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Retreatment time, efficacy and cleaning ability: Hand versus four rotary devices for gutta-percha removal in single-rooted teeth

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Abstract:
Endodontic retreatment aims to remove root canal filling material and facilitate effective canal re-cleaning and disinfection. Therefore, it is of interest to compare the manual Hedstrom files with four rotary retreatment systems in 75 extracted single-rooted teeth. Rotary systems significantly reduced procedural time, with the HyFlex™ retreatment system demonstrating the fastest gutta-percha removal. HyFlex™ also left the least residual debris, while Hedstrom files showed the highest debris, particularly in the apical third. Thus, rotary retreatment systems, especially HyFlex™, provide superior efficiency and cleaning ability, although additional measures may be required for complete canal cleanliness.

Keywords: Endodontic retreatment, gutta-percha removal, rotary files, Hedstrom files, cleaning ability, proTaper retreatment, NeoEndo, HyFlex™, R-Endo.

Background:
The goal of endodontic therapy is to remove microorganisms from the root canal system and to not allow reinfection by properly cleaning, shaping and obturating the root canal system. Although endodontic procedures and materials have improved, failures can occur from persistent or secondary infections, poor obturation or procedural mistakes, requiring retreatment **[1, 2]**. Non-surgical endodontic retreatment is often the preferred treatment because it preserves the natural dentition and treats the cause of failure **[3]**. Complete removal of the previously placed root canal filling materials is a critical step in retreatment and most of these materials are gutta-percha with sealers, which are most commonly epoxy resin based sealers. Residual filling material may contain microorganisms and prevent irrigants and intracanal medicaments from reaching the dentin, thereby affecting treatment results **[4, 5]**. However, it is difficult to completely remove it because of the anatomical complexities, irregular canal walls and adhesion of filling materials to dentinal surfaces **[6]**. Hand instruments like Hedstrom files have been extensively used in hand retreatment procedures. The cutting action and engagement of filling materials with these files make them effective but are also linked to increased procedural time and operator fatigue **[7]**. Nickel-titanium (NiTi) rotary retreatment systems have transformed endodontic retreatment by enhancing efficiency, flexibility and canal centering ability **[8]**. The ProTaper Universal Retreatment system is a rotary system that is extensively researched and has a series of files that are optimized for the coronal, middle and apical thirds, allowing for efficient removal of gutta-percha **[9]**. Likewise, the NeoEndo retreatment system is a cost-effective alternative that is suitable for clinical applications and it has a crown-down approach and a controlled torque **[10]**. HyFlex™ retreatment files are designed with controlled memory technology to offer more flexibility and resistance to cyclic fatigue for better canal morphology adaptation **[11]**. In contrast, the R-Endo system uses a set of manual and rotary instruments that are used sequentially to remove filling materials with minimal canal transportation **[12]**. Although these sophisticated systems are available, literature indicates that none of these methods would allow complete removal of gutta-percha and sealer from the root canal system. In addition, there are differences in efficiency, in the time it takes to do the procedures and in the cleaning capacity between different systems. Using stereomicroscopy, the effectiveness of retreatment procedures in various apical thirds of canals **[13]** can be evaluated reliably by the evaluation of the residual filling material. Therefore, it is of interest to compare the retreatment procedural time, efficacy and cleaning ability of Hedstrom files with four rotary retreatment systems (ProTaper Universal Retreatment, NeoEndo Retreatment, HyFlex™ Retreatment and R-Endo Retreatment systems) in single-rooted teeth.

Materials and Methods:
Study design:
This *in vitro* experimental study was conducted in Department of Conservative Dentistry and Endodontics, to evaluate and compare the retreatment efficiency of 1 (one) manual and 4 (four) rotary systems in gutta-percha removal.

Sample size and source:
A total of 75 extracted single-rooted human teeth were collected from:

[1] Department of Oral and Maxillofacial Surgery
[2] Public Health Dentistry outreach camps
[3] Private dental clinics

Teeth were cleaned of debris and stored in normal saline at room temperature until use to prevent dehydration.

Selection criteria:
Inclusion criteria:

[1] Single-rooted teeth with single canal
[2] Teeth free from caries, cracks and restorations
[3] Straight or mildly curved canals
[4] Fully formed apices

Exclusion criteria:

[1] Teeth with fractures or cracks
[2] Open apices

[3] Severe curvature or anatomical variations
[4] Multi-rooted teeth
[5] Calcified canals

Specimen preparation:
[1] Standard access cavities were prepared using airotor and round burs.
[2] Canal patency was established using #10 and #15 K-files.
[3] Working length was determined using an apex locator.
[4] Cleaning and shaping were performed using step-back technique up to #30 master apical file, flaring up to #50 K-file.
[5] Irrigation was done using normal saline/NaOCl (as per protocol).

Obturation procedure:
[1] Canals were dried and obturated using:
a. 0.02 taper gutta-percha
b. AH Plus sealer
[2] Lateral condensation technique was used.
[3] Specimens were stored at 37°C and 100% humidity for 7 days.

Grouping:
Samples were randomly divided into 5 groups (n=15 each):
Group 1: Hedstrom Files + Xylene:
[1] Solvent (xylene) used
[2] Sizes 35, 30, 25 used in push-pull motion
[3] Apical enlargement up to size 40

Group 2: ProTaper Universal Retreatment:
[1] D1 (coronal), D2 (middle), D3 (apical)
[2] Speed: 500 rpm, Torque: 3 Ncm
[3] Brushing motion used

Group 3: NeoEndo Retreatment system:
[1] N1, N2, N3 sequence
[2] Speed: 350 rpm, Torque: 1.5 Ncm
[3] Crown-down technique

Group 4: HyFlex™ Retreatment system:
[1] Size 25, 0.09 taper
[2] Used throughout canal
[3] Emphasis on tactile control

Group 5: R-Endo system:
[1] Rm hand file followed by rotary files
[2] Re, R1, R2, R3 sequence
[3] Speed: 300 rpm, Torque: 1.2 Ncm

Evaluation criteria:
Procedural time:
Time recorded using stopwatch:
[1] Time to reach working length
[2] Total time for complete gutta-percha removal

Efficacy:
Assessed based on completeness of removal of filling material

Cleaning ability:
[1] Teeth were longitudinally sectioned
[2] Examined under stereomicroscope
[3] Residual debris evaluated in:
a) Coronal third
b) Middle third
c) Apical third

Scoring criteria:
[1] Score 0: No debris
[2] Score 1: <25% debris
[3] Score 2: 25–50% debris
[4] Score 3: >50% debris

Statistical analysis:
[1] Data analyzed using ANOVA and Post-Hoc Tukey test
[2] Significance level set at $p < 0.05$

Results:
A total of 75 single-rooted teeth were evaluated across five groups (n = 15 per group). The parameters assessed included time to reach working length (WL), time for complete gutta-percha removal (CR) and cleaning ability based on residual gutta-percha scores in the coronal, middle and apical thirds. The HyFlex™ retreatment system demonstrated the shortest mean time to reach WL (2.23 ± 0.43 min) and complete gutta-percha removal (3.51 ± 0.49 min), indicating the greatest procedural efficiency. In contrast, the Hedstrom file group required the longest time for both WL (7.26 ± 1.05 min) and CR (9.98 ± 1.11 min). The ProTaper retreatment system was the second fastest, followed by NeoEndo and R-Endo. One-way ANOVA revealed highly significant differences among the groups for both WL time ($F = 142.12$, $p < 0.001$) and CR time ($F = 177.76$, $p < 0.001$) **(Table 1)**. Post hoc analysis showed significant differences between most group pairs, except between the NeoEndo and R-Endo systems ($p > 0.05$). Regarding cleaning ability, the HyFlex™ retreatment system exhibited the lowest mean residual gutta-percha scores in the coronal (1.07 ± 0.26), middle (1.07 ± 0.26) and apical (1.07 ± 0.26) thirds, whereas the Hedstrom file group showed the highest residual debris, particularly in the apical third (2.07 ± 0.59). Significant intergroup differences were observed in the coronal third ($F = 4.17$, $p = 0.004$) and apical third ($F = 7.44$, $p < 0.001$), while differences in the middle third were not statistically significant ($F = 2.34$, $p = 0.06$) **(Tables 2 and 3)**. Overall, rotary retreatment systems demonstrated superior procedural efficiency compared with manual Hedstrom files. Among the rotary systems, HyFlex™ provided the fastest retreatment and the most effective removal of residual gutta-percha, particularly in the apical third, whereas cleaning performance in the middle third was comparable across the study groups.

Table 1: Comparison of Mean Retreatment Time (WL and CR) among Groups

Group	System	WL Mean ± SD (min)	CR Mean ± SD (min)
Group 1	Hedstrom + Xylene	7.26 ± 1.05	9.98 ± 1.11
Group 2	ProTaper Retreatment	3.68 ± 0.44	5.01 ± 0.78
Group 3	NeoEndo	4.96 ± 0.44	6.74 ± 0.50
Group 4	HyFlex™	2.23 ± 0.43	3.51 ± 0.49
Group 5	R-Endo	5.45 ± 0.48	7.08 ± 0.43

Table 2: Mean Residual Gutta-Percha Scores (Cleaning Ability)

Group	Coronal (Mean ± SD)	Middle (Mean ± SD)	Apical (Mean ± SD)
Group 1	1.67 ± 0.72	1.60 ± 0.74	2.07 ± 0.59
Group 2	1.07 ± 0.26	1.27 ± 0.46	1.40 ± 0.51
Group 3	1.13 ± 0.35	1.33 ± 0.49	1.73 ± 0.70
Group 4	1.07 ± 0.26	1.07 ± 0.26	1.07 ± 0.26
Group 5	1.47 ± 0.74	1.53 ± 0.64	1.87 ± 0.64

Table 3: Summary of Statistical Significance (ANOVA)

Parameter	F Value	P Value	Significance
WL Time	142.12	<0.001	Highly Significant
CR Time	177.76	<0.001	Highly Significant
Coronal Cleaning	4.17	0.004	Significant
Middle Cleaning	2.34	0.06	Not Significant
Apical Cleaning	7.44	<0.001	Highly Significant

Discussion:

Endodontic retreatment is an essential component of the treatment for failed root canal therapy. Effective removal of the previous obturation materials is crucial to the success of retreatment and allows for adequate disinfection and re-obturation. In the present *in vitro* study, the efficiency of manual Hedstrom files and four rotary retreatment systems was evaluated in terms of the time required for the procedure and the ability to clean. The results were clearly evident that rotary retreatment systems were superior to manual instrumentation, especially in time savings. HyFlex™ retreatment files had the shortest time to reach working length and to remove gutta percha. This is because of their controlled memory NiTi alloy that provides improved flexibility and adaptation to canal anatomy **[1]**. These results are in line with the results of Zupanc *et al.,* who found that the HyFlex systems are more efficient and less fatiguing **[3].** ProTaper Universal Retreatment files also demonstrated better performance than manual files. D1, D2 and D3 instruments are designed to remove gutta-percha from coronal to apical areas, which is more efficient. The same has been reported by Odabaşı Tezer *et al.,* who concluded that ProTaper retreatment systems significantly reduced retreatment time **[5].** The efficiency of NeoEndo and R-Endo systems was moderate. While both systems employ crown-down approaches and controlled torque, their performance may be influenced by design differences and cutting efficiency. Although the R-Endo system was a multi-instrument sequence, there was slightly higher residual debris, which may be attributed to the limited apical enlargement capability. The manual Hedstrom files took the longest time in the procedure. They are technique sensitive and need more operator effort, but their aggressive cutting action helps to engage gutta-percha. This is consistent with the results of Shivanand *et al.* who found higher working time with hand instruments **[8].** When it comes to cleaning ability, HyFlex™ performed best in all thirds of the canal. The lower residual debris scores indicate enhanced canal wall contact and better removal of filling materials. The ProTaper and NeoEndo systems also had good cleaning ability, but not as well in the apical third. In all groups, the apical third always had the greatest amount of debris remaining. This is consistent with previous studies, which has pointed out the challenges of cleaning the apical regions because of anatomical complexity and the limited penetration of the instrument **[10]**. The statistically significant differences in the apical third ($p < 0.001$) highlight the significance of instrument design in cleaning. Interestingly, no significant difference was found between the middle third of the groups ($p = 0.06$). This indicates that most of the systems have comparable performance in this area, probably because the canal diameters are fairly uniform and the canals are more accessible. No systems completely eliminated gutta-percha, confirming previous studies that complete removal of gutta-percha is not often possible **[11]**. Residual debris can remain in dentinal tubules, fins and irregularities, thus requiring the use of adjunctive techniques like ultrasonic activation or solvents **[12]**. In the present study, the use of stereomicroscopic evaluation was found to be a reliable method for visualizing the residual debris. Similar methodologies have been used in previous research for assessing cleaning efficiency **[13–15]**. Clinically, the results indicate that rotary systems, especially the HyFlex™ system, are the most efficient and effective systems to use for retreatment procedures. Clinicians should be cognizant of the restrictions of apical cleaning, however and should consider using additional methods.

Conclusion:

Rotary retreatment systems were more efficient than manual Hedström files, with HyFlex™ showing the short procedural time and least residual debris. The apical third remained the most challenging region and none of the systems completely removed the filling material. HyFlex™ appears promising for efficient endodontic retreatment, although supplementary cleaning may be required for optimal canal debridement.

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