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3D Evaluation of Various Rotary Instruments for the Removal of Gutta-Percha and Resilon from Root Canals

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Abstract
Aim: *To assess the effectiveness of Protaper and Mtwo retreatment files in the elimination of Gutta-Percha and Resilon from uncomplicated root canals.*
Material and Methods: *Thirty six freshly extracted single rooted teeth with Weine's class I canal configuration were taken. The crowns were de-crowned to a depth of 16mm, and the working length was determined to be 15mm. Root canal preparation was done using rotary Protaper universal files and irrigated with 1 ml of 3% sodium hypochlorite. Samples were divided into four groups of nine specimens each with regards to filling material and instruments used for removing filling material as follows:-*
Group A: Gutta-percha/Protaper;
Group B: Resilon/Protaper;
Group C: Gutta-percha/Mtwo;
Group D: Resilon/Mtwo.
In groups A & C root canals were obturated with gutta- percha using zinc oxide eugenol as sealer and in groups B & D Resilon points were used with Real seal dual curable resin sealer using cold lateral condensation technique. Samples were stored at 37 ºC for two weeks and then removal of root filling material was carried out using specified instruments. Samples were assessed through cone beam computed tomography for canal area and residual filling material.
Statistical analysis used: *Statistical analysis was conducted through the utilization of one-way ANOVA followed by post hoc tests.*
Results: *No individual system achieved total elimination of the root filling material from the inner walls of the root canal. ProTaper retreatment files demonstrated greater efficacy in gutta-percha removal compared to Mtwo retreatment files, with no statistically significant difference observed in comparison to Resilon (P>0.05).*
Conclusion: *Gutta-percha was removed significantly better from the canal walls than Resilon by the ProTaper retreatment files as compared to Mtwo retreatment files.*
Key-words*: Gutta-percha, Mtwo retreatment files, ProTaper retreatment files, Resilon.*

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I. INTRODUCTION

The use of non-surgical retreatment has become a common practice in contemporary dentistry. Ongoing advancements in technology and scientific knowledge have led to the preservation of countless teeth that might have otherwise been extracted. Post-treatment complications usually occur because of persistent bacteria in the root canal system due to insufficient cleaning, untreated missed canal, inadequate filling or coronal leakage [1]. Non-surgical root canal]retreatment is usually preferred over the invasive surgical procedures. Several techniques are available for the extraction of filling material, including manual hand files, rotary nickel-titanium (NiTi) instruments, Gates Glidden burs, heat application, ultrasonic instruments, and lasers, either with or without the use of supplementary solvents [2-5].

ProTaper and Mtwo NiTi systems have specifically designed instruments for root canal retreatment. The ProTaper universal rotary retreatment files comprise a set of three instruments (D1, D2, D3) that come in different sizes and have varying tapers and tip diameters, including size 30 with a 0.09 taper, size 25 with a 0.08 taper, and size 20 with a 0.07 taper [6].

Two retreatment files comprise two instruments featuring active cutting tips: R1 (size 25, Furthermore, there are also the R1 (size 10, 0.05 taper) and R2 (size 15, 0.05 taper) files, which have an S-shaped cross-section. However, they have a shorter pitch length designed to enhance -the file's ability to navigate through the filling material [7-9].

Till date, fewer studies have been published on the removal of gutta-percha and Resilon with these files. Furthermore, the R1 files (size 10 with a 0.05 taper) and R2 files (size 15 with a 0.05 taper) are offered as well, featuring an S-shaped cross-sectional design and a shorter pitch length aimed at enhancing the file's movement through the filling material.

II. MATERIAL AND METHODSs

Specimen selection

A total of 36 intact single-rooted teeth were selected (18 maxillary lateral incisors, 18 mandibular premolars) from a pool of extracted teeth discarding teeth with previous root canal treatment, presence of dentine pins, internal resorption, localized or diffuse calcifications. Mechanical means were used to eliminate soft tissue and calculus from the root surface. All the samples were radiographed in a bucco-lingual direction.

Initial endodontic treatment

The teeth were standardized by reducing them to a length of 16mm through the use of a low-speed diamond disc, which involved removing the crowns. Working length (WL) was determined by inserting a size 10 K-file (Dentsply Maillefer), which was passively introduced into the canal until the tip was seen to exit at the major foramen. We recorded the precise canal length and established the working length by subtracting 1 mm from this measurement, yielding a length of 15 mm.

The root canals were shaped using the crown-down method, employing rotary Protaper universal files up to size F2 from Dentsply Maillefer. Throughout the shaping process, each canal received irrigation with 1 mL of 3% sodium hypochlorite (NaOCl) between instrument changes. The smear layer was eliminated by irrigating with 1 mL of 17% EDTA followed by 1 mL of 3% NaOCl. Any remaining irrigants were thoroughly flushed out with a final rinse of 9 mL of distilled water. Lastly, the root canals were dried using size 25 paper points.

The root samples were randomly allocated into four groups, each consisting of nine specimens. The grouping was based on the type of filling material and the instruments employed for the removal of filling material. You can find a summary of the experimental groups. in Table 1.

Table 1. **Experimental Groups with Retreatment technique and type of filling material.**

Groups	Samples	Retreatment Technique	Filling Material
GA[#]	9	ProTaper R	Gutta-percha
GB	9	ProTaper R	Resilon
GC	9	Mtwo R	Gutta-percha
GD	9	Mtwo R	Resilon

 # GA-Group A, GB-Group B, GC-Group C, GD-Group D.

Obturation of samples

In groups A & C root canals were obturated with gutta- percha using zinc oxide eugenol as sealer and in groups B & D Resilon points were used with Real seal dual curable resin sealer using cold lateral condensation technique. The access openings were closed using a temporary filling material (Cavit; DeTrey Dentsply, Konstanz, Germany) and then placed in an environment with 100% humidity at a temperature of 37°C for a period of two weeks.

Methods for Re-treatment

The temporary filling substance was eliminated using a round bur of size no. 4.

Group A

In this group**,** the ProTaper universal retreatment instruments were employed to eliminate the filling material, which consisted of gutta-percha combined with a zinc oxide eugenol sealer. Sequentially, the instruments D1 (size 30/0.09), D2 (size 25/0.08), and D3 (size 20/0.07) were used in a crown-down technique until reaching the working length (WL). These instruments were operated with an electric motor (X-Smart; Dentsply Maillefer) at a consistent speed of 500 revolutions per minute for D1, D2, and D3, with a torque setting of 3Ncm.

Group B

In this group, filling material (Resilon) was also removed using ProTaper universal retreatment files in the same manner as in group A.

Group C

Mtwo retreatment files were used to remove the filling material (gutta percha with zinc oxide eugenol sealer). These consist of 2 files R1-15/0.05 and R2-25/0.05 which were used sequentially, applying a crown-down

technique, upto the WL The instruments were employed with a consistent speed of 250-300 rpm using an electric motor (X-Smart; Dentsply Maillefer).

Group D

In this particular group, the Resilon filling material was removed using Mtwo retreatment files, following the same method as in group C. To ensure procedural uniformity, each file was designated for replacement after being used five times. Notably, only one instrument experienced breakage while employing the two retreatment files. The assessment for complete removal of obturating material was based on the absence of debris either on the instrument surfaces or within the irrigation solution. The smoothness of the canal walls was evaluated by assessing tactile sensitivity using the final instrument.

To assess the presence of remaining filling material on the canal walls, Cone Beam Computed Tomography (CBCT) imaging was employed using the ORTHOPHOS XG 3D system by SIRONA [Fig. 1]. The 36 specimens were securely positioned within 1-cm thick wax plates and positioned on the tomography device's platform. After configuring the appropriate scanning parameters, axial, tangential, and cross-sectional images were generated [Fig. 2]. Subsequently, image analysis was conducted using the Galileos Viewer software.

Fig. 1: 3-Dimensional Cone Beam Computed Tomography (CBCT) image after Retreatment.

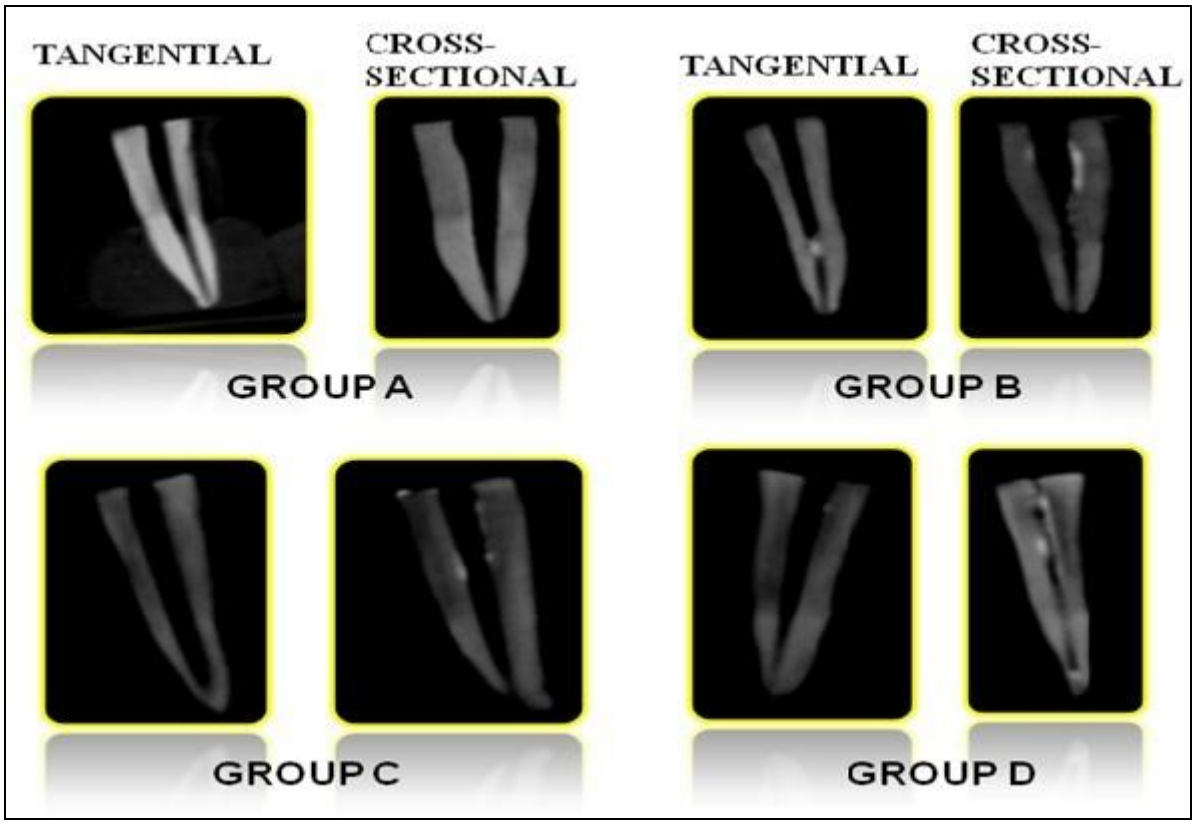

Fig. 2: Tangential and Cross-sectional CBCT image after Retreatment.

Measurements were taken to determine the canal and residual filling material areas within the apical, middle, and coronal thirds. The calculation of the percentage of residual filling material on the canal walls was performed using the subsequent formula:

Percentage of Remaining Filling Material = (Area of Remaining Filling Material / Area of Canal Wall) * 100.

Statistical analysis was conducted to assess parametric data via one-way ANOVA, while non-parametric data were analyzed using the Kruskall-Wallis test, both executed using the Statistical Package for Social Sciences (SPSS) software. A significance level of $p \leq 0.05$ was employed to establish statistical significance

III. RESULTS

The mean percentages of remaining filling material, as determined through CBCT analysis, are presented in Table 2. It's important to note that all instruments left some amount of filling material within the root canal.

Table 2. The percentage of remaining debris ± SD in each treatment group by means of Cone Beam Computed Tomography analysis

	Remaining debris (%)			
	GP/ProTaperR	**Resilon/ProTaperR**	**GP/MtwoR**	**Resilon/MtwoR**
Coronal	0.26 ± 0.74	1.03 ± 2.14	3.59 ± 4.46	4.79 ± 8.85
Middle	0.00 ± 0.00	2.18 ± 3.83	2.94 ± 6.76	8.33 ± 14.37
Apical	0.75 ± 2.26	4.32 ± 8.70	2.26 ± 6.30	26.03 ± 56.51

In terms of the percentage of remaining debris, Group D exhibited the highest values in the apical, middle, and coronal thirds, as illustrated in Figure 3.

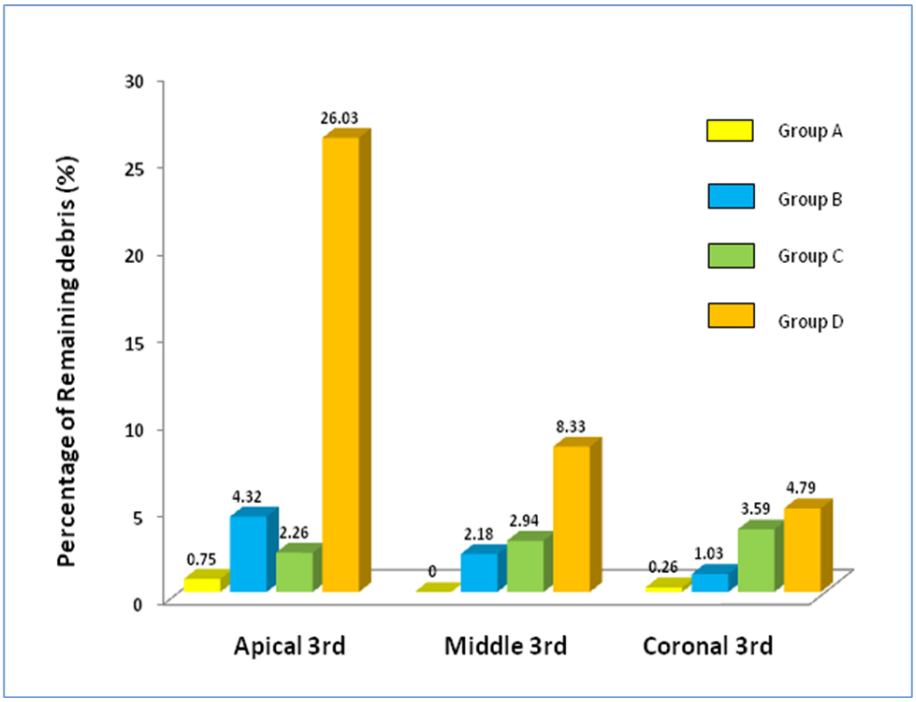

Fig. 3: Histogram representing the percentage of remaining debris in various groups.

The descending order of remaining debris in the various groups is as follows, as depicted in the graph:
Apical third - D > B > C > A
Middle third - D > C > B > A
Coronal third - D > C > B > A

IV. DISCUSSION

The effectiveness of endodontic retreatment is closely linked to the thorough elimination of the filling material from the root canal [10]. In case of root canal failure where persistent periapical inflammation may be attributed to residual necrotic tissue or bacteria, it is essential to thoroughly eliminate the filling material. This thorough removal facilitates effective cleaning and subsequent refilling of the root canal system [11].

One notable characteristic of the ProTaper shaping files is their progressively tapered construction, which has been demonstrated in clinical practice to significantly enhance flexibility and cutting efficiency. These instruments have a convex triangular cross-section, reducing the contact area between the file's blade and dentin, thereby improving its cutting effectiveness. The ProTaper files exhibit continuously changing helical angles and pitches along their 14 mm of cutting blades, carefully balancing these parameters to optimize cutting performance, efficiently clear debris from the canal, and prevent the instruments from getting stuck. Moreover, the ProTaper file is equipped with an altered guiding tip, specifically engineered to improve its maneuverability within the canal, particularly when encountering soft tissue and loose debris.

On the contrary, Mtwo files possess an "italic S" shaped cross-section with dual cutting edges.". The rake angle of Mtwo is a highly effective feature that boosts its cutting efficiency. These instruments are designed with a non-cutting tip and variable helical angles, which help minimize the risk of the instrument becoming inadvertently threaded into the canal [12].

Endodontic research employs various techniques to assess the effectiveness of root filling removal, such as radiography and digitized images. Nevertheless, these methods offer only two-dimensional insights into a three-dimensional (3D) object. Alternative approaches involve longitudinally splitting the teeth and observing them through a stereomicroscopeCone beam computed tomography (CBCT) is purpose-built for capturing three-dimensional (3D) data related to the maxillofacial skeleton, encompassing the teeth and their adjacent tissues. In recent times, the adoption of CBCT in endodontic research has facilitated the comprehensive assessment of root canal procedures in a 3D context. This non-invasive technique offers a detailed view of anatomical structures without the need for destructive measures on the teeth [13].

The findings from this study indicate that, consistent with prior reports (Schirrmeister et al., 2006), none of the experimental techniques can ensure the complete removal of filling materials Hammad et al. 2008). The highest percentage of remaining debris was found in apical third in group D, in which Mtwo retreatment files were used for removing filling material (Resilon). The reason for this can be because of micromechanical bonding between Resilon points and root canal dentinal walls. But in group B in which Protaper retreatment

files were used to remove Resilon, there was significantly less debris in the apical third of samples. In group A, ProTaper retreatment files significantly removed the filling material (gutta percha with zinc oxide eugenol sealer) especially in the middle third as compared to other groups.

This aligns with the findings of Hassanloo et al. in their 2007 study, where they concluded that during retreatment of teeth, there was a lower presence of filling residue in cases involving the gutta-percha sealer combination compared to the Epiphany system [14].

This study was conducted on teeth possessing straight root canals, and therefore, the findings should not be directly extrapolated to teeth with curved root canals. It is evident that additional research is necessary to evaluate the effectiveness, preservation of the original canal morphology, and safety of NiTi rotary instruments in the context of retreatment involving complex root canal anatomies.

V. CONCLUSION

Based on the conditions of this laboratory-based study, it can be deduced that neither of the retreatment systems employed for the extraction of obturating material in endodontic retreatment achieved complete effectiveness; however, among the groups assessed, the ProTaper retreatment files demonstrated superior efficiency in removing the obturating material (gutta-percha with zinc oxide sealer) when compared to the other techniques.

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