Original Research Article

Comparison of Efficacy of H-File and ProTaper for Removal of Gutta-Percha from Root Canal in Non-Surgical Endodontic Retreatment: An *in-vitro* Study

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Abstract: *Effective removal of root canal filling materials is critical for successful endodontic retreatment. Various instrumentation systems have been developed to optimize gutta-percha removal. Among them, hand files such as Hedström (H) files and rotary systems like ProTaper Universal Retreatment files are commonly used.* ***Objective:*** *To compare mean percentage of total root canal filling material remaining between H-files and Pro Taper universal retreatment rotary system extracted teeth with root canal fillings.* ***Study Design:*** *Randomized controlled trial.* ***Place and Duration of Study:*** *Department of Operative Dentistry, Islamic International Dental Hospital, Islamabad from 30th September 2024 to 29th March 2025.* ***Methodology:*** *Sixty extracted single-rooted teeth were divided into two groups (30 each for H-file and ProTaper). After access cavity preparation and working length determination, canals were shaped up to a size 40 K-file using the step-back technique. Irrigation was done with 1% sodium hypochlorite, saline, and 17% EDTA, then obturated using gutta-percha and zinc oxide eugenol sealer. The teeth were stored at 37°C in 100% humidity for 30 days. After decoronation, the teeth were randomly assigned to either the H-file group or the ProTaper group. Retreatment began with gutta-percha removal using Gates Glidden drills and xylene, followed by retreatment with the respective systems. Roots were sectioned and examined under a 100xmicroscope, and images were analyzed with AUTOCAD software. Statistical analysis was done with the use of SPSS software, version 22.0. Descriptive statistics (mean and standard deviation) were calculated to assess the amount of residual gutta-percha in the canals of both experimental groups (H file and ProTaper).* ***Results:*** *The Shapiro-Wilk normality test revealed that the distribution of the amount of remaining gutta-percha in Group A (H files) and Group B (ProTaper) was not normal. The p-values were 0.039 for Group A and 0.045 for Group B—both less than the 0.05 level—indicating that the data are not normally distributed in either group. The results showed a statistically significant difference in the amount of the remaining gutta-percha after retreatment with H files (Group A) and ProTaper files (Group B). Group A (H files) had a significantly lower mean rank of 16.65, while Group B (ProTaper) had a higher mean rank of 44.35. This reflects that samples treated with H files had significantly less gutta-percha than the samples instrumented with the rotary ProTaper system. The sum of ranks also reflected this difference, being 499.50 for Group A and 1330.50 for Group B.* ***Conclusion:*** *In conclusion the ProTaper file-instrumented specimens (Group B) had significantly higher mean ranks compared to the H file-treated specimens (Group A), indicating that H files were more effective in removing gutta-percha from the root canal system (p < 0.001).*

Keywords: Gutta-percha, H-file, ProTaper, Endodontic retreatment

Introduction

The main aim of root canal therapy is to eliminate the bacteria and debris from the intricate anatomy of root canals by meticulous cleansing and shaping (1). Sealing of the canals by a combination of sealer and gutta-percha follows this procedure to avoid reinfection (2). Treatment failure is still possible due to procedural or non-procedural reasons. In these cases, nonsurgical retreatment is usually the best method to correct any lingering problems and restore the health and function of the tooth (3).

Retreatment means removal of old root canal filling material, through and through cleaning, shaping, and re-sealing of canals (4). Non-surgical retreatment is often found to be favored for treating unsuccessful endodontic cases (5). The primary step here includes the thorough extraction of gutta-percha from the root canal system. Many instrumentation techniques are used, like H-files, safe-sided H-files, ProTaper Universal rotary system, and ultrasonic retreatment tips. Manual debridement with H-files is very effective because of the enhanced friction that is supplied by their roughened finish (4,6). Studies indicate that ultrasonic retreatment tips exhibit better efficacy in removing gutta-percha and sealer from root canals than other techniques. The reason behind this effectiveness lies in ultrasonic vibrations, which dislodge filling material from the canal walls (1, 7). Ultrasonic heat also softens

and aids in removing gutta-percha (8).

Kasam et al. compared the effectiveness of different endodontic files to debride gutta-percha and sealer based on apical debris extrusion and time of gutta-percha removal. They presented the mean percentage of coronal, middle, and apical third remaining root canal filling material for two groups. In the coronal region, H-files retained 7.38% (SD±0.41) and proTaper retreatment files removed 7.71% (SD±0.37). In the middle area, H-files removed 13.82% (SD±0.57) and proTaper retreatment files removed 11.29% (SD±0.49). In the apical region, H-files retained 15.71% (SD±0.33), while ProTaper retreatment files removed 13.82% (SD±0.57) (4).

The importance of this research lies in the function of non-surgical endodontic retreatment as a minimally invasive and patient-friendly treatment option for treating failed root canals. Through the resolution of treatment failures, retreatment ensures the conservation of natural dentition and avoids extractions. Among the several instruments used for gutta-percha removal, H-files and proTaper systems are commonly employed because they are easy to use, less technique-sensitive, and economical. But notwithstanding the clinical interest of this issue, there are no local studies on the matter. Moreover, anatomical variations due to genetic and ethnic considerations underscore the

importance of comparative research to assess the efficacy of these two instruments among various populations.

Methodology

A randomized controlled trial was done from 30th September 2024 to 29th March 2025, at the Department of Operative Dentistry, Islamic International Dental Hospital, Islamabad. A total sample size was 60(30 each group), using a statistical calculation calculated on OpenEpi. The sample was drawn from the reported mean values of coronal root canal filling material: 7.38 ± 0.41 for H-file and 7.71 ± 0.37 for Protaper. The parameters for this calculation were set at a confidence interval of 95% and test power of 80%. The study included only single-rooted fully developed teeth with fully developed root structure, no history of previous endodontic treatment, and no internal or external root resorption. Teeth were excluded if they showed root fracture during extraction or had dilacerated root anatomy. Non-probability consecutive sampling was used. The single-rooted extracted teeth were debrided and stored in normal saline. Access cavity was done, and working length was determined 1 mm short of the apical foramen using a 15 K-file. The canal was flared up to size 40 K-file based on the step-back technique. Canals were irrigated during the instrumenting phase with 2 ml of 1% sodium hypochlorite solution, followed by saline. 17% EDTA solution was used for 3 minutes, and then the area was rinsed with normal saline. Canals were dried using paper points before obturation with zinc oxide eugenol-based sealer and gutta-percha through the lateral condensation technique. Zinc oxide eugenol cement was used to seal the coronal access cavity. Lastly, the treated teeth were stored at 37°C with 100% humidity for about 30 days to allow adequate setting of the sealer. The teeth were decoronated at the cementoenamel junction with an enamel disk. The teeth were randomly divided by lottery system into two groups: the H-file group and the ProTaper group, each containing an equal number of teeth. Retreatment involved the removal of 2–3 mm of gutta-percha from the coronal segment using Gates Glidden drills. A drop of xylene was applied to the tooth for 2 minutes to assist the procedure. Two methods were used to retreat the teeth: H-files and the ProTaper Universal Retreatment rotary system. Following the extrusion of gutta-percha and sealer by these treatments, the roots were sectioned longitudinally into coronal, middle, and apical thirds with the assistance of a chisel. Sections were studied

$$\text{Volume\% of remaining filling material} = \frac{\text{Volume of remaining filling material}}{\text{Volume of original filling material}} \times 100$$

under a microscope at 100X magnification. Photographs of the specimens
    The proportion of residual filling material on the canal walls was calculated using the following formula.

GroupcA: H files
Hand instrumentation using H files, sizes 15-40, was carried out in a crown-down manner to remove gutta-percha.

Group B: (Universal treatment rotary system)
A ProTaper file system was utilized in a crown-down approach. The coronal third gutta-percha in the root canal was eliminated through the use of the D1 ProTaper file (300 rpm, 0.09 taper). Gutta-percha within the coronal two-thirds was eliminated utilizing the D2 ProTaper file (300 rpm, 0.08 taper). Complete removal of any remaining gutta-percha was carried out by the D3 ProTaper file (300 rpm, 0.07 taper), applying gentle pressure.

Statistical analysis was done with the use of SPSS software, version 22.0. Descriptive statistics (mean and standard deviation) were calculated to assess the amount of residual gutta-percha in the canals of both experimental groups (H file and ProTaper). The Shapiro-Wilk test was used to determine the normality of the data distribution of residual gutta-percha. Depending on the result of the normality test, either the independent samples t-test (in case of normally distributed data) or the Mann-Whitney U test (in case of non-normally distributed data) was applied to compare the two groups. Analysis was also stratified by tooth type (incisor, canine, and premolar) and dental arch (maxillary and mandibular) to identify any effect modification. Subgroup comparison was then performed after stratification using the independent samples t-test. Less than 0.05 was used as a statistically significant p-value. Categorical variables like arch location and tooth classification were expressed in terms of frequencies and percentages.

Results

The maxillary arch was more frequently affected in both groups, with 18 (60.0%) cases in Group A (H files) and 16 (53.3%) cases in Group B (ProTaper), making a total of 34 (56.7%) cases. In contrast, the mandibular arch had 26 (43.3%) cases. As for the nature of teeth treated, the most commonly involved were the 1st premolars, accounting for 37 (61.7%) of all cases—16 (53.3%) in Group A and 21 (70.0%) in Group B. They were followed by 2nd premolars (11 cases; 18.3%), incisors (7 cases; 11.7%), and canines (5 cases; 8.3%). Group B had a greater frequency of involvement of the 1st premolars than Group A. As a whole, the maxillary and 1st premolars were most affected in both groups, and proTaper files were used more frequently in 1st premolar cases (Table 1). The Shapiro-Wilk test for normality indicated that the distribution of the quantity of remaining gutta-percha in Group A (H files) and Group B (ProTaper) was not standard. The p-values were 0.039 for Group A and 0.045 for Group B—both below the 0.05 level, meaning that the data are generally not distributed in either group (Table 2).

The statistical comparison between gutta-percha residues of the two instrumentation groups was performed using the Mann-Whitney U test, a non-parametric test suitable for independent samples that are not normally distributed. The findings indicated a statistically significant difference in the quantity of the residual gutta-percha left after retreatment with H files (Group A) and ProTaper files (Group B). Group A (H files) had a significantly lower mean rank of 16.65, and Group B (ProTaper) had a higher mean rank of 44.35. This reflects that samples treated with H files had significantly less gutta-percha than the samples instrumented with the rotary ProTaper system. The sum of ranks also reflected this difference, being 499.50 for Group A and 1330.50 for Group B. Mann-Whitney U was found to be 34.500, which had a Z-score of -6.165 and which reflected a significant deviation from the null hypothesis of no between-groups difference. The test determined an asymptotic significance (2-tailed) value of 0.000, which confirmed that the difference noted is extremely statistically significant ($p < 0.001$). These results affirm that the hand technique with H files is significantly more efficient for cleaning gutta-percha particles from the canal system than the rotary ProTaper technique. The significant difference in mean ranks and the very low p-value strongly validate the inference that instrumentation type has a significant effect on the efficiency of canal debridement during retreatment (Table 3).

Stratified analysis per dental arch and tooth type identified that Group B (ProTaper) invariably left more significantly remaining gutta-percha in the canal than Group A (H file) in all subgroups. In the maxillary and mandibular arches, ProTaper had greater mean values (7.94 ± 0.23 and 7.95 ± 0.21, respectively) than H files (7.26 ± 0.24 and 7.21 ± 0.34), with P<0.001 in each instance. Similarly, for incisors (P=0.013), canines (P=0.031), first premolars (P<0.001), and second premolars (P=0.001), ProTaper left noticeably more gutta-percha residue than H files. Regardless of the arch or tooth type, these data show that H files are superior to ProTaper at eliminating gutta-percha (Table 4).

Table 1: Frequency distribution of dental arch and tooth type

Variables	Group-A (H files)		Group B (ProTaper)		Total
	No.	%	No.	%	

Dental arch					
Maxilla	18	60.0	16	53.3	34(56.7%)
Mandible	12	40.0	14	46.7	26(43.3%)
Total	30	100.0	30	100.0	60(100%)
Tooth type					
Incisor	3	10.0	4	13.4	7(11.7%)
Canine	4	13.4	1	3.3	5(8.3%)
1st premolar	16	53.3	21	70.0	37(61.7%)
2nd premolar	7	23.3	4	13.3	11(18.3%)
Total	30	100.0	30	100.0	60(100%)

Table 2: Data check for normality

Test of Normality				
Variable Tested	Group	Shapiro-Wilk		
		Statistic	df	Sig.
Amount of remaining gutta-percha in the canal	Group-A (H files)	0.926	30	0.039
	Group B (ProTaper)	0.928	30	0.045

Table 3: Mann-Whitney U test results for mean % amount of remaining gutta-percha between Group A (H files) and Group B (ProTaper)

Group	n	Mean Rank	Sum of Ranks
Group-A (H files)	30	16.65	499.50
Group B (ProTaper)	30	44.35	1330.50
Total	60		
Test statistics			
Mann-Whitney U	34.500		
Wilcoxon W	499.500		
Z	-6.165		
Asymptomatic significance (2-tailed)	P<0.001		

Table 4: Stratification for dental arch and tooth type about mean % of remaining gutta-percha

Variables	n	Group	Remaining gutta-percha		P value
			Mean	S.D	
Dental arch					
Maxilla	18	Group-A (H file)	7.26	0.24	P<0.001
	16	Group B (ProTaper)	7.94	0.23	
Mandible	12	Group-A (H file)	7.21	0.34	P<0.001
	14	Group B (ProTaper)	7.95	0.21	
Tooth type					
Incisor	3	Group-A (H file)	7.40	0.20	P=0.013
	4	Group B (ProTaper)	7.92	0.17	
Canine	4	Group-A (H file)	7.10	0.16	P=0.031
	1	Group B (ProTaper)	7.80	0.00	
1st premolar	16	Group-A (H file)	7.22	0.31	P<0.001
	21	Group B (ProTaper)	7.93	0.23	
2nd premolar	7	Group-A (H file)	7.31	0.27	P=0.001
	4	Group B (ProTaper)	8.05	0.20	

Discussion

The current study compared the effectiveness of two instrumentation methods-Group A (H files) and Group B (ProTaper)-in endodontic retreatment gutta-percha removal as quantified by remaining gutta-percha amount. Mann-Whitney U test demonstrated a significant difference between groups (U = 34.5, Z = -6.165, p < 0.001) with Group B (ProTaper) having a significantly higher mean rank of remaining gutta-percha than Group A (H files).

These results indicate that the H files were more efficient in gutta-percha removal than the proTaper rotary files at the tested conditions. This outcome is consistent with other studies that have compared the effectiveness of manual versus rotary instrumentation in retreatment procedures.

The measured difference in residual gutta-percha between H-files (Group A) and ProTaper (Group B) must cast doubt on the allegedly superior rotary instrumentation. Previous reports on the ProTaper Universal Retreatment system highlighted its shorter working time and similar effectiveness in debris removal when compared with hand techniques (9,10).

Nevertheless, studies have highlighted some of the limitations inherent in rotary systems. Colaco and Pai (11). In their study comparing rotary techniques (ProTaper, D-RaCe) and manual techniques (H-files with xylene), they discovered that while rotary instruments were faster, they were less efficient in completely removing filling material, especially in curved root canals (11).

Consistent with this, a 2018 study comparing reciprocating and retreatment files noted that while ProTaper-R resulted in quicker outcomes (averaging 4.95 minutes), it also left more residual material behind than reciprocating instruments such as Reciproc (12).

This supports the notion that certain design aspects—like ProTaper's progressive taper and flute design—could restrict it from providing cleanability in anatomically challenging canals (12).

The results of the present study corroborate previous findings in that H-files achieved a mean rank of 16.65, significantly lower than ProTaper's 44.35, indicating a substantially smaller amount of remaining material. This discrepancy could be ascribed to the increased tactile sensitivity and accurate pressure control that is endemic to manual instrumentation, allowing for a more effective adjustment to canal irregularities than that provided by the uniform taper of rotary systems (10, 13).

A 2021 comparison of the ProTaper and NeoEndo systems further supported this idea, noting that the efficacy of rotary instruments is highly dependent on the skill of the operator and the anatomical complexity of the canal (13). Factors are addressed more directly by manual methods through ongoing sensory feedback.

H-file design allows for forceful contact with gutta-percha, especially in the apical third, where rotary files tend to get stuck. Manual technique dependence on filing motion, coupled with solvents such as xylene, might better soften and mechanically remove debris. ProTaper's dependence on constant rotation might "pack" material into lateral canals or apical recesses, however, particularly if the three-step D1-D2-D3 protocol is not followed closely (13). This corresponds to in vitro research where rotary systems left residues in 51% of canals as opposed to manual approaches (12).

The current study indicates H-files can be the preferred option in challenging anatomy or refractory infections, despite taking more time, whereas proTaper systems are still options for simple cases where efficiency is a significant consideration. Hybrid protocols incorporating manual debridement and rotary shaping should be investigated in future research to realize the best of both techniques.

Conclusion

In conclusion, the present study demonstrated a statistically significant difference in the amount of remaining gutta-percha between the two instrumentation techniques. The ProTaper file-instrumented specimens had significantly higher mean ranks compared to the H file-treated specimens, indicating that H files were more effective in removing gutta-percha from the root canal system (p < 0.001). These findings show that hand instrumentation with H files can offer greater debridement efficiency in endodontic retreatment compared to rotary ProTaper systems.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.
Ethics approval and consent to participate
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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

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