is recommended for more curved root canals to minimize instrument separation; the Protaper Universal will achieve faster cleaning in larger root canals. However, like hand instruments, they cannot completely remove all material from the root canal and require access to be established with hand instruments before preparation, following the principles of nickel-titanium instrument use.

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