COMPARISON OF RECIPROCATING VERSUS ROTARY MOTION FOR GUTTA-PERCHA REMOVAL USING CONE BEAM COMPUTED TOMOGRAPHY (AN IN VITRO STUDY)

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ABSTRACT

INTRODUCTION: the maximum removal of root canal filling material is essential for successful endodontic retreatment.
OBJECTIVE: to compare the efficacy of two reciprocating systems Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland), compared with (NiTi) rotary system (ProTaper Universal Retreatment, Dentsply Maillefer) in the removal of root canal filling material
METHODS: Thirty messiobuccal canals of mandibular first molars were prepared using NiTi Revo-S (Micro-Mega, France) until SU file and then obturated. The specimens were divided into 3 groups (n=10) according to the system used for filling removal: group 1: Reciproc R25, group 2: WaveOne primary file, and group 3: ProTaper Universal retreatment rotary system. Cone beam computed tomography (CBCT) was used to scan the specimens before and after retreatment to measure the volume of filling material by using (Osirix 32-bit) software. Kruskal-Wallis test was used while the Wilcoxon test was used to test for changes of median volume before and after intervention. The Friedman test was used for all groups to test for differences of volume (%) of filling material remaining between the coronal, middle and apical zones
RESULTS: All teeth examined had filling remnants within the canals. No statistically significant differences ($P > 0.05$) in residual filling material were observed among the groups, with 11.03% in (Group 1), 6.80% in (Group 2), and 10.15% in (Group 3). ProTaper Universal retreatment system left more remnants in the apical part with no significant difference between groups ($P>0.05$).In the middle part, the Reciproc group had higher remnants than the other groups with significant difference between them
($P<0.05$).Coronally, WaveOne left less remnants with no significant difference between the groups.
CONCLUSION: The Reciproc and WaveOne reciprocating systems were as effective as the ProTaper Universal retreatment system for root canal filling material removal although the WaveOne system appeared to give the best results.
KEY WORDS: Endodontic Retreatment, Reciproc, WaveOne, cone beam computed tomography.

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INTRODUCTION

Persistent or secondary intraradicular infection is a major cause of post treatment disease (1). Non-surgical retreatment is indicated in cases of failed endodontically treated teeth (2). The effective removal of filling material from the root canal system is essential to ensuring a successful outcome of the retreatment procedure (3-5).

Several techniques have been used to remove root canal filling materials, including the use of rotary systems specially designed for retreatment (6). One of these systems is ProTaper Universal retreatment system (Dentsply Maillefer, Ballaigues, Switzerland) (7, 8). It consists of 3 instruments used with continuous rotation: D1 with tip 30 and taper 0.09, D2 with tip 25 and taper 0.08, and D3 with tip 20 and taper 0.07. In addition, the D1 working tip facilitates initial penetration into the filling material (3). Recently, a new reciprocating motion approach was introduced for instrumentation using nickel-titanium instruments with M-Wire alloy which increases the resistance and flexibility of the reciprocating instruments than the conventional alloy (9, 10). Two systems, Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer), are based on this motion. Reciproc has an S-shape cross-section. While Wave One has a modified convex triangular cross section at the tip end and convex triangular cross-section at the coronal end (11). The manufacturers claim that the reciprocal motion would reduce the torsional stress by periodically reversing the rotation (150° counter clock wise, then 30° clockwise rotation for Reciproc; 170° counterclockwise, then 50° clockwise rotation for Wave One) of the file. (12)

Previous studies have used different methods to assess remaining filling material, such as the use of radiographs and digitized images (13) (which only provides 2D information for a 3D object) or clearing techniques and digitized images (11) were also used as evaluation methods. Other studies used vertically sectioned roots, and then digital images were carried out (7) to see the amount of remnants of gutta-percha. This might not be accurate because some remaining filling material might be lost in the process (14).

Recently the amount of the residual filling material in the root canal after retreatment has also been investigated by using 3D cone beam computed tomography (15), which is more easy to be used as there is no root sectioning, also there is no loss of the residual filling material in the root canal. This helps in determining the accurate amount of the residual filling material in the root canal. The cone beam computed tomography can give 3D volumetric analysis and measurement of the volume of the root canal residual gutta-percha.

Based on this, the aim of the present study was to determine the effectiveness of WaveOne and Reciproc systems in root canal retreatment versus the Protaper universal retreatment system using a non-invasive assessment technique; cone beam computed tomography.

MATERIALS AND METHODS

Thirty freshly extracted mature human mandibular first molars were collected from the out-patient clinic of the Oral Surgery Department, Faculty of Dentistry, Alexandria University and other private dental offices. The mesiobuccal canal was selected from each tooth. Teeth were selected such that the mesial root curvature angle was between 10-25 degrees according to the Schneider technique(16) .

Canal preparation

The working length was standardized between 18-20 mm. The pulp chambers of thirty extracted mandibular first molars teeth were accessed conventionally by using high speed round and endo-Z burs under copious water cooling. A size 10 k-file (Dentsply Maillefer, Ballaigues, Switzerland) was inserted through the canal 1mm beyond the apical foramen to establish apical patency. The working length (WL) was established as 0.5mm shorter than the length of the root.

After introduction of hand files Size 10 and 15 hand k-files were used for establishment of a glide path. Revo-S (Micro-Mega, France) files were then used to clean and shape the root canals following manufacturer's instructions until the SU file was reached. During preparation and between each file, canals were irrigated with 2 mL of 5.25% Sodium Hypochlorite (NaOCl) using a conventional syringe with 27 gauge and the canal patency was checked.

After completion of instrumentation, all specimens were irrigated with17% (ethylenediaminetetracetic acid) EDTA solution for 1min. A final flush with 5.25% NaOCl was then done and canals were dried with paper points.

Canal filling

For all teeth, ADSEAL resin based sealer (META BIOMED, Chungcheongbuk , Korea), was mixed according to the manufacturer's instructions. The canal was filled using the lateral compaction technique. Size 25 taper (6% taper) gutta-percha (MICRO-MEGA, France) cone was selected. Afterwards, a sealer coated gutta-percha cone was placed up to the working length then the accessory cones (sizes 20 and 25) were laterally compacted until the canal was filled. A heated hand plugger was used to sear-off the gutta-percha at the entrance orifice of the canal. Each tooth was sealed with MD-Temp (META BIOMED, Chungcheongbuk , Korea),temporary restorative material until the time of analysis.

The distal root was amputated by using a diamond disc mounted on a straight hand piece, to avoid the superimposition of the distal root which interfered with evaluation of the integrity of the root canal filling in the digital periapical radiographs.

The teeth were digitally radiographed by using a (DURR DENTAL, Bietigheim-Bissingen, Germany) size 1 sensor in both mesio-distal and bucco-lingual directions to ensure consistency of root filling. Samples displaying lack of homogeneity or improper compaction were discarded and new samples were prepared.

The teeth were randomly divided into three groups of 10. They were then mounted onto a rubber base platform (5 in each block) and accurately labeled prior to cone beam computed tomography analysis.

Cone beam computed tomography (CBCT) analysis

A J.Morita R100 cone beam 3D imaging system (JMORITA MFG. CORP. Kyoto Japan) was used to scan the specimens at two stages (after root filling and after removal of the root filling) (Fig 1). The scan was done with a field of view (FOV) of 100mm x H 80mm. The volumes of interest were then reconstructed with 0.260 mm isometric voxel size. The tube voltage was 90kVp and 8 mA and the exposure time was 9.4 seconds.

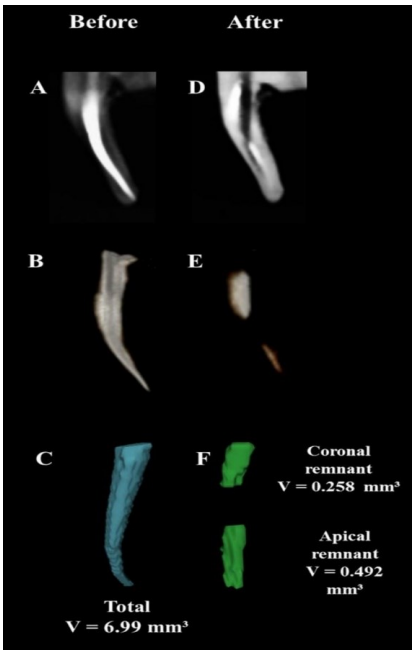

Fig 1: Showing the method of calculation of the volume of filling material from CBCT images processed using Osirix software for one representative sample where A, B, C are images of the sample after filling (before re-treatment) and D, E, F are images of the sample after re-treatment. (A and D) sagittal sections through sample; (B and E) Extracted VOIs after thresholding of the images to identify ONLY the filling material remaining; (C and F) Calculated volumes of filling material in mm^3. (V; volume).

Three-dimensional volumetric image analysis

After acquisition of CBCT images, the dicom files were imported into an image analysis software program (Osirix 32-bit, Geneva, Switzerland).

In order to accurately distinguish between the root canal filling material and the dentinal walls, the level of contrast was adjusted with a threshold range (Fig 1). This range was maintained for all samples in order to standardize the method of measurement.

Using the software, a region of interest (ROI) was selected by outlining the external margins of the filling at 3 to 5 zones along the entire length of the canal.

The software then used these measurements to compute the entire volume of the filling material present in the canal.

This volume was then measured in mm^3 (Fig 1). The same process was followed to calculate the residual filling material. The percentage of volume of remaining filling material on canal walls was calculated with the following equation:

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

Techniques for removal of the filling material

Group 1

In this group, a Reciproc R25 (VDW, Munich, Germany) file was used to remove the filling material. The instrument was introduced into the canal, activated by a WaveOne electric motor (Dentsply, Maillefer, Ballaig, Switzerland) and applied in reciprocating motion (according to the saved program). After three pecking motions, the instrument was removed from the canal and cleaned with sterile gauze and the canal was irrigated with 2ml of 5.25% NaOCL using a conventional syringe with (27 gauge). This procedure was repeated until the instrument reached the original working length.

Group 2

In this group, a WaveOne primary file (Dentsply, Maillefer, Ballaig, Switzerland) was used to remove the filling material. The instrument was introduced into the canal, activated by the WaveOne electric motor and applied in reciprocating motion (according to the saved program). After three pecking motions, the instrument was removed from the canal and cleaned with sterile gauze and the canal was irrigated with 2ml of 5.25% NaOCL using a conventional syringe with (27 gauge). This procedure was repeated until the instrument reached the original working length.

Group 3

In this group, Protaper universal retreatment instruments (Dentsply, Maillefer, Ballaig, Switzerland) were used to remove filling material. These were used in crown down manner. The D1 file was used to remove the coronal third of the canal filling material, followed by the D2 for the middle third of the root canal. Finally, the D3 was used to reach the working length. The instruments were used with a WaveOne electric motor at constant speed of 500 rpm for D1, D2 and D3, with a torque of 2Ncm. During preparation and between each file, canals were irrigated with 2 mL of 5.25% NaOCl using a conventional syringe with (27 gauge). Retreatment was considered complete when no gutta-percha or sealer was visually detected on the instrument surfaces.

Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply, Maillefer, Ballaig, Switzerland) files were used once according to manufacturer's recommendations.

The ProTaper universal retreatment system ((Dentsply, Maillefer, Ballaig, Switzerland) was used for 3 canals or discarded once signs of deformation appeared.

STATISTICAL ANALYSIS

After Data were collected and coded, they were subjected to statistical analysis using the SPSS IBM version 20 software.Graphs were then constructed using Microsoft excel software / SPSS software. All statistical analysis was done using two tailed tests with an alpha error of 0.05.

Descriptive statistics in the form of mean with standard deviation and median for scale data was done. Median was the measure of concern. To test for differences of median between study groups and the measured outcome, the Kruskal-Wallis test was used while the Wilcoxon test was used to test for changes of median volume before and after intervention. The Friedman test was used for all groups to test for differences of volume % of filling material remaining between the coronal, middle and apical zones per group while the Kruskal-Wallis test was used to compare between groups at each zone.

RESULTS

This study showed that the three systems are effective in removing root canal filling material, but none could completely remove the root canal filling material.

There was no statistically significant difference (P>0.05) between the volumes of filling material remaining between the three groups after retreatment (Table 1).

However, we found that there was less remaining filling material following the use of the WaveOne system (6.80%) followed by the ProTaper Universal retreatment system (10.15%) and finally the Reciproc system (11.03%) (Fig 2).

Additionally, it was found that the distribution of remaining filling material among the coronal, middle and apical thirds of the canal was not equal (Table 2). Although the result showed there was no statistically significant difference in the coronal part for the three groups however; it was shown that the ProTaper Universal retreatment system left more remnants in the coronal third (13.7%) followed by Reciproc (12.3%). The least amount of remnants in the coronal third was found in the WaveOne group (6.8%) (Table 2).

In the middle third, there was a statistically significant difference in the amount of remnants found between the Reciproc group and the 2 other groups (P<0.05) as Reciproc left more remnants (21.6%), followed by the ProTaper Universal retreatment system(9%) with the least remnants being found in the WaveOne group (3%). On the other hand, there was no statistically significant difference between the WaveOne and the ProTaper retreatment system groups (table 2).

Table 1: Describes the (Mean, SD, and Median) of the volume by % of the remaining filling material in each group.

Group	Volume %			"P
	Mean	SD	Median	
Reciproc	11.03	9.00	10.26	0.74 (0.691)
WaveOne	6.80	5.01	5.06	
ProTaper Universal retreatment system	10.15	11.27	7.05	

H: Kruskal-Wallis test

* P < 0.05 (significant)

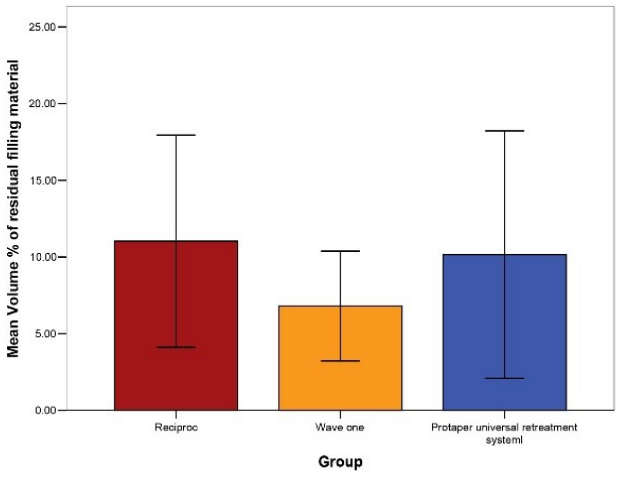

Fig 2: Graph representing the mean volume of remaining filling material by (%) in each group.

Table 2: Represents the volume % of remaining filling material in the three groups regarding coronal, middle and apical zones.

Group	Coronal		Middle		Apical		X^2 (P)
	Mean	SD	Mean	SD	Mean	SD	
Reciproc	12.3	8.8	21.6	9.4	6.6	8.2	0.048*
Wave one	6.8	4.6	3.0	2.2	7.9	5.7	0.458
Protaper universal retreatment system	13.7	13.0	9.0	2.5	8.6	3.5	0.395
H (P)	0.074		0.047*		0.336		

X^2: Friedman test

H: Kruskal-Wallis test

* P < 0.05 (significant)

Regarding the apical third, there was no statistically significant difference found in between the groups as the percentage of remnants found in the ProTaper Universal retreatment system group was (8.6%) followed by WaveOne (7.9%) and finally by the Reciproc group (6.6%) (Table 2).

DISCUSSION

Endodontic retreatments are a challenge with a high level of difficulty, and they are time consuming (17). Thus, it has been considered that the use of rotary instruments for retreatment could reduce the fatigue and time of endodontic retreatments (18). Previous studies have found that mechanical removal of root canal filling material was more rapid with rotary systems than hand files (12, 19, 20).

Some studies have found no significant difference between rotary and hand files regarding efficacy in removing root canal filling material (8, 21). On the other hand, Unal et al (4), Gergi et al (13), Schirrmeister et al (18), Hammad et al (22) and Barletta et al (23) found that hand files were more effective in removing filling materials than rotary files.

Conversely, Gu et al (3), Zoher et al (24), and Teixeria et al (25) showed that the use of rotary instrumentation for removing root canal filling material was more effective than hand files. The findings of the present study also found that rotary retreatment was effective in removing the root canal filling material.

Gu et al (3) suggested that better performance of ProTaper universal retreatment system was due to the progressive taper of these files compared to the hand files which have a constant taper of 2%. This feature of rotary files may enable them to cut not only the filling material, but also the superficial layer of dentin during removal of root canal filling material and therefore enhance removal of necrotic and infected tissue.

In the present study we did not employ solvents during retreatment, as the use of solvents has been a controversial issue. Solvents have been used in many studies demonstrating efficacy in enhancing removal of the remnant filling material (8, 15, 26, 27). Otherwise several studies have shown that solvents led to more gutta-percha and sealer remnants on root canal walls and inside dentinal tubules (12, 24, 27). In order to avoid such complications, the present study design excluded the use of solvents.

The introduction of reciprocating rotary instruments in addition to other systems working in continuous rotation has also had an impact on advancing rotary techniques used for removal of filling materials during retreatment procedures (28, 29). Reciprocating systems produce a broader motion in the counterclockwise direction yet shorter in the clockwise direction, keeping the file more centered in the canal (9, 30).

As previously mentioned, together with the marked taper of these files, creates a greater contact area between the instrument and gutta-percha, allowing filling removal that is as effective as that produced with continuous rotation.

There are several techniques to evaluate remaining root canal filling material after retreatment procedures. Some studies have used digital images of longitudinally sectioned roots but this technique could lead to loss of remaining filling material during the sectioning process (28). Radiographic examination has been used as a non-destructive evaluation method, but this only provides 2D information and fails to accurately detect the amount of residual filling material since radiographs may not accurately detect very small amounts of residual material (31).

A non-destructive method to evaluate residual material is to decalcify and clear the teeth, which can allow 3D visualization. However, evaluation scales used with this method are subjective (19).

On the other hand, Micro-computed tomography (Micro CT) imaging has also been used to analyze the volume of residual filling material (15, 22). This non-destructive method allows 3D quantitative evaluation and a step-by-step analysis by scanning after each stage of the procedure during re-treatment.

In the present study we used CBCT to evaluate the remaining filling material present after retreatment with the different system as a non-invasive and quantitative method to estimate the volume of filling material (31).

The results of the present study demonstrated that none of the three techniques completely removed the filling material from the canal walls. This finding is in agreement with those of Bramante et al (32) and Xu et al (33), who reported the virtual impossibility of removing 100% of the residual gutta-percha and sealer from root canal walls with different techniques used in root canal retreatment.

However, there was no statistically significant difference between the three systems used in this study regarding their ability to totally remove residual material. Others such as Yigit et al (34), Silva et al (35), souza et al (36) also documented similar outcomes.

Regarding where most of the residual filing material was found, we showed that the highest remnants in the apical third were found in the ProTaper Universal retreatment group. Because the aim of this study was to compare the efficacy of the techniques for removal of gutta-percha and sealer up to the working length, the canals were not re-instrumented in accordance with the study by Takahashi et al (8) and Bramanter et al (32). This may have resulted in the higher amount of remnants found in the apical part in this group. To achieve enhanced cleansing, reinstrumentation up to the working length using large size instruments than those used during initial treatment has been recommended (32).

Hassanloo et al (37) reported that, the remnants of root canal filling material are reduced when the last file used in retreatment is larger than the last file used during canal shaping.

Yuruker et al (38) found that the additional use of Reciproc or hand H-files significantly improved the

removal of filling material when compared with ProTaper Universal retreatment system alone.

Indeed, while the D3 file of the ProTaper Universal retreatment system is size 20 and it is the final instrument recommended by the manufacturer, the Reciproc R25 and the primary WaveOne file have a tip size of 25. These are the closest equivalents to the tip of the D3 instrument. This fact may have accounted for higher percentage of remnants found apically with protaper as compared to the other groups.

In this present study we observed that two primary WaveOne files were separated in two samples and ledge formation occurred in one sample. These samples were discarded and replaced with other samples. Kim et al (39) reported that Reciproc showed higher cyclic fatigue than WaveOne and WaveOne had a higher torsional stiffness than Reciproc.

In the ProTaper universal retreatment system two D3 files showed signs of deformation during filling material removal.

Beasley et al (40) reported fractures and deformation in some D3 files of the ProTaper Universal retreatment system during filling removal in moderately curved canals. The authors attributed these drawbacks to the high taper of the instrument and the speed applied during its use, these factors which could lead to an increase in the torsional fatigue of the instruments in contact with filling material (40).

It is also important to document that in two samples of the ProTaper Universal retreatment system group, no remnants of filling material could be found in any of the 3 segments indicating complete removal of the filling material.

CONCLUSIONS

Although the Reciproc and WaveOne reciprocating systems were not originally designed for retreatment, the hypothesis that the special design of their instruments as well as the reciprocating motion can be potentially beneficial for the effective removal of filling material was confirmed in this study. Indeed there was no significant difference between the ProTaper Universal retreatment system which was designed originally for retreatment and the Reciproc and WaveOne systems. Particularly, reciprocating systems appear to be equally effective as those working in continuous rotation for retreatment if not more superior as demonstrated by the results of the WaveOne system.

STATEMENT OF CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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