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ASSESSMENT OF THREE HEAT TREATED SINGLE FILE SYSTEMS IN GUTTA-PERCHA REMOVAL USING CONE BEAM COMPUTED TOMOGRAPHY (AN IN VITRO STUDY)

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ABSTRACT

INTRODUCTION: Absolute removal of the defective root filling material and regaining apical patency is the primary factor of endodontic retreatment success.

AIM OF THE STUDY: Assessment of the ability of Reciproc R25 (VDW, Munich, Germany), Reciproc blue (VDW, Munich, Germany) and the XP-endo shaper (FKG Dentaire, La Chaux-de-Fonds, Switzerland) thermally treated rotary files in removing of the root filling material from oval shaped canals using cone beam computed tomography (CBCT).

MATERIALS AND METHODS: Thirty six extracted single canaled human mandibular premolar teeth were prepared chemo-mechanically using Revo-S rotary file system (Micro-Mega, France) and obturated. The teeth were randomly allocated into three groups (n=12 each) depending on files used in retreatment procedure as follow: Group I: Reciproc R25, Group II: Reciproc blue, Group III: XP-endo shaper. Pre and post retreatment scans were done using CBCT to calculate the volume of the remaining gutta percha by using computer software (Osirix lite). Time consumed by each file was recoded until gutta percha was completely removed.

RESULTS: All used files were not able to remove the entire root filling material from the canals. No statistically significant differences (P> 0.05) in residual gutta percha were detected between the groups, the percentage of reduction was 88.87 % in (Group Ⅰ), 92.22 % in (Group Ⅱ), and 88.60 % in (Group Ⅲ). The XP-endo shaper required more time with statistically significant difference than the Reciproc groups in gutta percha removal.

CONCLUSION: All systems removed the root filling material from oval shaped canals effectively. Both reciproc systems were faster than XP-endo shaper in gutta percha removal.

KEYWORDS: Endodontic retreatment, Reciproc blue, Reciproc R25, Retreatment rotary files systems, XP-endo shaper.

RUNNING TITLE: Assessment of Heat Treated Systems In Endodontic Retreatment

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INTRODUCTION

Persistent or secondary intra-radicular infections are considered to be the main factor in initial endodontic treatment failure (1,2). In this situation nonsurgical endodontic retreatment is mandatory to enhance the root canal disinfection and debridement (3). For achieving this purpose, removal the previously infected root filling material and the assurance of the patency of the apical foramen is essential (4,5).

Various techniques have been recruited in the old infected gutta percha removal including: manual files, gates glidden drills, heat carrying devices, nickel titanium (NiTi) rotary and reciprocating files, ultrasonic tips and laser (6,7). Despite their ability in removing large portion of the gutta percha, no method has the ability to leave the canal free from gutta precha (8). This becomes even more challenging in more complex oval shaped canals (9).

M-wire reciprocating rotary files was fabricated by a proprietary thermomechanical processing procedure. All three crystalline phases, including deformed and micro twinned martensite, R-phase, and austenite presents in it (10). It is able to remove root filling material faster than conventional NiTi instruments (11).

Reciproc R25 and Recipoc blue are two reciprocating single file systems with S-shaped cross section, two cutting edges and non-cutting tip design with taper of 0.08. Reciproc blue introduced to molecular structure alternation to increasing the flexibility and resistance to cyclic fatigue by an

innovative heat treatment mechanism presenting its surface with visible blue titanium oxide layer (12).
A snake shaped XP-endo shaper file was introduced by FKG Dentaire, which is fabricated from a proprietary alloy (MaxWire, Martensite-Austenite Electropolish-flex) (13). Because of this new alloy, the file changes its shape according to the temperature. When cooled, in its martensitic phase, the file stands straight with a D0 of #27 and an initial taper of 0.01. However, when submitted to body temperature during rotation inside the canal, it changes to its austenitic phase assuming a snake shape and D0 increase to #30 and the taper to 0.04. The manufacturer claimed that the alloy's properties and the new design of the file enable it to become more efficient in mechanical debridement and decrease the untouched areas of the canal than any conventional NiTi instruments (13,14).
Many methods have been advocated to assess the remaining gutta percha after endodontic retreatment. Among these methods are conventional and digitalized radiographs, the splitting method and cone beam computed tomography (CBCT) which can be used for 3D volumetric analysis of the root canal space and the residual obturating material after endodontic retreatment without causing any destruction for the tooth (15-16).
Several studies have investigated the performance of reciprocating files and XP-endo shaper file in root canal preparation and they were efficient. Would they be efficient in root canal retreatment?
The aim of this study was: to assess the ability of XP-endo shaper, Reciproc R25 and Reciproc blue heat-treated rotary files in removing of the root canal filling material from oval shaped canal. Also, to evaluate the time needed by each rotary file to completely remove the root filling material.
The null hypothesis of this study was that there was no significance differences between the tested groups in the removal of root filling materials

MATERIALS AND METHODS

This study was approved by the ethics committee of Faculty of Dentistry, Alexandria University (serial no. 0228-03/2021) **(**IRB no: 00010556 – IORG 0008839) . It was conducted at the Faculty of Dentistry, Alexandria university, Egypt.

Sample size calculation

Sample size was estimated assuming 5% alpha error and 80% study power. The mean (SD) percentage reduction in volume of root filling when M-Wire Reciproc, Reciproc Blue, and XP-endo Shaper were used= 85.03 (7.52), 81.94 (5.55), and 90.46 (5.13), respectively (17). Sample size was calculated to be 11 specimens per group using F test. This was increased to 12 specimens to make up for processing errors. Total sample size = Number per group × Number of groups = 12 × 3 = 36 specimens
Sample size was based on Rosner's method (18) calculated by Gpower software ver 3.0.10. (Universität Düsseldorf, Germany)

Canal preparation

Thirty-six extracted human mandibular premolars with single root and single canal (vertucci type Ⅰ) included in this study. The selected premolars had mature apices and the canals were patented with K-file size #10 and the initial file did not exceed K-file size #15. The premolars were free from cracks, calcification, root caries, fractures, external or internal resorption. The premolars were accessed in the conventional way by a high-speed round bur and Endo-Z bur (Dentsply Maillefer, Ballaigues, Switzerland). The working length (WL) was determined by inserting K file #10 (Dentsply Maillefer, Ballaigues, Switzerland) till it is just visible from the apical foramen and then 1mm will be reduced from this point. Manual glide paths for all teeth were established till K file #15 (Dentsply Maillefer, Ballaigues, Switzerland), the teeth were prepared chemo-mechanically using Revo-S rotary files (MicroMega ,Besancon, France) to the full working length (WL) till size #25 taper 6%. The canals were irrigated during the preparation and between each file with 1 mL 5.25% NaOCl using 30G side vented syringe (Endo-Top, Cerkamed, Poland). After cleaning and shaping, all teeth were irrigated with 3 mL 17% EDTA solution for 1 minute then a final rinse by 1 mL 5.25% NaOCl and the canals were dried by paper points.

Canal obturation

Teeth were filled by 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 (DiaDent, Korea) 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. All premolars were radiographed mesio-distally and bucco-lingually to assess root filling quality. Access cavity was sealed by temporary filling and stored for one week to allow complete setting of the sealer.
All premolars were fixed in condensation silicon rubber base inside custom made resin molds to standardize the angulation of the CBCT scans before and after endodontic retreatments (5 in each block).

CBCT evaluation before retreatment

All teeth were scanned before retreatment procedure to calculate the volume of the filling material in the canals by using J.Morita R100 (Morita 3DX; J.Morita Mfgcorp., Kyoto, Japan) cone beam 3D imaging system for image with the following parameters: field of view of 100mm x H 40mm. The voxel size was set to be 0.65 mm. The tube voltage was

75kVp 1 mA with exposure time 9.4 seconds. The volume of root canal filling was calculated using OsiriX lite software. (Figure 1)

Retreatment Technique

The premolars were randomly allocated into three groups (n=12 teeth) depending on the file system used in retreatment procedure.

Group I

The Reciproc R25 rotary file was used for the root filling removal until reaching the WL. The rotary file was activated using Endo Gold endodontic motor (Woodpecker , Guilin, China) in a reciprocating movement at speed 300 rpm, and angle 150° REV–30° FWD, following the manufacturer's recommendation. The Reciproc R25 rotary file was used in a slow 3-mm amplitude in and out pecking motions with gentle apical pressure combined by a lateral brushing motion against all canal walls. After three pecking movements, the file was taken outside the canal, cleaned and reinserted.

Group II

Reciproc Blue 25 rotary files was used in the same way as group I.

Group III

The XP-endo Shaper rotary file was activated using Endo Gold endodontic motor in continuous rotating motion at 1000 rpm and 1 Ncm, following manufacturer's recommendation. The rotary file was used in long gentle strokes until reaching the full WL. Then it was held for 30 seconds.

The same irrigation protocol used during primary shaping was used again during retreatment procedures in all groups.

Retreatment procedures for all groups were considered to be finished when the retreatment files reach the working length and no more gutta percha was observed on it.

For each tooth one files was used and then discarded as recommended by the manufacturer.

CBCT evaluation after retreatment

After retreatment, each premolar undergone another CBCT scan to calculate the volume of the remaining filling material inside the canal using the Osirix lite software. The percentage of the residual root canal filling volume was calculated using the subsequent formula (19):

$$\frac{\text{Volume of the remaining root canal filling}}{\text{Volume of the original root canal filling}} \times 100\% = \text{The percent of remaining filling material}$$

Time required for gutta-percha removal:

The total time elapsed during gutta percha removal by each file was measured by a stopwatch. The total time was considered to be the duration lapsed from the second the files firstly introduced into the root canal until it reached the working length and no more filling material is detected on it. The stopwatch was paused, whenever the file is taken outside the root canal (20).

Statistical analysis

Normality was checked using Shapiro Wilk test, box plots and descriptives. Time required for gutta percha removal was normally distributed and volume of remaining obturating material was not normally distributed. Data was presented using mainly Median, Inter Quartile Range (IQR) and Minimum and Maximum values for and volume of remaining obturating material in addition to Mean, Standard deviation (SD) for Time required for gutta percha removal.

Percent change in volume readings was calculated according to the following formula: [(readings after – readings before) / readings before)] x 100.

Differences in time required for gutta percha removal were compared using One Way ANOVA test and followed by Tukey's post hoc test while volume of remaining obturating material was compared between groups using Kruskal Wallis Test. Intragroup comparisons before and after gutta perch removal were done using Wilcoxon Sign Rank test. Comparisons between apical, middle, and coronal thirds percent reduction within each group were done using Freidman test. Significance level was set at *P* value of 0.05. All tests were two tailed. Data were analysed using SPSS (IBM Corporation, NYC, USA) for windows version 23.

RESULTS

According to the amount of filling material calculated pre and post retreatment in the canals, it was found that all files significantly removed the filling material when comparing between pre- and post-retreatment CBCT images (Table 1) ($P<0.05$). The highest percentage of reduction was in the Reciproc blue system by average median (92.22%) followed by the Reciproc R25 (88.87%) and finally the XP-endo shaper system (88.6%). Even though there was no statistically significant difference in the percentage of reduction of the volume of residual obturating material between the three groups after retreatment (Table 2, Figure 2).

The results showed that there was no statistically significant difference in the amount of remaining filling material in the coronal, the middle and apical thirds for the three groups (Table 3).

However, it was shown that in the coronal third the Recipro blue has the highest reduction percentage by average median (97.86%) followed by the XP-endo shaper (95.73 %). The least reduction percentage were found in the Reciproc R25 group (83.91 %).

In the middle third, the XP-endo shaper showed the highest reduction percentage by average median (98.14 %) followed by Reciproc blue system (95.42%) and finally Reciproc R25 (90.23 %).

For the apical third, Reciproc R25 has the highest percentage of reduction y average median (99.28 %), followed by XP-endo shaper (95.62%) and finally Recipoc blue (95.6%).

Concerning the time taken by each file to totally remove the root filling material, more time was needed by the XP-endo shaper by average mean (10.52 min) followed by Reciproc blue (6.67 min) then Reciproc R25 took the least time (5.38 min). (Table 4,5) showing statistically significant difference between Reciproc systems (R25 and Reciproc blue) and XP-endo shaper.

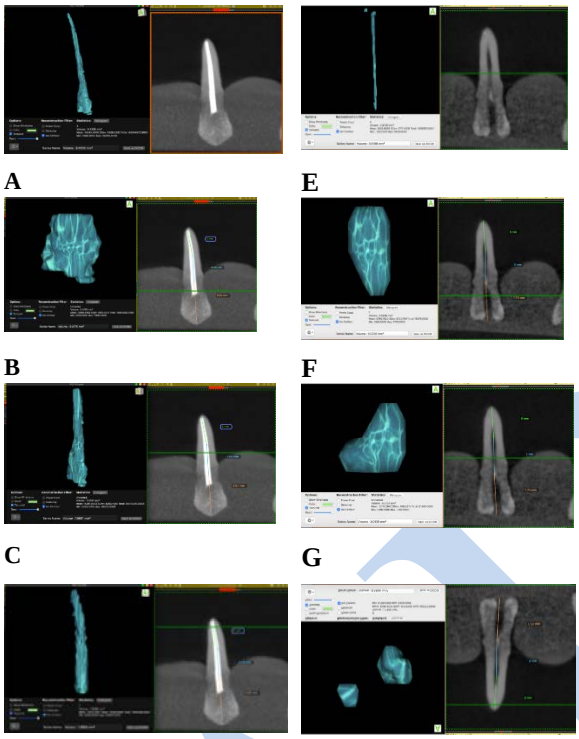

Figure 1: Showing the method of calculation of the volume of the filling material from CBCT images processed using Osirix dicom software for one representative sample where (A, B,C,D) are images of sample after filling (before retreatment) and (E,F,G,H) are images of the sample after retreatment. (A and E) calculating the filling material in the whole canal (B and F) in the coronal third (C and G) in the middle third (D and H) in the apical third.

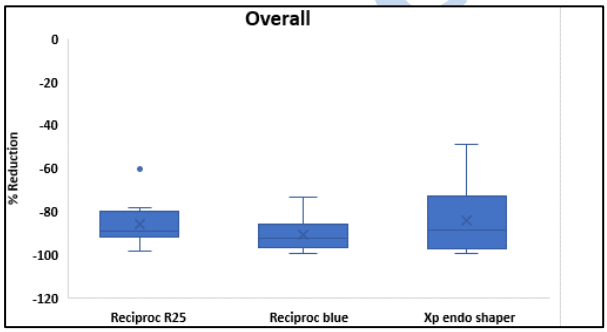

Figure 2: Box plot of percent reduction in overall volume of remaining obturating material among the study groups.

Table 1: Overall volume of remaining obturating material among the study groups.

		Reciproc R25 (n=11)	Reciproc Blue (n=11)	Xp Endo Shaper (n=11)	Test (*p* value)
Before	Mean (SD)	5.21 (2.77)	4.27 (2.05)	3.32 (1.16)	5.115 (0.078)
	Median (IQR)	4.78 (1.50)	3.61 (1.86)	3.70 (1.98)	
	Min - Max	1.68 – 10.35	2.42 – 8.35	1.49 – 5.06	
After	Mean (SD)	0.76 (0.67)	0.47 (0.61)	0.46 (0.42)	3.262 (0.196)
	Median (IQR)	0.53 (0.59)	0.37 (0.31)	0.39 (0.60)	
	Min - Max	0.04 – 2.23	0.02 – 2.20	0.01 – 1.48	
Test (*p* value)		2.934 **(0.003*)**	2.934 **(0.003*)**	3.059 **(0.002*)**	

Kruskal Wallis test
Wilcoxon tes
*Statistically significant difference at *p* value≤0.05

Table 2: Percent reduction in overall volume of remaining obturating material among the study groups.

		Reciproc R25 (n=11)	Reciproc Blue (n=11)	Xp Endo Shaper (n=11)	Test (*p* value)
% Reduction	Mean (SD)	85.86 (10.25)	90.47 (7.59)	84.27 (15.21)	1.397 (0.497)
	Median (IQR)	88.87 (11.83)	92.22 (10.92)	88.60 (24.64)	
	Min - Max	60.17 – 98.20	73.61 – 99.16	49.09 – 99.57	

Wilcoxon test
Kruskal-Wallis test

Table 3: Percent reduction in volume of remaining obturating material among the study groups between coronal, middle and apical thirds.

		Reciproc R25 (n=11)	Reciproc Blue (n=11)	Xp Endo Shaper (n=11)
Coronal	Mean (SD)	72.97 (29.66)	81.99 (24.79)	80.78 (30.0)
	Median (IQR)	83.91 (52.62)	97.86 (38.22)	95.73 (32.34)
	Min - Max	12.36 – 100.0	29.16 – 100.0	1.40 – 100.0
Middle	Mean (SD)	91.04 (8.65)	91.43 (9.78)	86.31 (20.09)
	Median (IQR)	90.23 (10.16)	95.42 (12.53)	98.14 (22.39)
	Min - Max	69.76 – 100.0	67.30 – 100.0	40.19 – 100.0
Apical	Mean (SD)	81.38 (26.95)	88.28 (16.67)	83.27 (24.54)

	Median (IQR)	99.28 (35.03)	95.60 (17.46)	95.62 (34.85)
	Min - Max	27.59 - 100	46.92 – 100.0	27.81 – 100.0
Test (*p* value)		1.33 (0.513)	0.326 (0.850)	1.773 (0.412)

Table 4: Time required for gutta percha removal among the study groups in minutes.

	Reciproc R25 (n=11)	**Reciproc Blue (n=11)**	**Xp Endo Shaper (n=11)**	**Test (*p* value)**
Mean (SD)	5.38 (1.63)	6.67 (2.37)	10.52 (2.34)	18.688 **(<0.0001*)**
Median (IQR)	5.39 (2.09)	6.83 (3.76)	10.85 (3.25)	
Min - Max	2.02 – 8.04	3.21 – 11.10	5.45 – 13.44	

*Statistically significant difference at *p* value≤0.05
One Way ANOVA test
Tukey's post hoc test

Table 5: Pairwise comparisons between groups regarding time required for gutta percha removal

Groups	**Compared to**	***P* value**
Reciproc R25	Reciproc Blue	0.317
	Xp Endo Shaper	**<0.0001***
Reciproc Blue	Xp Endo Shaper	**<0.0001***

*Statistically significant difference at *p* value≤0.05

Table 6: Length of the root canals among the study groups

	Reciproc R25 (n=12)	**Reciproc Blue (n=12)**	**Xp Endo Shaper (n=12)**	**Test (*p* value)**
Mean (SD)	20.71 (1.54)	21.46 (1.59)	20.62 (1.77)	0.942 (0.400)
Median (IQR)	20.50 (2.0)	22.00 (2.1)1	20.75 (3.0)	
Min - Max	18.0 – 24.0	18.0 – 24.0	18.0 – 23.0	

One Way ANOVA test
Tukey's post hoc test

DISCUSSION

Failure of primary endodontic treatment can be corrected through nonsurgical retreatment by enhancing the debridement and the disinfection of the whole root canal system, followed by obturating it with more homogenous and 3D tight filling (4). Endodontic retreatment success relays on the total removing of filling material in order to reach the infected pulp tissues that harbour microorganisms responsible to primary treatment failure (21,22).

The main aim of this study was to compare between three single heat-treated file systems (Reciproc R25, Reciproc blue and XP-endo shaper) with two different types of motion (rotary and reciprocating) in gutta percha removal and the time consumed until complete removal.

Single oval canaled human mandibular premolars were used in this study, as oval-shaped canals considered to be challenging to any mechanical system to prepare or to remove the filling material from it during retreatment procedure (23) as the files cannot touch flattened areas of the canal (24). Different files designs with different types of motion (rotary and reciprocating) were tested in this study to evaluate their efficacy in gutta percha removal in the crucial condition of oval-shaped canals (25).

In this study standardization of the anatomical morphology was done following Paque and Peters suggestions (26) by periapical radiographs in the mesiodistal and buccolingual planes and CBCT scans by recruiting only mandibular premolars with single root straight or with moderate curvature with single canal (type I vertucci) with no cracks, calcification, root caries, fractures, external or internal resorption.

Gutta percha solvent soften the gutta-percha chemically making it easier to be enforced to settle into the complex canal anatomies making its removal more difficult, so it was not used in this study (25).

Micro-CT imaging is recognizably an excellent non-destructive high-resolution imaging method that provides a highly accurate quantitative 3D analysis of filling material volume before and after the retreatment procedure, allowing for calculating the percentage of filling material left in the canals after retreatment (23). However, its unavailability and its highly expensive cost remains a limitation.

As a non-invasive quantitative technique CBCT was recruited to assess volume of filling material pre and post retreatment procedure. CBCT showed that it can detect the remnants of filling material and outline areas of the canal they are found at (27). Gad et al., (28) and Azim et al., (8) confirmed CBCT efficacy in assessing the residual filling material during retreatment procedure. One of the limitations of this method, that it was unable to distinguish between the gutta percha and the sealer in the remaining filling material (27,28).

Bramante et al., (29) and Xu et al., (30) stated that entire removal of filling material is impossible to all different techniques used during retreatment. Most of these untouched spots are related to the inability of the files to reach and adapt to all root canal walls. As the roots were oval, the instruments did not adapt completely to the canal walls so the unreached parts remained unshaped during the primary treatment and also after the retreatment procedures, despite the usage of novel NiTi alloys and file designs (30). The present study demonstrates the same findings as none of files render the canal free of filling material.

The results of this study showed that Reciproc blue displayed the best results of removing gutta percha during retreatment procedure while Reciproc R25 and XP-endo shaper showed almost the same results. However, there was no statistically significant difference among the three systems used

according to their ability in removing of root filling material. Therefore, the null hypothesis was accepted.

The high ability of the Reciproc systems (R25 and Reciproc blue) in removal gutta percha is probably due to their special design, which is characterized by an S-shaped cross section, the angle of the two sharp cutting edges are more positive with larger chip space which increase the removal capacity (31,32). Based on Plotino et al., (31) and Bürklein et al., (32) the cutting efficiency of an instrument depends on its cross-sectional design. So, it can be assumed that the high efficiency of the Reciproc systems during retreatment is due to their S-shaped cross section.

The XP-endo Shaper file represents the Max-Wire NiTi alloy, owing to its unique characterization of shape memory when introduced to body temperature it expands. It has the ability to transform to a predetermined shape while expanding and contracting inside the canal allowing it to reach untouched areas. Its improved efficiency can be attributed to its slender design with a narrow triangular cross-section with a 4% taper and a six-blade booster tip. Also, at high speed of rotation it can plasticize and soften the gutta-percha, allowing it to be removed easily (13,33).

Results of this study were in the line with Emre et al., (34) showing no statistically difference between XP-endo shaper and Reciproc R25. Also, it was in accordance with Kırıcı et al., (35) and Bago et al., (36) reporting advancement of Recipoc blue over Reciproc R25 with no statistically significant difference in gutta percha removal.

However, our results were in contrast to Bago et al., (37) showing superiority of Reciproc R25 over Recipoc blue during retreatment with statistically significant difference. This might be due to the use of Reciproc R40 instead of R25 in our study.

Moreover, De-Deus et al., (17) showed superiority of XP-endo shaper with significant difference over Recipoc blue in gutta percha, removal this might be due to the use of D-Race rotary retreatment system in removing coronal and middle portion of gutta percha in XP-endo shaper group.

In this study, results showed no significant differences in the amount of remaining filling material in the coronal, the middle and apical thirds for the three groups. These findings is coincided with Martins M et al.,(38) as they found no significant difference in the residual gutta percha in the coronal, the middle and apical thirds between ProTaper next and Reciproc systems. Also, Faus-Llácer V et al.,(39) found no significant difference in the residual gutta percha in the coronal, the middle and apical thirds when XP endo shaper used to remove either Guttacore and Thermafil gutta-percha carrier-based root canal filling materials.

In this study, all teeth from all groups were free from perforation or ledges. However, one tooth in each group exhibited the incident of incident of separated file, these samples was discarded. These findings were in the same line with a previous study by Rodig et al., (40) and Azim et al., (13) stating that reciprocation files exhibit a fracture rate of 5% during retreatment procedures. Meanwhile De-Deus et al., (17) and Azim et al., (8) stated that XP- endo shaper is safe in endodontic retreatment even if it is operated at 3000 rpm which was in contrast to our results this could be due to that De-Deus used D-Race rotary retreatment system in removing coronal and middle portion of gutta percha before XP-endo shaper and Azim used lower incisors which have smaller root canal.

It was stated that in nonsurgical retreatment the volume of the remaining gutta percha could be minimized by enlarging the final apical size (41). However, in our study apical enlarging didn't minimize the volume of the remaining gutta percha, as Reciproc blue size 25 taper 0.08 which has the same size of the primary apical size had a better result than XP-endo shaper that enlarge the primary apical size to #30.

Reciprocating movement and continuous rotation movement have been profusely assessed in term of endodontic retreatment. Rossi-Fedele et al., (42) stated that reciprocation and continuous rotation systems show in gutta percha removal comparable capabilities. The results of this study showed the same findings as there was no difference in the ability of both movements in removing of gutta percha.

Results of this study revealed that Reciproc systems (R25 and Reciproc blue) were significantly faster than XP-endo shaper in gutta percha removal to the full working length. These results coincided with the results of Emre et al., (34). On the contrary, AlOmari et al (43) showed that XP-endo shaper was faster than Reciproc blue in gutta percha removal, this might be due to the difference in the methodology used in their study, where the coronal portion of gutta percha was removed by Gates-Glidden drills and the XP-endo shaper was operated at a speed of 3000 rpm while we used XP-endo shaper at a speed of 1000 rpm.

The current study had faced some limitations one of them the inability of all systems to completely remove the entire filling material, also CBCT was not able to distinguish between the gutta percha and the sealer in the remaining filling material.

Further investigations should be carried out to study the effect of the files on the thickness of the dentin walls, the use of larger files and supplementary cleaning methods on the removal of filling material and finally using different methods of evaluation of remaining obturation materials as micro-ct.

Although Reciproc R25, Reciproc blue and XP-endo shaper systems were fabricated for primary endodontic treatment and not for retreatment purposes, the hypothesis that their unique design in

addition to their movement kinematic can possibly enhance the removal of gutta percha was confirmed in this study. Despite their effectiveness in retreatment procedures, they still slower than rotary retreatment files and consume more time.

CONCLUSIONS

Despite the fact that these files were not designed for retreatment all of them were effective in root canal filling material removal during retreatment procedure. Both reciproc systems were faster than XP-endo shaper in gutta percha removal.

CONFLICT OF INTEREST

The authors proclaimed no conflicts of interest.

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