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RESEARCH ARTICLE

Evaluation of Obturating Material Removal from Root Canal by Hedstrom and Rotary Retreatment File

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ABSTRACT

An in vitro investigation was conducted to assess the efficacy of Hedstrom and Rotary Retreatment File using Cone Beam Computed Tomography (CBCT) in removing obturating material from moderately to severely curved root canals. Thirty-six removed human molar teeth were split into two groups based on the canal curvature using the Schafer and Schneider method. Each group consisted of 18 teeth. Teeth in Group A had roots that were moderately curved (angles between 10 and 20 degrees), whereas teeth in Group B had roots that were severely curved (angles more than 20 degrees). Following decoronation, each root was ready for obturation using the appropriate rotary files, following the manufacturer's recommendations. Using the CBCT image, the total surface area of the root canals in the axial cross-section and the volume analysis of the obturated area were calculated. H files were used to retreat half of each group, while Rotary (ProTaper) retreatment files were used for the other half, in accordance with their retreatment protocol. It was noted how long it took to reach the working length and remove all obturating items. Cone beam computed tomography and Auto CAD software are used to analyze the surface area and volume of any residual obturating material in the canal after it has been completely removed. An analysis of the data using the ANOVA test was conducted between four groups. When $p < 0.05$ was reached, it was deemed statistically significant. Rotary retreatment files were discovered to be the most efficient method for removing obturating material and to take the least amount of time to achieve working length. Compared to the Rotary retreatment file, the H file left greater residue in the root canal. Compared to moderately curved root canal groups, severely curved root canal groups have noticeably more residues. In all four groups, the apical part had more residues than the middle and coronal portions. The obturating substance in the root canal could not be entirely removed using any of the retreatment procedures. Furthermore, there was no advantage in terms of root-filling removal's effectiveness.

Keywords: CBCT, curved root canal, endodontic retreatment.

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1. Introduction

A crucial step in the endodontic retreatment process is removing the root canal filling material as effectively as possible. This is followed by cleaning and shaping the root canals appropriately to enable sufficient disinfection and re-obturation [1]. Several methods, such as the use of endodontic hand files, rotary instruments made of nickel-titanium, Gates Glidden burs, heated instruments, ultrasonic instruments, lasers, and supplementary solvents, have been proposed to remove filling materials from root canal systems [2]. The method most frequently employed is the removal of GP using a Hedstrom file by itself or in conjunction with Gates Glidden drills, either with or without solvent [3]. A significant amount of root canal obturating materials remain in the root canals following retreatment, particularly in curved canals with Hedstrom files, according to certain research. This is a laborious and time-consuming process [4].

In order to remove obturating elements from canals that have already undergone treatment, several rotary nickel-titanium files have undergone additional special design [5], [6]. Less chair time is advantageous for both the patient and the operator because rotary instruments require less time to clean the canals than hand instruments do [7]. It is also a safe and effective method. However, additional research has shown that rotary instruments are just as effective as manual files, except for having a shorter operating time [8]. According to other research, in retreatment circumstances, the manual approach produced cleaner canal walls than rotary files [2]. Nevertheless, a small number of studies have suggested that using a hand file in addition to a rotary tool improves the effectiveness of obturating material removal from curved canals [2]. However, according to some other research, none of the methods could completely remove the obturating materials from the curve root canals [9]. Thus, searches for effective retreatment equipment continue to be conducted globally. With the use of cone-beam computed tomography (CBCT), residual root canal material can be quantitatively analyzed in three dimensions (3D) and measured with greater accuracy. It is a nondestructive technique that allows for detailed feature visualization without causing tooth destruction [10]. With the use of CBCT, the current in vitro study aims to assess and contrast the effectiveness of Hedstrom and Rotary retreatment files in extracting gutta-percha and sealer materials from curved root canals.

2. Materials and Methods

2.1. Preparation of Tooth

36 human molars were extracted, and the teeth that met the inclusion criteria were split into two groups. Using the approach proposed by Schafer and Schneider, the canal's curvature was computed, and the following means were found: Group B is substantially curved (angle >20°), whereas Group A is moderately curved (angle 10–20°). To remove calculus and tissue tags from teeth, an ultrasonic scaler was used. Following that, the teeth were decorated to the CEJ. After that, a no. 15 k-file with a silicone rubber stop was introduced until the apical foramen was barely visible at the tip. The file was then removed from the root canal and the actual root canal length was measured using an endodontic ruler in millimeters. Next, the silicone rubber stop was adjusted to a precise coronal reference point on the decoronated tooth at CEJ.

2.2. Root Canal Treatment Procedure

Every sample was created using ProTaper instruments up to the F2 file, which was then inserted in an electric motor with a torque of 3 N/m and a speed of 300 rpm. A 30-gauge needle was used to introduce 5.25 percent NaOCl into the canals in between files to irrigate them. Following pretreatment, the smear layer was eliminated using paper points to dry it off and a final rinse in 17% EDTA and 1% NaOCl. Using the lateral compaction technique, the root canals were obturated with gutta-percha cones coated with AH-Plus sealant (Dentsply, De Trey, Konstanz, Germany); excess gutta-percha was removed with a hot plugger.

Radiography was used to assess the buccolingual and mesiodistal directions of the obturation's quality and apical extension. By now, every primary CBCT image has been captured. For the time being, the access cavity was sealed. After that, the samples were kept for 14 days at 100% relative humidity and 37 °C to allow the sealer to fully set. The samples were then separated into four groups (n = 9) according to the retreatment method used. Group A was moderately curved (angle is 10–20°), and obturating filler materials were removed using a ProTaper retreatment file and a Hedstrom file. Hedstrom files and ProTaper retreatment files were used to remove the obturating filling material in Group B, which was highly curved (the angle was more than 20°).

2.3. Root Canal Retreatment Procedure

The temporary restoration was taken out of all groups, and the first two millimetres of the OM were softened with a single drop of chloroform.

Group A1: Gates-Glidden drills (Mani, Tochigi, Japan) in sizes 3 and 2 were used to remove the coronal third of the OM from a fairly curved root canal at 2000 rpm. Subsequently, the remaining OM was eliminated using H-files #30, 25 and 20 (DentsplyMaillefer, Ballaigues, Switzerland) in descending order, quarter-turn push-pull movements, and circumferential filing until they reached the working length.

Group A2: ProTaper files were used to remove obturating material from moderately curved root canals at a speed of 300 rpm and a torque of 3 N/m. The ProTaper D1 file (30/0.09) was used to clear the coronal third of the canal. The D2 (25/0.08) and D3 (20/0.07) files were used to eliminate the OM in the middle and apical thirds.

Group B1: Gates-Glidden drills (Mani, Tochigi, Japan) in sizes 3 and 2 were used to remove the coronal third of the OM from a significantly curved root canal at 2000 rpm. The remaining obturating material was then removed using #30, #25, and #20 H-files (DentsplyMaillefer, Ballaigues, Switzerland) in descending sequence, quarter-turn push-pull operations, and circumferential filing until they hit the working length.

Group B2: ProTaper files were used at 300 rpm and 3 N/m torque to remove obturating material from strongly bent root canals. The ProTaper D1 file (30/0.09) was used to clear the coronal third of the canal. D2 (25/0.08) and D3 (20/0.07) files were utilized to eliminate the obturating material located in the middle and apical thirds, respectively. F2 (25/0.08) and F3 (30/0.09) instruments were used to prepare the apical region.

Any faults in procedure were noted. The divided segment was removed using a manual file in the event of an instrument fracture. 17% EDTA and 1% NaOCl will be used for the last rinse. After that, paper points were used to dry the root canals. The time required to attain the working length (T1) and to fully remove the obturating material and make a final preparation (T2) was measured using a digital stopwatch. It is not possible to calculate or record the amount of time required to switch instruments and water the canals. T1 plus T2 added together recorded the total time recorded (TT). The confirmation of complete removal of obturating material occurred when the instrument's

flutes showed no signs of gutta-percha or sealer, even after irrigation. A post-retreatment CBCT was then performed.

2.4. CBCT Measurements and Evaluation

2.4.1. Area Analysis

Three different CBCT imaging plans were assessed: axial, coronal, and sagittal. 0.5 mm portions of the canal from the apical to the coronal of the root were used to create 1 mm thick CBCT cross-sections. In these cross-sections, the root length of each sample was divided into three areas: apical, middle, and coronal. Using AutoCAD software, the percentage of residual obturation material on the walls, if any, was determined at 1-mm intervals from the apical area toward the canal orifice with the following formula: (S1/S2) × 100, where S1 denotes the root canal's surface area and S2 the surface area of the leftover OM. In addition, the highest concentration of residual gutta-percha in the three apical, middle and coronal areas of the CBCT cross-sections was recorded.

2.4.2. Volume Analysis

Following obturation, volume was analyzed, and retreatment was measured in millimetres using CBCT. Using AutoCAD software, the volume of filler material that was left was determined. By dividing the volume of the residual filling material by the volume of all the filling material in the canal prior to retreatment, volume fractions of the root canal wall covered by remaining filling material were computed in percentage terms.

3. Results

Rotary retreatment files were found to be the most efficient method for removing obturating material and to take the least amount of time to achieve working length. Compared to a Rotary retreatment file, an H file left more residue in the root canal. Compared to moderately curved root canal groups, there are noticeably more residues in severely curved root canal groups. In four groups, the apical part had more residue than the middle and coronal portions.

The results of evaluations demonstrated that no retreatment approach could get rid of the root canal filler material entirely. Although no significant differences were found in the residual obturating material between two groups of moderately curved root canals (Group A1 and Group A2) and between two groups of severely curved canals (Group B1 and Group B2), there was less residue in different portions of the root canal in the Rotary Retreatment file groups than in the H file groups (p-value > 0.05).

The Rotary Retreatment file and H file were more effective in removing obturating material from moderately curved channels than they were from substantially curved canals. The apical part of the rotary retreatment file and the H file both left more residue than the middle and coronal portions. Apical, middle, and coronal portions of all groups showed significant differences ($P < 0.05$).

For both moderately and severely curved canals, the Rotary Retreatment File resulted in a considerably shorter mean time to attain working length (T1) and maximal removal of obturating material (TT) than the H file (p-value < 0.05). In a moderately curved canal, the Rotary Retreatment file and H file both reached the full working length and removed the maximum amount of obturating material more quickly than in a severely curved canal.

All the findings of current research works are presented in Figs. 1–4 and Table I. In severely curved canal groups, there was more residual obturating material present in comparison with the surface area of root canals than the moderately curved canal groups and the retreatment file showed better efficacy than the Hedstrom file (Fig. 1). A larger volume of residual obturating material is present in severely curved root canal groups than in moderately curved canal groups, and the retreatment file shows better efficacy than the Hedstrom file (Fig. 2): In *Group A*, before the retreatment average depth was 0.3353 mm, the Surface area was 0.0114 mm^2, and the volume was 0.00382242 mm^3 while after retreatment, the average depth was 0.1616 mm, the Surface area was 0.0058 mm^2, and volume was 0.00093728 mm^3; In *Group B*, before retreatment, average depth was 0.9465 mm, the Surface area was 0.0189 mm^2, and volume = 0.01788885 mm^3 while after retreatment, average depth was 0.3358 mm, the Surface area was 0.0038 mm^2, and volume = 0.00127604 mm^3.

The shortest time to reach working length and to maximal removal of obturating material was found with Group A2 followed by Group A1, Group B2, and Group B1 (Fig. 3). There was more residue present in the apical portion of all groups than middle and coronal portions (Fig. 4). There was no discernible variation in the mean residual volume percentage of obturating material after retreatment (Table I).

The moderately curved canal retreated with the Rotary Retreatment File (Group A2) and had the shortest time to reach working length and the fastest technique to remove gutta-percha maximally; the severely curved canal retreated with the H file (Group B1) had the longest time to reach working length and the fastest technique to remove gutta-percha maximally. There was a significant difference ($p < 0.05$) between all four groups. The data was represented as Mean±SD and an ANOVA test was used to determine the degree of significance between four groups and a post hoc test between two groups.

In this investigation, we discovered that no retreatment strategy could totally remove the root canal filler material. There are more residues in the apical region of each group, followed by the intermediate region, and fewer residues in the coronal region of each group. This image shows that the apical area of severely curved root canal groups (Group B) has higher residue than the apical area of moderately curved root canal groups (Group A). In the event of a substantially bent root canal, cleaning the apical area becomes more challenging. In the apical middle coronal part of each of the four groups, there were no discernible changes in the residual obturating material ($P > 0.05$). In all four groups, the apical part had considerably more residue than the intermediate and coronal portions ($P < 0.05$). The ANOVA test produced a p-value.

Between the four groups, there was no discernible variation in the mean residual volume percentage of obturating

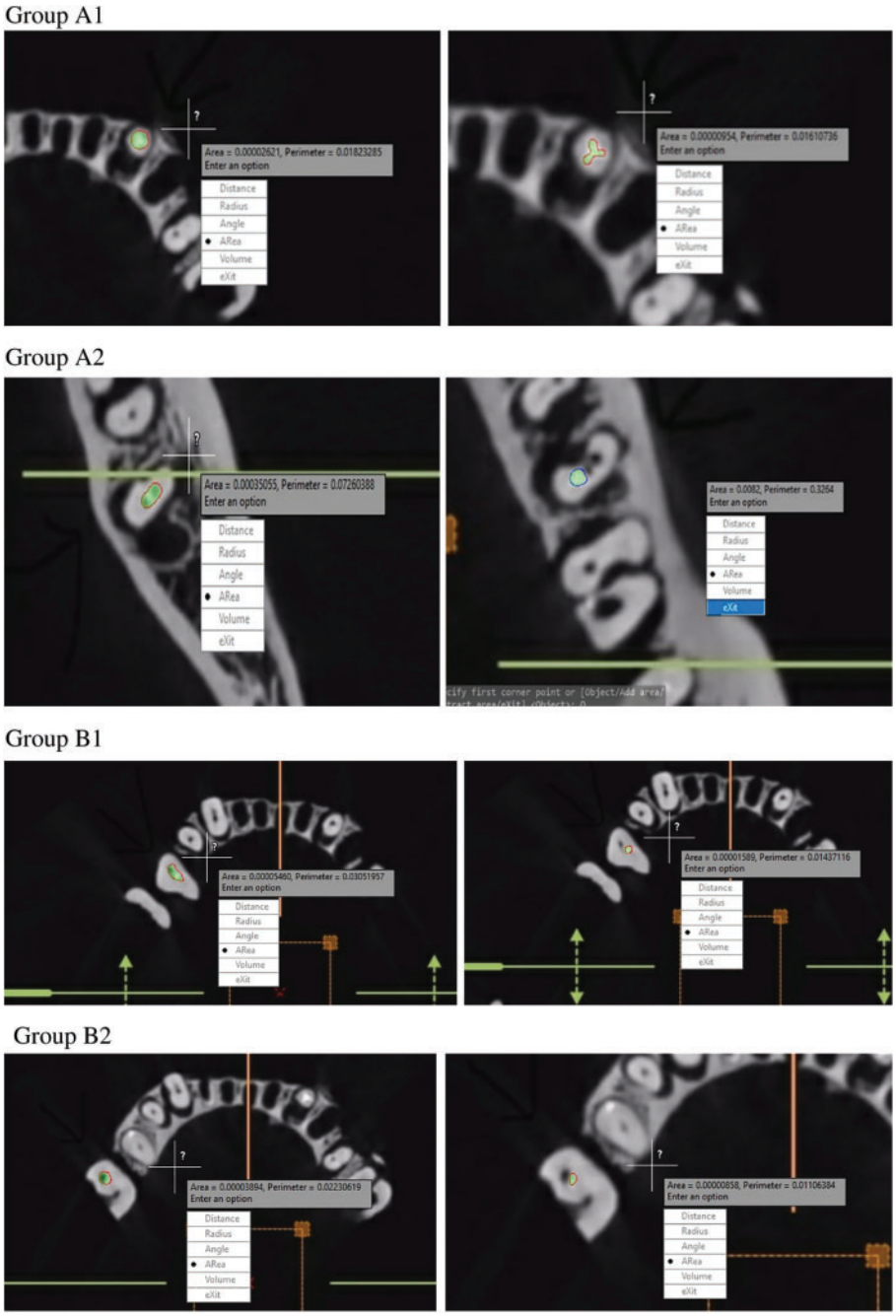


Fig. 1. Surface area of the root canal and residual obturating material measurement of four groups: Group A1, moderately curved root canal retreated with H file; Group A2, moderately curved root canal retreated with retreatment file; Group B1, severely curved root canal retreated with H file; Group B2, severely curved root canal retreated with retreatment file.

material upon recovery. The ANOVA test produced a p-value. The result is significant because a p-value < 0.05 is considered statistically significant.

4. Discussion

In this investigation, we discovered that in both cases of moderately and severely curved canals; the time to reach working length (T1) was shortened while using a Rotary Retreatment File as opposed to an H file. Both in the case of a severely curved canal and a moderately curved canal, the total time for maximal removal of obturating material (TT) was likewise reduced while using a Rotary Retreatment File as opposed to an H file. The design of Rotary (ProTaper) retreatment tools is responsible for their superior performance. Gutta-percha tends to be drawn into the file flutes and directed toward the orifice by the unique flute design and rotating action of ProTaper retreatment devices. Additionally, a certain amount of frictional heat produced by the engine-driven files' rotating rotations plasticizes gutta-percha, making it less resistant and easier to remove [8].

The results of this study were comparable to those of some earlier research. According to Saad *et al*. [11], Pro Taper and K3 left less filling material behind after removing filling material than Hedstrom files and did so in a much shorter amount of time than hand instruments. The retreatment time with Mtwo and ProTaper instruments

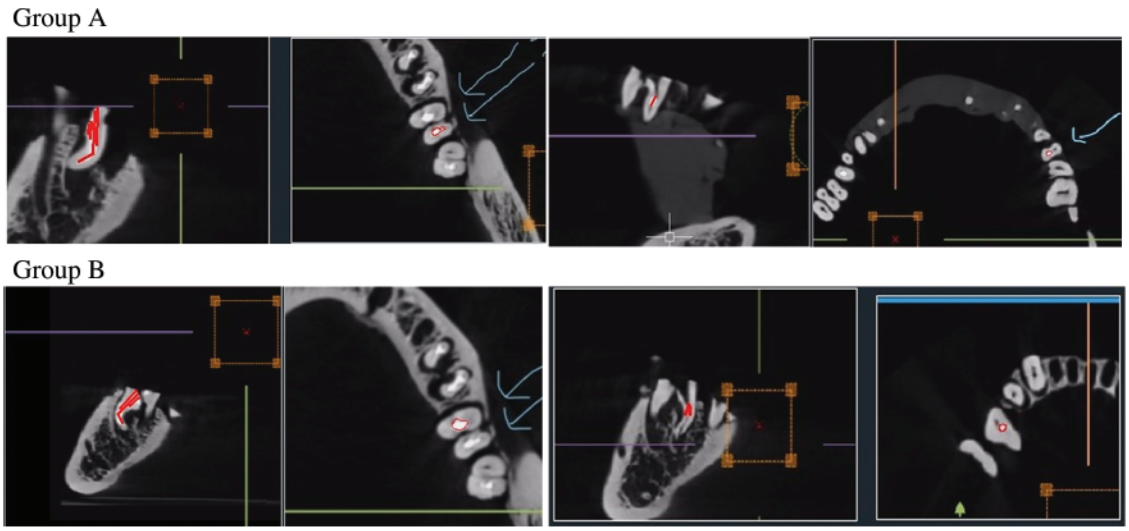
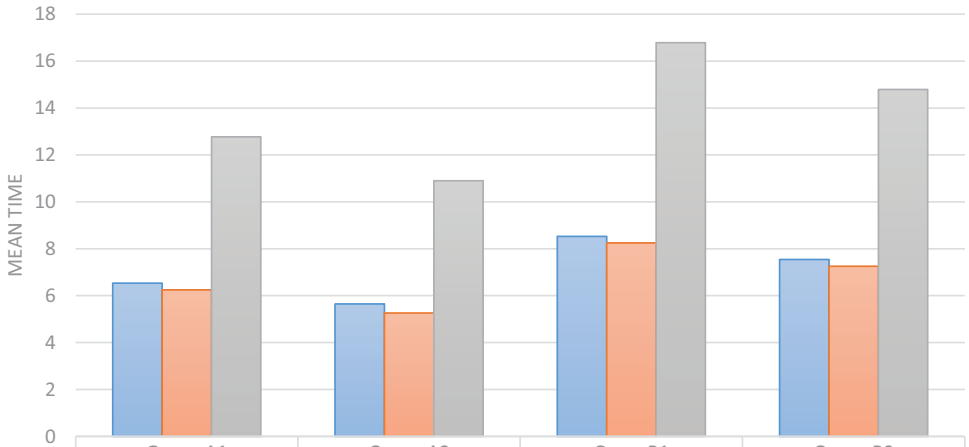


Fig. 2. Volume measurement of obturating material before and after retreatment: Group A, moderately curved root canal groups and Group B, severely curved root canal groups.



	Group A1	Group A2	GroupB1	Group B2
T1	6.53	5.64	8.53	7.54
T2	6.24	5.26	8.25	7.25
TT	12.77	10.9	16.78	14.79

Fig. 3. The means of the time taken to reach working length (T1) and time taken for maximal removal of gutta-percha (T2) and total time (TT) for each group are shown here.

was much shorter than manual instrumentation with Hedstrom files, according to Tasdemir *et al*. [12] comparison of ProTaper, R-Endo, Mtwo, and Hedstrom files. In comparison to Hedstrom files and GT rotary instruments, Hülsmann and Bluhm [6] showed that ProTaper and Flexmaster, both with and without Eucalyptol, took less time to remove any leftover gutta-percha. In contrast to hand devices, rotary and reciprocating files in curved canals took less time, according to research by Rödig *et al*. [13]. Nevertheless, some research contradicts the results of this study. Imura *et al*. [14] found that using a combination of gates, glidden drills, and H-files, followed by a rotary retreatment file, can achieve the working length in the lowest amount of time. Variations in the interior architecture of the samples, variations in the sealer composition, variations in the obturation technique, and variations in the evaluation techniques could all contribute to differing findings from this study. Pre-curved hand files, which are advised as an addition to rotary files during retreatment, were found to improve tactile sensation and facilitate the removal of gutta-percha in research by Hülsmann and Bluhm [6].

As with earlier comparable investigations, none of the retreatment methods employed in this study succeeded in fully extracting the obturating material from the root canal [15]. The percentages of residual obturating material in the H file groups and Rotary Retreatment file groups did not differ significantly. According to a study by Dall'agnol *et al*. [16], there were no appreciable differences found between manual instruments, ProTaper retreatment files, and reciprocating files. The complicated anatomy of the root canal system and the binding of AH-Plus sealer to the root dentin were blamed for the high amount of residual gutta-percha and the difficulty in removing the obturation materials.

Micro-computed tomography (μ-CT) was used in a study by Rödig *et al*. [13] to assess the effectiveness of hand and rotary files in removing gutta-percha from curved root canals. In contrast to the findings of the current study, their results demonstrated that hand files left significantly less

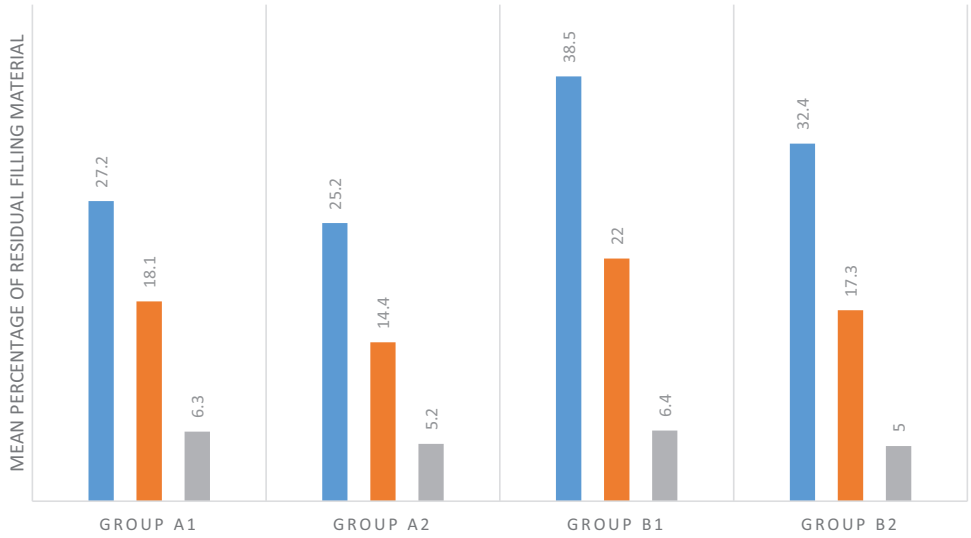


Fig. 4. The mean percentages of the obturating material remaining in the apical, middle and coronal thirds of all four groups.

obturating material during retreatment. This discrepancy may be related to variations in the internal anatomy of the samples and the curvature of the canals, as well as variations in sealer composition and obturation technique. More residues were found in the apical, middle, and coronal portions of the rotary retreatment file. There were also more residues in the apical, middle, and coronal portions of the Hedstrom file groups. Comparing the ProTaper file with the Hedstrom file, Hülsmann and Bluhm [6] revealed that the apical third of the root canals had more gutta-percha than the coronal and middle. Similarly, Giuliani *et al*. [5] examined the profile system, ProTaper retreatment system, and H-files and found that the ProTaper retreatment system performed better in the coronal and middle third, followed by the profile in the crown down technique and that the use of Hedstrom files revealed the majority of residual gutta-percha. Additionally, Gergi and Sabbagh [17] assessed the efficacy of ProTaper, R-endo, and H-files in curved root canals and came to the conclusion that both rotary NiTi systems were safe and useful tools for removing gutta-percha. The apical region is generally more variable anatomically and more challenging to instrument. The presence of these less instrumented sections, which prevent the use of nickel-titanium instruments against whole root canal walls, may be explained by the deep grooves and depressions on dentin walls in the apical third.

ProTaper retreatment instruments performed better in the middle and coronal sections of the root canals than in the apical area, which was caused by the instrument's varying taper. The reason behind the Hedstrom file's superior junk removal in the coronal and middle thirds could be attributed to the stainless-steel instruments' increased stiffness and their safe direction toward the canal walls, which enhances performance.

In line with earlier research, the current study's findings demonstrated that no retreatment strategy can ensure that all gutta-percha has been completely removed. Nonetheless, research in the literature reveals the following studies that dispute the current study's conclusions. In their comparison of R-Endo retreatment files, profile, and ProTaper retreatment systems with gutta-percha removal, Ünal *et al*.

TABLE I: Comparison of Mean Residual Volume Percentage (MRVP) of Root Canal Filling Material after Retrieval among Four Groups

Groups	Number (N)	MRVP	P-value
Group A1	9	3.19 ± 0.66	**>0.05**
Group A2	9	2.93 ± 0.71	
Group B1	9	4.52 ± 1.06	
Group B2	9	4.10 ± 1.39	

[18] found that the use of K-files and H-files together was more effective in eliminating gutta-percha. Similarly, Bharathi *et al*. [19] found that the quickest time to attain working length was required when combining gates, glidden drills, and H-files. This was followed by profile, H-files, and xylene. Additionally, xylene and H-files revealed fewer gutta-percha residues. Furthermore, research by Imura *et al*. [14] revealed that H-files outperformed K-files, Quantec LX rotary instruments, and profile 0.04 taper devices in terms of removing more gutta-percha in less time.

According to the manufacturer's instructions, Celik *et al*. [20] found that ProTaper files were less effective than hand files in curved canals. They attributed this superiority to canal enlargement beyond the D3 (20/0.07) retreatment file. On the other hand, a hand K-file with a size of #30 showed higher efficacy in removing obturating material from the root canal than rotary files with a larger size and taper. This investigation was done on root canals with moderate to severe curvature. Most research on the quantity of leftover obturating material in root canals was done on straight roots [21]. In most circumstances; straight canals do not accurately depict the clinical scenario. Curved canals have been utilized in numerous other experiments [12]. The intricate structure of the curved molar canals may have contributed to the difficulty in removing the filling material in this study. Dentin can be bound by the AH plus sealer [12]. Digital pictures of longitudinally sectioned roots have been employed in certain research; however, this method may cause residual filler material to be lost during sectioning [22]–[24].

As a non-destructive technique, radiographic exams have been employed; however, they only yield two-dimensional data and are unable to precisely determine the quantity of leftover filling material since minute amounts of residual material may not be visible on radiographs [22], [23]. Decalcifying and clearing the tooth allows for 3D viewing, however, this method's judgment is subjective. This is another non-destructive approach [6]. Schirrmeister *et al*. [22] employed image analysis software to measure the remaining filling area on the canal wall of the teeth that had been removed in order to get around this restriction.

Additionally, the residual filling material volume has been analyzed using micro-CT imaging [10]–[13]. This non-destructive technique scans following each step of the operation during re-treatment, enabling 3D quantitative evaluation and step-by-step analysis. The challenge of telling the gutta-percha from the sealer in the leftover material is the sole drawback to this technique. To successfully use these devices for endodontic retreatment, additional long-term clinical investigations should be conducted to bolster the findings of this study. Examining the amount of apically extruded filler material during processing was one of the study's other goals. Debris extrusion apically may cause pain, irritation, and discomfort following surgery [25]. Apically extruded debris was discovered in all four groups in the current investigation. Saad *et al*. [11] conducted a retreatment study to assess the effectiveness of ProTaper and K3 in gutta-percha removal. The results showed that ProTaper and K3 extruded less debris than Hedstrom files. When compared to Hedström file equipment, the ProTaper Universal Tulsa rotary system produced noticeably less debris extrusion during endodontic retreatment, according to a different investigation by Huang *et al*. [26]. Our findings were consistent with earlier research using rotary NiTi instruments, which extruded far less debris after retreatment than manual Hedstrom file instrumentation. This outcome could have resulted from rotational motion, which tends to direct debris toward the orifice and prevent it from becoming compacted in the root canal, and early flaring of the coronal part of the preparation, which enhances instrument control during preparation of the apical one-third of the canal.

5. Conclusion

The obturating substance in the root canal could not be entirely removed using any of the retreatment procedures. Furthermore, there was no advantage regarding how well root-filling removal worked.

Conflict of Interest

Authors declare that they do not have any conflict of interest.

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