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THE EFFICACY OF DIFFERENT KINEMATICS IN REMOVING ROOT CANAL FILLING MATERIALS: (AN IN-VITRO STUDY)

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ABSTRACT

Aim: To evaluate the efficacy of different kinematics in removal of root canal filling materials.

Methodology: A total of 60 human freshly extracted mature permanent maxillary central incisors were selected. Access cavities were prepared and the teeth were cleaned and shaped then obturated. Teeth were randomly divided into three groups according to removal technique (manual H-file, ProTaper NEXT file and Reciproc file), then split longitudinally and photographed. The images were transferred to a computer, and total canal space and the remaining filling material were quantified. The ratio of the remaining filling material to the total root canal space was computed with the aid of AutoCAD software. The mean percentages of the remaining filling material and removal time were analysed using the Kruskal–Wallis, Friedman's test and one-way ANOVA test.

Results: The mean percentage of the remaining filling material was significantly higher in group I than both II and III, While there is no statistically significant difference between group II and III. Regarding comparison between the root levels, the apical level showed the statistically significantly highest mean percentage of remaining endodontic filling material, followed by the middle and the coronal levels. The time required to remove filling material was significantly shorter in group III followed by II and I.

Conclusion: Total elimination of root canal filling is a challenge especially in the apical part. No statistically significant difference was found between the two kinematics regarding the efficiency in removing obturation materials, while reciprocation was faster than rotation in removal time**.**

Keywords: nickel–titanium, Reciproc files, reciprocating motion, root canal retreatment, rotary instruments, ProTaperNEXT.

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INTRODUCTION

The most common reason why endodontic therapy-related post-treatment illness develops is persistent and subsequent intra-radicular infection. For a tooth that is suffering from apical periodontitis is that it can either be lingered after the first root canal therapy or became worse, retreatment is often advised. Total removal of previous filling materials is an essential initial step in endodontic treatment procedures to the goal of having the root canal system be given the ability to be cleaned as thoroughly as possible, disinfected and filled [1].

The rate of success for completed plans of retreatment by using adequate methods aiming for the prevention and management of endodontic infection ranges from 62 % to 89 percent in cases of post-treatment disease. Secondary treatment root canal therapy has a much lower success rate compared to what is described as the initial root canal therapy because of persistent, resistant bacteria, including the development of an intratubular infection, challenges in removing the prior filling material to have a way or access to the germs, or long-term intra-canal infection [2].

With retreatment, it could be challenging to entirely remove gutta-percha first by initiating with the root canal. Manual instruments, rotary systems, ultrasonic instruments, and rotary systems created specifically for the removal operation, which may be paired with solvents or heat and lasers, have all been used aiming to be able to address the removal of the root canal filling material. But none of the current existing methods completely eliminates the filler[3].

In comparison with initial root canal treatment, retreatment consumes more in terms of time. It would be advantageous to have more effective and expeditious approaches for root filling material removal. The primary advantages of employing rotary instruments instead of traditional hand instruments for the engagement in the removal of a root canal fillings which are enhanced efficiency and decreased removal period. This perception has been reinforced by the great majority of investigations that used a range of rotating Ni-Ti systems. However, contrary findings from other investigations have been reported [4]. Some retreatment investigations claimed that using rotating devices did not result in a quicker retreatment [5]. The bulk of the literature, however, claimed that using rotational Ni-Ti devices to remove root canal fillings was quicker [6].

Recently, a novel idea was put out in the sense that canal preparation is something to be accomplished by utilizing a tool driven by a nickel-titanium engine that reciprocates. The same approach, in which the tools are employed in conjunction with a motion such as brushing up against the canal's lateral walls to eliminate any lingering material that exist because of the last filling, is advised for retreatment aims as well. Even without complete removal of the filling materials, certain studies have shown the effectiveness of reciprocating tools for the retreatment of both curved and straight canals [7].

According to certain researches, rotary tools were less successful than reciprocating ones in removing root canal filling materials [8]. According to further researches, rotary files are superior to reciprocating files in removing apical filling material [9]. Despite the canal shape, several studies have shown equivalent efficacies for both approaches [10]. So, our study aimed to evaluate the efficacy of reciprocating and rotary techniques in removal of root canal filling during root canal retreatment in terms of percentage of the remaining root canal filling material inside the root canals (a primary outcome) and time of root canal filling removal (a secondary outcome).

The null hypothesis

- For varying kinematics, the efficacy of extracting root canal filling materials is not different.

- Across different kinematics, the time necessary to eliminate root canal filling material doesn't really different.

MATERIALS AND METHODS

Sample size calculation

The size of the sample was established using an Open Epi tool with a competence of 80% and a level of confidence of 95%. The percentages of residuals left in root canal filling materials were employed as the main result in this investigation. Three samples from each group were used in the pilot research, and the findings were introduced to an effect size calculator for an ANOVA design. The results between the groups' effects were then put into the Open Epi program with a confidence level of 95 percent and a power of 80 percent. The average amount of time needed to remove the root canal fillings was 335.56+/-190.18 for the rotation motion approach and 194.44+/-160.8 for the reciprocation technique [(11)]. So, the sample size was 60.

Ethical approval

The Faculty of Dentistry at Minia University's Research Ethical acceptance Committee gave its approval to the current research (Meeting No. 69, Date: 24/2/2020).

Selection of the samples

In order to facilitate instrumentation in tapered canals with a well-developed apical constriction, 60 recently derived human intact mature maxillary central incisors of a single root canal (type I Vertucci's categorization [(12)]) and a complete root formation (mature apex) were gathered first from an outpatient clinic, Faculty of Dentistry, Minia University which were extracted for periodontal reasons. Root caries, internal or exterior resorption, prior endodontic therapy, fissures visible on the tooth, repeated root curvatures, fast apical curvatures, calcified canals, root fracture, and anatomic anomalies like fusion were the study's contraindications. The chosen teeth were free of soft and hard tissue attachments and submerged in sodium hypochlorite solution for 30 minutes. They were then cleansed and submerged in Formula e Acao's 0.1 percent thymol solution (Sao Paulo, SP, Brazil) until they were ready to be used. Specifically chosen teeth with a high degree of similarity in root canal morphology, such as dentin thickness, root canal space, and average length [(11)].

Preparation of the samples

To establish clear and straight path to the root canal, a typical opening to a cavity has to be created using a round diamond bur (Dentsply, Tulsa Dental, Maillefer, USA). To use a manual stainless-steel K-file ISO size #10, patency was guaranteed (MANI, INC. Industrial Park, Utsunomiya, Tochigi, Japan). To uniformly lengthen the teeth across all samples, the incisal margins were shortened. All root canals were manually scoped using a stainless-steel K-file ISO size #10 until the main apical foramen became apparent. The needed length was then estimated by a method of deducting 1mm from such measurement. Fanta Rotary Files (Fanta Dental, China) instrumented canals utilizing a crown-down approach in the following order: 18/.04, 20/.04, and 25/.06. Using a manual stainless-steel K-file, cleaning and shaping were carried out up to a master apical file ISO size #40 (MANI, INC. Industrial Park, Utsunomiya, Tochigi, Japan). A 30 gauge Fanta side-vented closed-end irrigating needle (Shanghai Fanta Dental Materials Co. Ltd., India) was used to deliver 5.25 percent NaOCl (Clorox; Household Cleaning Products of Egypt, 10th of Ramadan, Egypt) as a root canal irrigant during root canal preparation. A final irrigation protocol was completed by alternate use of 5 ml of 5.25 percent NaOCl, 5 ml of 17 percent EDTA (Ethylene di-amine tetra-acetic acid; Prevest DenPro Limited, India) with an intermediate rinse of the same volumes using saline.

Obturation

Dryness of the canals was done by paper points (DiaDent, Korea) size # 40 followed by alcohol before root canal obturation. The sealer (Adseal, META BIOMED CO., Korea) was combined with relivance and accordance to the manufatuter's plans or orders until it reached the consistency of a creamy mix. Root canals are to be sealed up with the use of what is known as cold lateral compaction. The samples were radiographically evaluated to check the quality of the obturation; if the gutta-percha included any radiological voids, the sample was discarded. To ensure that the sealer had properly been set, samples were taken and saved at 37 degrees Celsius and approximately 100 percent humidity for 14 days. After this, those teeth were coherently and randomly divided into three retreatment groups.

Removal of root canal filling (Endodontic re-treatment)

In accordance with the file motion that has been used to establish a plan to remove the filling from the root canal, all samples (n=60) were randomly and evenly divided into the following three groups:

Stainless-steel H-file group: (Manual motion)

Up to the first 4 mm of the in question root canal, Dentsply, Maillefer's, On a low-speed handpiece (NSK, Japan), Glidden burs sizes 2 and 3 (corresponding to tip sizes 70 and 90) were employed. Before further instrumentation, 2 to 3 drops of chloroform (Prevest DenPro Carvene, India) (0.1 ml) were inserted into the canals to dissolve the gutta-percha. Stainless steel H-files ISO sizes (25, 30, 35, and 40) were manually used for a circumferential filing motion to remove root canal fillings. Before being discarded, each instrument set was set up to be used to prepare a quanitity which is three of root canals.

ProTaper NEXT group: (Rotation motion)

Steps 1 and 2 as in the manual technique were also repeated. Removal of obturation materials was done by using ProTaper NEXT in a continuous rotation motion with a sequence; of X1, X2, X3, and X4 (X4; 40, .06) according to the manufacturer's recommendations, at 400 rpm with 1.5 N of torque. Before even being discarded, every instrument set was used to prepare three root canals.

Reciproc group: (Reciprocation motion)

Above that the methods' stages 1 & 2 were also repeated. Canal filler components being cleaned utilizing Reciproc file of size (40, 0.06) in a mutuality action at a 30 rpm with in direction of 150 CCW with 30 CW as well as a torque of 1.5 N in compliance with the manufacturers ' instructions. Because the Reciproc is indeed as one-time use tool, every file was really only utilized to prepare single root canal.

To clear any leftover root canal filling and debris from the canals, 5 ml of sodium hypochloride acid at a level of 5.25 percent was irrigated for each canal in each group. The time required to remove the root canal fill from the start of using each file to the finish of the treatment, including the irrigation procedure, was timed using a stopwatch. When the working length was reached, the final file used was unable to remove any more obturating material, and the irrigating solution seemed to be clear of any remaining debris, the retreatment operation was finished. To confirm the removal of the root filling, a confirmatory periapical radiograph was conducted on each sample.

Assessment of the samples

These samples were assessed and decoronated using a double-sided diamond disc (Dentsply, Maillefer, Switzerland) mounted on a reduced speed handpiece to be a uniform root length of 13 mm. Longitudinal lines running perpendicular to the tooth's long axis identified the buccal and lingual edges of the root, and then gently separated into two halves using a double-sided diamond disc. The grooves were made with care to ensure

that they were short and did not pierce the canal. A digital stereomicroscope was used to scan and take pictures of the samples at a 30X magnification (Olympus, Japan). Clearer images were saved using a computer. From coronal to apical, the cervical, middle, and apical thirds of root canals were assessed. The apical, intermediate, and coronal levels of the root canal area were evaluated sing the AutoCAD software (Autodesk, San Rafael, California, USA), the residuals of the root filling material were traced, and the histogram feature of the program has been used to calculate how so many pixels the residuals of something like the root filling material held. The percentage of remaining root filling materials was calculated using the following calculation [11]: Percentage of remaining root filling material =A/B×100, where A is the total number of pixels in each canal third and B is the percentage of remaining root filling material at each third, is the equation for the percentage of remaining root filling material. Confirmation samples from each group were divided into their coronal, middle, and apical thirds using horizontal sectioning. To prevent operator bias, each component was marked, and a certain groove was made in the same spot on the buccolingual surface of the root. To improve the assessment of surface remains on the root canal wall, these samples were processed for SEM (Jeol, JSM-IT200InTouchScope, Tokyo, Japan) at a magnification of 1000X. The amount of time needed to remove the root filling was calculated based on how long it took the instruments to stretch back to their original working length after being inserted into the canal for the first time. When the instrument was removed from the canal, the stopwatch timer was stopped, and it was restarted when another instrument was used to complete the setup.

Statistical analysis

To ascertain if numerical data were normal, normality tests and data distribution were applied (Kolmogorov-Smirnov and Shapiro-Wilk tests). The quantity of endodontic filling still present did not follow a normal (parametric) range, in contrast to the removal time. Non-parametric data were shown as median, range, mean, and standard deviation (SD) values, while parametric data were presented as mean and standard deviation. Non-parametric data and the Kruskal-Wallis test were used to compare the three groups. Friedman's test was used to compare varied root levels within each group. If a significant difference was found using Kruskal-Wallis or Friedman's tests, Dunn's test was used for pair-wise comparisons. For parametric data, a one-way ANOVA was used to compare the three groups. When the ANOVA test was significant, pair-wise comparisons were made, and the Bonferroni post-hoc test was used. The significance level limit was set at P 0.05. Utilizing IBM SPSS Statistics for Windows, Version 23.0, statistical analysis was carried out. Armonk, New York, and IBM Corp.

RESULTS

None of the three different kinematic techniques completely eradicated the root canal filler materials. The Reciproc file (4.67 + (0.9) and the ProTaper NEXT rotary file (4.94 + (0.82)) were statistically equal (P > 0.05), although group I's percentage of residual filler material was greater when using the manual approach (P 0.05). (Fig. 1, Table 1) The root levels with the statistically significantly larger mean percentage of endodontic filling material were the middle root level and coronal root level, which had the statistically significantly lowest mean percentage of leftover endodontic filling material (Table 2, Fig. 2, 3). Group III eliminated the filler material at 4:37 + 0:11 minutes, whereas groups II and I took 6:29 + 0:09 and 11:31 + 0:11 minutes, respectively (P 0.05). (Fig. 4 and Table 3)

TABLE (1): Shows descriptive data and the results of the Kruskal-Wallis test for comparing how much endodontic filling material is still present in each group (in percent):

Root level	Reciprocity (n = 20)		ProTaper NEXT (n =20)		Manual (n = 20)		***P***-value	Effect size (Eta squared)
	Median (Range)	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)	Mean (SD)		
Coronal	0.84 (0-1.71) [B]	0.79 (0.57)	1.42 (0-4.03) [B]	1.63 (1.33)	3.13 (0.13-4.28) [A]	2.87 (1.21)	0.005*	0.326
Middle	4.42 (1.42-7.14) [B]	4.27 (1.88)	3.68 (1.99-6.59) [B]	3.98 (1.5)	9.43 (1.24-19.77) [A]	10.08 (5.44)	0.010*	0.27
Apical	12.1 (4.82-22.03) [B]	12.73 (4.67)	12.1 (8.49-19.25) [B]	12.56 (3.52)	31.08 (22.1-43.74) [A]	31.6 (7.73)	<0.001*	0.643
Total	4.64 (2.47-5.74) [B]	4.67 (0.9)	5.19 (3.57-5.99) [B]	4.94 (0.8)	11.33 (8.4-16.58) [A]	11.45 (2.5)	<0.001*	0.653

****: A significant variation between groups is shown by several superscripts appearing in the same row. At P 0.05, a difference is deemed significant.***

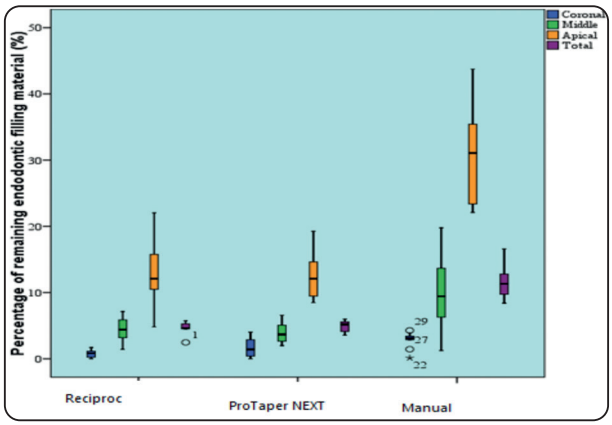

Fig (1): Box plot showing the median and range values for the proportion of endodontic filling material still present in each of the three groups (Circles and stars represent outliers).

TABLE (2): Descriptive data and the outcomes of Friedman's test for comparing the percentages of endodontic filling material still present (in each group) at various root levels

Root level	Reciprocity (n =20)		ProTaper NEXT (n =20)		Manual (n = 20)	
	Median (Range)	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)	Mean (SD)
Coronal	0.84 (0-1.71) [C]	0.79 (0.57)	1.42 (0-4.03) [C]	1.63 (1.33)	3.13 (0.13-4.28) [C]	2.87 (1.21)
Middle	4.42 (1.42-7.14) [B]	4.27 (1.88)	3.68 (1.99-6.59) [B]	3.98 (1.5)	9.43 (1.24-19.77) [B]	10.08 (5.44)
Apical	12.1 (4.82-22.03)[A]	12.73 (4.67)	12.1 (8.49-19.25) [A]	12.56 (3.52)	31.08 (22.1-43.74) [A]	31.6 (7.73)
***P*-value**	<0.001*		<0.001*		<0.001*	
Effect size (w)	1		0.925		0.925	

****: Significant at P ≤ 0.05, Different superscripts in the same column indicate a statistically significant difference between root levels within each group.***

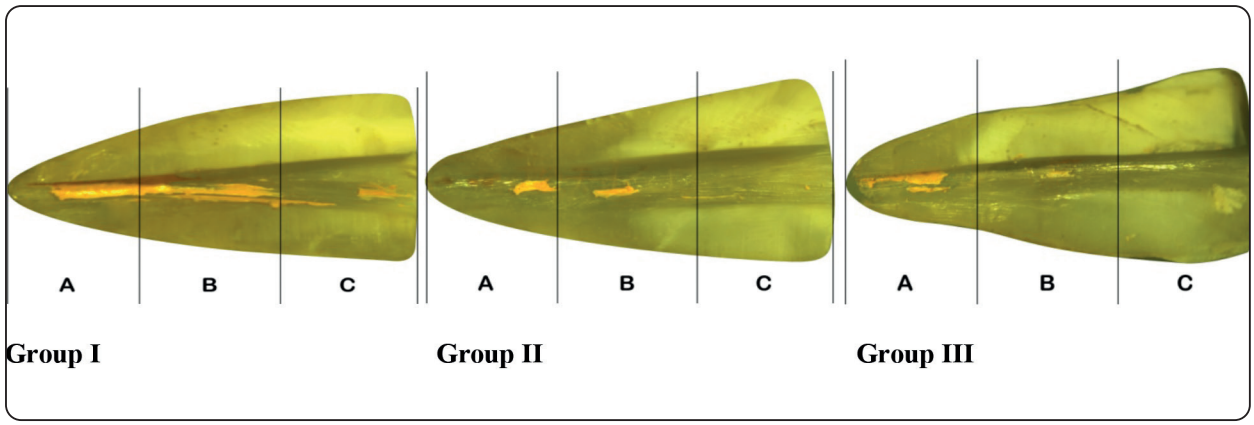

Fig. (2): stereomicroscopic evaluation of each group (A: Apical third B: Middle third C: Coronal third).

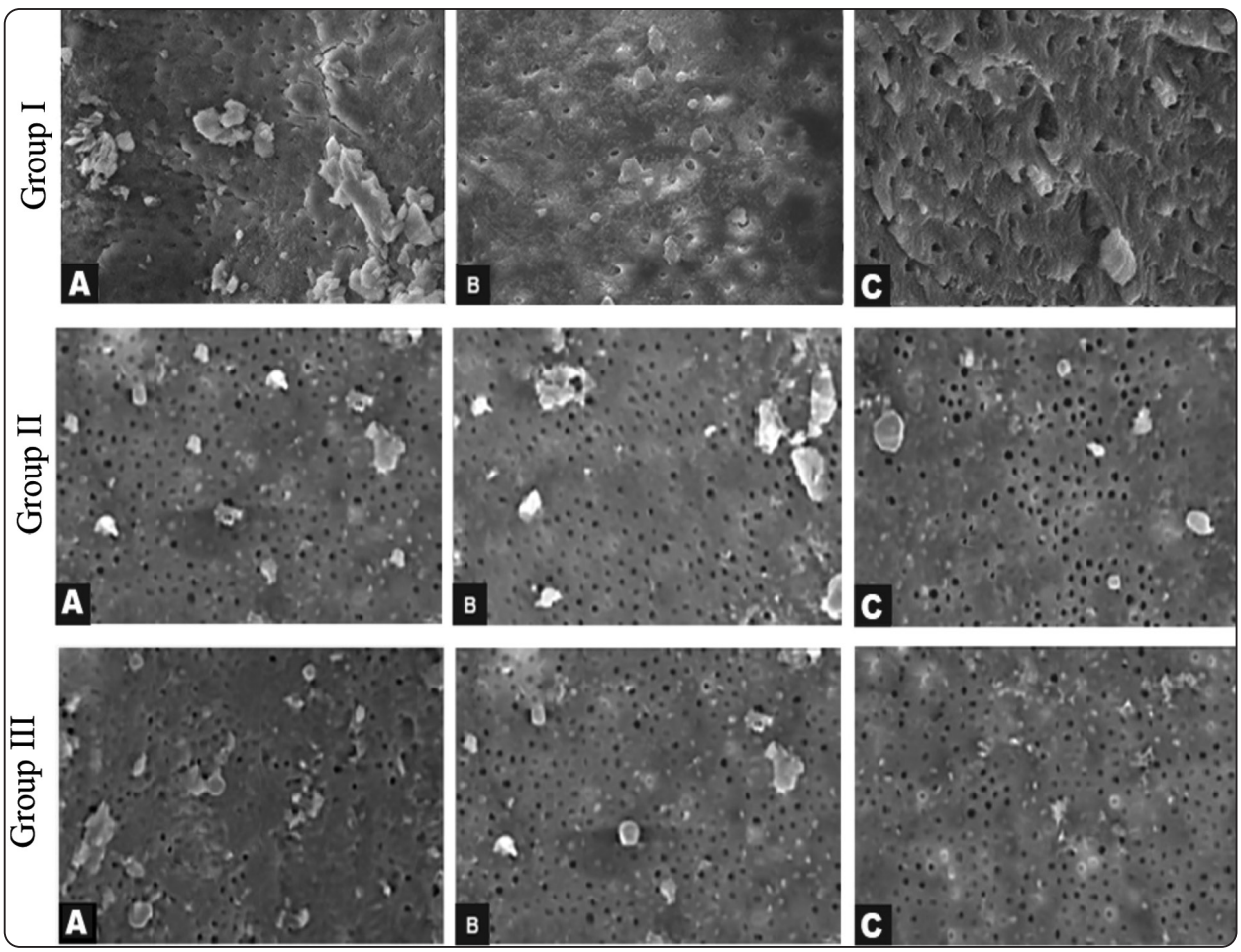

Fig. (3): SEM evaluation of each group (A: Apical third, B: Middle third, C: Coronal third)

TABLE (3): Descriptive statistics and results of one-way ANOVA test for comparison between removal time (minutes: seconds) in the three groups

Reciprocity (n = 20)		ProTaper NEXT (n = 20)		Manual (n = 20)		***P*-value**	***Effect size (Eta squared)***
Mean	SD	Mean	SD	Mean	SD		
4:37 ^{C}	0:11	6:29 ^{B}	0:09	11:31 ^{A}	0:11	<0.001*	0.997

****: Significant at P ≤ 0.05, Different superscripts indicate a statistically significant difference between groups.***

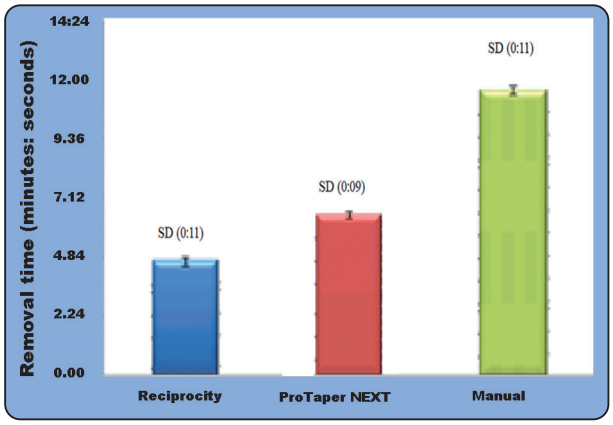

Fig. (4): Bar chart representing mean and standard deviation values for removal time of endodontic filling material.

DISCUSSION

Root canal fillers have indeed been taken out of the root canals using a variety of tools, including stainless-steal manual files, Ni-Ti files, ultrasonic files, or even lasers. We looked at three different methods to extract material from root canals with different kinematics to see if a new endodontic instrumentation technique is capable of doing so more quickly and effectively than the alternative approaches [11].

Single-rooted human teeth were selected for this investigation even though the architecture of root canals varies significantly because they are easy to handle, make it easier to standardize the specimens, and provide a problem when it comes to removing root canal fillings from teeth with large canals [11, 13].

In this study, a conventional access cavity rather than other modified access cavities was prepared to create straight-line access to the root canal in order to optimize chemo-mechanical preparation, filling procedures, retreatment, and also to avert the potential complications with altered connect cavities linked to canal orifice position, quality of canal preparation work, disinfection, debridement, filling procedures, and additionally, iatrogenic deviations and instrument failure [13, 14].

Cold lateral compaction (CLC) was used as an obturation technique which provides a good seal with the root canal system. The high bond strength offered by the CLC obturation technique was attributable to; the compaction pressure with utilizing a finger spreader to form a space that permits the application of accessory cones, that offer better contact at the sealer/dentin interface, decrease the voids in the sealer, and fills the irregularities of the root canal, thereby decreasing the sealer thickness and enhancing retentionwhich improves the adaptation of the obturating materials and decreases the percentages of failure [15].

Root canal admixture has been eliminated from root canals utilizing a range of techniques, including lasers, ultrasonic files, Ni-Ti files, stainless hand files, and Ni-Ti files. In order to determine if an endodontic instrumentation technique that has just entered the market is capable of doing so more rapidly and efficiently than the alternative approaches, we examined three distinct ways to remove filling material from root canals using various kinematics. It has been used in our research to access the root

canal during retreatment operations by softening and dissolving gutta-percha [11, 13].

Several methods have been employed for the monitoring and evaluation of residual root canal filler particles (RRFMs) such assegments and sub tomography (micro-CT)images [16,17], 3-dimensional cone-beam computerized tomography (CBCT) [18, 19], scanning electron microscopy (SEM) [20, 21], radiographic analysis [22], teeth clearing [23] and two dimensional assessment of divide teeth images [11, 22]. Any approach might have advantages and disadvantages. Micro-CT is one non-destructive technique that provides precise three-dimensional examinations. However, it takes a lot of time and is expensive, particularly when examining several samples [16]. Small amounts of debris cannot be also exhibit distortions due to magnification [8]. To improve the evaluation procedure and provide more precise results, a scanning electron microscope and stereomicroscopic analysis were employed in the current study [21].

To fully see the canals, the specimens were scanned and photographed with a digital stereomicroscope at a 30X magnification [24]. As an adjunct to stereomicroscopic evaluation, a confirmatory scanning electron microscope evaluation was used because it provides images with high resolution and magnification [3]. The SEM images were captured at a magnification of 1000X [20] to provide images with high resolution which aids in the identification of dentinal tubules, an inspection of some details such as remnants of the smear layer, remnants of gutta-percha, and sealer on the root canal wall and differentiation between them [25].

According to the present study's results, none of the three kinematics-based removal techniques could completely remove the root canal fillimg material. This was consistent with other prior studies. Researchers Tasdemir et al. (2008) [5], Zuolo et al. (2013) [11], Mutar et al. (2020) [14] and Nevares et al. (2016) [26]; discovered that.

During our experiment, it was employed to open the root canal during retreatment procedures and to dissolve and soften gutta-percha. The results of Eldemerdash et al. (2019) [24] and Fruchi et al. (2014) [27] that perhaps the apical third had the greatest filling material left over compared to the middle and cervical thirds were consistent with this outcome. Our results were contradictory to the results reported by Mutar et al. (2020) [14] and Schirrmeister et al. (2006) [23]; who concluded that there was no significant differences between the root canal thirds. The previous study's lower sample size and different assessment techniques may be to blame for this disparity. Their 2-D radiographic examination wasn't precise enough to be evaluated. The employment of different equipment in their retreatment methods, however, may be the cause of the disparity in the latter investigation.

There had been a statistically significant difference in the percentage of leftover endodontic filling at the various root levels in the current research when compared the root levels within each group. The radicular root level showed the statistical significant least percentage of residual root canal system filling, followed by the middle third root level, as well as the apical level showed the statistically significantly highest percentage of endodontic filling material, according to earlier studies (Mutar et al. (2020) [14], Eldemerdash et al. (2019) [24] and Fruchi et al. (2014) [27]) showed that there's no substantial.

The manual group in the current study was the group that had the worst performance removing root canal fillings and showed the statistically significantly greatest proportion of leftover endodontic filling material in terms of overall percentages (total percentage of the three root levels). According to certain research, there is no discernible difference between rotary and manual files when it comes to the effectiveness of removing root canal filling materials. Examples of these

studies are those by Tasdemir et al. (2008) [5] and Schirrmeister et al. (2006) [23]. While the latter study also used different methods of evaluation (radiographic examination and scoring system), which gave an overly optimistic impression of cleanliness, the former study used a unique method of evaluation, a technique described by Robertson et al. (1980) [28] and smaller size instruments in removing root canal fillings than the final size of the primary endodontic treatment. Additionally, during the observers' microscopic study of the retracted root canal, additional unidentifiable gutta-percha was seen. Therefore, many root canals with leftover gutta-percha and AH Plus root canal sealant would have been regarded as clean if only radiographs had been used. The microscope's improved illumination and magnification made it seem to be simpler to detect any remaining filler material that can hide pathogens or necrotic tissues and be the root of post-treatment failure.

Our findings, however, were in direct opposition to those of Hammad et al. (2008) [6] and Unal et al. (2009) [8], who found that hand files worked better than rotary files in removing root canal filling materials. The latter research used a different assessment technique, curved canals as opposed to the straight ones we utilized in our study, K-files in combination with Hedstrom files to remove the gutta-percha mass, which may have also improved hand removal. In the previous work, the canals were instrumented up to two sizes bigger than the original master apical file, as well as employing several files in the retreatment process with varying cutting efficiencies and various assessment techniques (radiographic examination was used in their study).

The reciprocation and rotation groups in the current study did not differ statistically significantly in terms of the overall percentages of endodontic filling material, so the first null hypothesis was accepted because both showed the statistically significantly lowest percentages of endodontic filling material (more effective groups in root canal filling removal). According to earlier research by Crozeta et al. (2016) [7], Martins et al. (2017) [25] and Nevares et al. (2016) [26] who discovered that the quantities of obturation material left over after removing root canal fillings were comparable. According to Zuolo et al. (2013) [11]; When the effectiveness of reciprocating motion, a continuous rotating system, and hand files were compared for the removal of filling material from the root canal, the reciprocating system and hand tools outperformed the continuous rotating system. ProTaper files, which were utilized in our trial, were shown to be much more effective than Mtwo R instruments (used in their study) in removing root filling material when rotated.

The gutta-percha may have become even more pliable due to frictional heat generated by the rotational motion, making removal easier and requiring less time in the present experiment. When it came to eliminating filler material, all Ni-Ti rotary file groups outperformed the manual file group by a wide margin [1, 23]. The assertion that rotary instruments may remove root filling material more rapidly than manual instrumentation was refused by Unal et al. (2009) [8] and Kfir et al. (2012) [29]; who agreed that manual files were speedier. They claimed that the Hedstrom and K files needed less time than the other methods to remove the larger particles of gutta-percha.

The Reciproc group demonstrated the statistically significant lowest removal time, which may be attributable to its pronounced cutting efficiency (S-shaped cross section), in the current investigation. There was a statistically significant difference in the removal time between the various kinematics [7, 11]. Our findings were in conflict with those of Yigit et al. (2014) [30]and Ozyurek & Demiryurek (2016) [31]. They found that the reciprocating and rotating procedures took about the same amount of time to extract root canal fillings. Using different

instruments to extract the root canal filler materials may have caused the variances. Reciproc files required less time for the retreatment procedure because to its S-shaped cross section, whole work portion, and consistent taper for the first 3 mm of something like the working part before a declining taper up to the shaft. They may have highly effective debris removal capabilities due to their specific cross-sectional and flute design features, which also lead to less filler material compaction in the apical area (sharp cutting edges and large chip gap) [7, 11]. The ProTaper NEXT files' rectangular pass, two points of touch, and asymmetric movement enable proper waste clearance, which boosts the effectiveness of their cutting [31].

CONCLUSIONS

It is very challenging to completely remove root canal filling in the apical region. Rotating tools sped up and improved the removal of the root canal filling. There was less root canal filling material left after using reciprocating and continuous rotating movements. Even yet, reciprocation reduced the root canal filling more quickly than continuous rotation.

RECOMMENDATIONS

- For a more accurate assessment of the remaining root canal filling materials, a non-destructive, low-cost, and three-dimensional picture of the root canal system is perfect.
- Future studies are required to determine the best auxiliary procedures, such as agitation techniques or finishing files like the XP-endo Finisher or XP-endo Finisher R, to remove additional root canal filling.
- Utilizing Micro-CT to examine RRCFMs (remaining root canal filling materials) could be more advantageous.

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