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Retreatment Efficacy of Continuous Rotation Versus Reciprocation Kinematic Movements in Removing Gutta-Percha with Calcium Silicate-Based Sealer: SEM Study

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ABSTRACT

Background: The removal of maximum amount of root canal filling materials is necessary for successful endodontic retreatment, several rotary systems have been used for removing obturating materials.

The aim of this study: To evaluate the effectiveness of continuous rotation retreatment systems (ProTaper Universal retreatment and XP-endo Retreatment) versus reciprocating systems (Reciproc Blue and Wave One Gold) in removing gutta-percha point and calcium silicate-based sealer from the root canal during endodontic retreatment.

Materials and Methods: Forty mandibular second premolars with straight oval canal were used and instrumented with ProTaper Next system up to size X3 file, then obturated with gutta-percha and TotalFill BC Sealer using single cone technique. The samples were divided into four groups according to the retreatment system used (n=10): group 1: ProTaper Universal retreatment system, group 2: XP-endo Retreatment system, group 3: Reciproc Blue, group 4: WaveOne Gold. Scanning electron microscope was used to evaluate the amount of residual materials. The data were statistically analyzed at ($p< 0.05$) significance level.

Result: The apical third was associated with more remaining filling materials, and there was no significant difference among four systems regarding the number of residual materials at the coronal and middle thirds. In the apical third, XP-endo Retreatment system was more effective than ProTaper Universal retreatment system and WaveOne Gold at (P=0.027, 0.031, respectively) ($p<0.05$). No significant difference among groups in retreatment time.

Conclusion: No system was able to remove obturated materials completely, XP-endo Retreatment system was the most effective in the retreatment ability.

Key words: Retreatment, Reciprocation, Second premolars, gutta-percha

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INTRODUCTION

The most important goal in endodontic retreatment is to reduce bacterial level inside the root canal by eliminating previous filling materials to allow for proper instrumentation and irrigation of the entire canal [1]. Non-surgical endodontic retreatment can be done by several approaches using hand files, nickel-titanium (NiTi) rotary and reciprocating systems with or without the aid of heat, solvents, and ultrasonic devices [2]. Some rotary NiTi systems were specially designed for retreatment such as ProTaper Universal retreatment system (Dentsply Maillefer, Ballaigues, Switzerland) and D-RaCe (FKG Dentaire, La Chaux-de-Fonds, Switzerland) [3]. In addition to XP-endo Retreatment system (FKG Dentaire, La Chaux-de-Fonds, Switzerland) developed recently where XP-endo Shaper and XP-endo Finisher R showed good effectiveness in retreatment [4].

Reciprocating files have been shown good ability in removing gutta-percha and sealer

with brushing motion against lateral walls of the canals [5]. However, the complete removal of root filling materials cannot be obtained with any retreatment technique [6]. Bioceramic sealer is one of the recent types of endodontic sealers which is tricalcium silicate-based sealer has good physical and antimicrobial properties [7], its bond strength to dentine more than conventional sealers [8], there for the use of bioceramic sealer may increase the difficulty of material removal [9]. The studies on bioceramic sealer removal are still insufficient and more informations are needed about its removal, especially it is commonly used nowadays. The aim of this study was to evaluate the effectiveness of continous rotation retreatment systems (ProTaper Universal retreatment and XP-endo Retreatment) versus reciprocating systems (Reciproc Blue and WaveOne Gold) in removing gutta-percha point and calcium silicate-based sealer from the root canal during endodontic retreatment. The null hypothesis was that there are no significant differences regarding effectiveness of gutta-percha and calcium silicate-based sealer removal among different systems with two types of kinematic movements.

MATERIALS AND METHODS

Forty single-rooted mandibular second premolars with straight oval canal and comparable sizes of canals were selected according to a protocol that has been accepted by The Research Ethics Committee of the College of Dentistry, University of Baghdad (no. 227520), which had been considered oval depending on cone beam computed tomography (CBCT) evaluations (NewTom, NNT Viewer version 7.1), performed under the following parameters: field of view(10x10 Hi Res), FSV(90 KV,4.00 mA), SSV (90 KV, 4.00 mA), Exposure time (3.7 s), mAs (14.88), Air Kerma (4.02 mGy), DAP (478.54 mGy. cm). When the buccolingual diameter measurement had to be twice or more than the mesiodistal diameter in the coronal and middle thirds of the canal, with other criteria mature apical foramen, no evidence of root caries, roots lack of cracks or fracture, and no internal resorption, standardized to a length 14 mm from the anatomical apex, canal patency was verified with using k file size 10. The root canals were prepared using ProTaper NEXT(PTN) rotary system up to size X3 (30/07) to determined working length. During instrumentation, the root canals were irrigated with 1 ml of 2.5% NaOCl. The final irrigation protocol was 2 mL of 2.5 % NaOCl followed by 2 ml of 17% EDTA for 1min then final rinsing with 5 ml distilled water and the canals were dried with sterile PTN X3 paper points. The dried canals were obturated by PTN X3 gutta-percha point (30/07) and TotalFill BC Sealer, using single cone technique according to the manufacturer's instruction, stored in an incubator at 37°C and 100% humidity for 2 weeks.

After storage forty samples were divided into 4 groups (n=10) according to the retreatment system used.

Group1: protaper universal retreatment system (PTUR)

The retreatment procedure was performed using the PTUR system sequentially (D1, D2, and D3) according to the manufacturer's instructions (speed of 500 rpm and torque 2 Ncm) in crown-down technique with brushing motion against canal walls until the working length was reached. Root canals were irrigated with 2ml of a 2.5 % NaOCl irrigation solution after using each file.

Group 2: XP-endo Retreatment system

The retreatment procedure was performed using XP-endo retreatment system sequentially (DR1, XP-endo Shaper, and XP- endo Finisher R) following manufacturer's instructions. Retreatment procedure carried out inside a room at a temperature of 37°C, also the irrigation solution has been maintained at 37°C for providing appropriate conditions allow the phase change of the XP-endo Shaper and XP-endo Finisher R instruments, firstly DR1(30/.10) was used with (speed of 800 rpm and torque 1.5 Ncm) for the coronal third, after that XP-endo shaper (30/04) was used with pecking motion (speed of 1000 rpm and torque 1Ncm), followed with light pressure until reaching working length. Root canals were irrigated with 2ml of a 2.5 % NaOCl irrigation solution after using each file. Finally, XP-endo Finisher R (30/00) was used with (speed of 800 rpm and torque 1Ncm), which was cooled with cool spray to be straight, thereafter the canal irrigated with 1ml 2.5 % NaOCl and XP-endo Finisher R used for 30 sec to full working length then irrigated again with 1ml 2.5 % NaOCl accompanied by another user of this file for additional 30 sec.

Group 3: Reciproc blue R25 system (RB)

The retreatment procedure was performed using Reciproc Blue file (25/08), in reciprocating mode following manufacturer's instructions with controlled (speed and torque), with in and out pecking motion by an extent of approximately 3mm in each time with slight apical pressure and brushing movements against the canal walls until the working length was reached. Root canals were irrigated with 2ml of a 2.5 % NaOCl irrigation solution after three pecks with file.

Group 4: Wave one gold system (WOG)

The retreatment procedure was performed using WaveOne Gold primary file (25/07), in reciprocating mode following manufacturer's instructions with controlled (speed and torque), with in and out pecking motion by an extent of approximately 3mm in each time with slight apical pressure and brushing movements against the canal walls. Root canals were irrigated with 2ml of a 2.5 % NaOCl irrigation solution after three pecks with file.

Total amount of irrigation that used for each sample was 8 ml of NaOCl. Retreatment procedure was considered complete when WL was reached, and no further debris of filling materials were be seen on the surface of instruments. Total time needed for retreatment procedure was recorded in seconds, time for irrigation and instruments change was not included in time calculation. After mechanical instrumentation, the final irrigation protocol was 5 ml of 17% EDTA for 3 min, followed by 5 ml 2.5% NaOCl for each retreated sample.

All teeth were grooved buccolingually with a diamond disc and separated into two halves. The half with a greater number of remnants and most visible apex was chose and prepared for scanning electron microscopy (SEM) evaluation, firstly dehydrated at 37°C for 7 days and sputtered with thin layer of Nano gold particles. Then the apical (1-5 mm), middle (5-9 mm) and coronal (9-13 mm) thirds of selected root half were examined with SEM (TESCAN, Vega III, Czech Republic) at two magnifications of (500X, 3000X), at a central point of each third.

The amount of residual filling materials on dentin at the three levels of each half (500X) was evaluated by the predefined scoring system [10] (Figure 1).

- ✓ Score 0: None to slight presence of remnants on dentine surface (0–25%)
- ✓ Score 1: Mild to moderate presence of remnants on dentine surface (25–50%)
- ✓ Score 2: Moderate to severe presence of remnants on dentine surface (50–75%)
- ✓ Score 3: Severe or complete presence of remnants on dentine surface (75–100%).

The SEM images were assessed individually by two blinded examiners.

Statistical analysis

Data description, analysis and presentation were performed using Statistical Package for social Science (SPSS version 21). Friedman test and Kruskal-Wallis test were used for the amount of residual obturation materials on dentine surface. One Way ANOVA test was used for retreatment time, at significance level of 0.05.

RESULTS

Friedman test in Table 1 showed the significant difference in the amount of the remaining root filling materials at three levels (coronal, middle, apical) for each group: In group 1 there was significant difference (P= 0.002), highest value of mean rank of remnant was at the apical third (2.65) followed by the middle third (2.05) and the lowest value was at the coronal third (1.30). In group 2 there was no significant difference (P= 0.062), highest value of mean rank was at the middle third (2.25) followed by the apical third (2.20) and the lowest value was at the coronal third (1.55). In group 3 there was significant difference (P= 0.001), mean rank was with highest value at apical third (2.55) followed by the middle third (2.15) and the lowest value at the coronal third (1.30). In group 4 there was significant difference (P= 0.001), the highest value of mean rank was at the apical third (2.65), followed by the middle third (2.20), and the lowest value at the coronal third (1.15). A comparison between each two thirds in the same group showed in group 1, 3, and 4 (coronal VS middle) and (middle *VS.* apical) there was no significant difference. (coronal VS apical) there was significant difference for group 1,3 and 4 at (p= 0.008, 0.016, 0.002 respectively) (Figure 2).

Kruskal-Wallis test in Table 2 showed the significant difference among the groups in different levels regarding the amount of residual

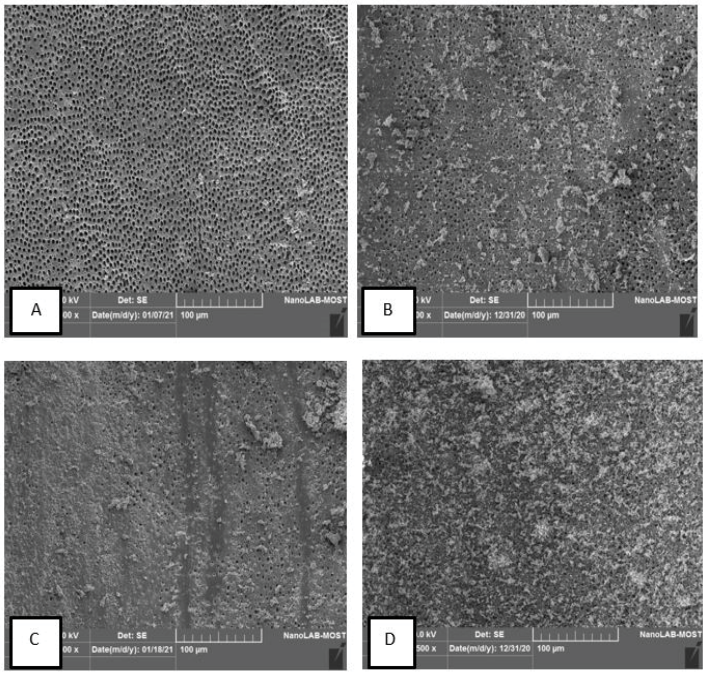

Figure 1: Descriptive images of SEM scores: A. Score 0, B. Score 1, C. Score 2, D. Score 3.

Table 1: Descriptive and statistical test of scores for the remaining root filling materials among thirds for each group using Friedman test.

Groups		Coronal	Middle	Apical
G1 PTU	Minimum	0	0	0
	Maximum	1	2	3
	Median	0	1	1
	Mean rank	1.3	2.05	2.65
	P value	0.002 [Sig.], Effect size=0.61[Large]		
G2 XP-endo Retreatment	Minimum	0	0	0
	Maximum	0	1	2
	Median	0	0.5	0
	Mean rank	1.55	2.25	2.2
	P value	0.062 [NS] , Effect size size=0.2725[Small]		
G3 RB	Minimum	0	0	0
	Maximum	1	1	2
	Median	0	1	1
	Mean rank	1.3	2.15	2.55
	P value	0.001 [Sig.], Effect size=0.652[Large]		
G4 WOG	Minimum	0	0	0
	Maximum	1	2	2
	Median	0	1	2
	Mean rank	1.15	2.2	2.65
	P value	0.001 [Sig.], Effect size=0.7182[Large]		
P>0.05 Not significant, P<0.05 Significant				

root canal filling materials: In the coronal third there was no significant difference (P=0.539), the highest value of mean rank was at group 4 (22.50), followed by groups 1,3 (20.50), and the lowest mean rank was at group 2 (18.50). In the middle third there was no significant difference (P=0.228), the highest value of mean rank was at group 4 (24.55), followed by group 1 (22.25), then group 3 (19.45), and the lowest mean rank was at group 2 (15.75). In the apical third there was significant difference (P=0.034), the highest value of mean rank was at group 4 (26.05), followed by group 1 (23.20), then group 3 (20.45), and the lowest mean rank was at group 2 (12.30). A multiple comparison between groups at the apical thirds, showed the significant difference was between (G1 VS G2) at (P= 0.027) and (G2 VS G4) at (P=0.031).

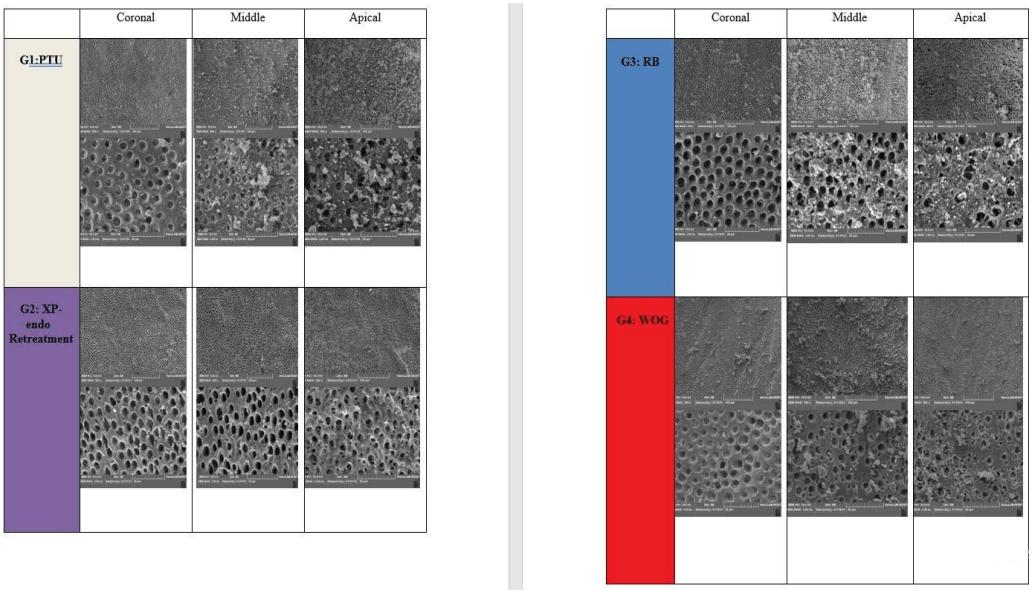

Figure 2: Representative SEM images of 4 tested groups at three levels (coronal, middle, apical) with two magnifications (500x-3000x).

Table 2: Descriptive and statistical test of scores among groups using kruskal-wallis test.

Thirds	Statistics	Groups			
		G1	G2	G3	G4
Coronal	Minimum	0	0	0	0
	Maximum	1	0	1	1
	Median	0	0	0	0
	Mean rank	20.5	18.5	20.5	22.5
	P value		0.539^		
Middle	Minimum	0	0	0	0
	Maximum	2	1	1	2
	Median	1	0.5	1	1
	Mean rank	22.25	15.75	19.45	24.55
	P value		0.228^		
Apical	Minimum	0	0	0	0
	Maximum	3	2	2	2
	Median	1	0	1	2
	Mean rank	23.2	12.3	20.45	26.05
	P value		0.034*		
P>0.05 Not significant, P<0.05 Significant					

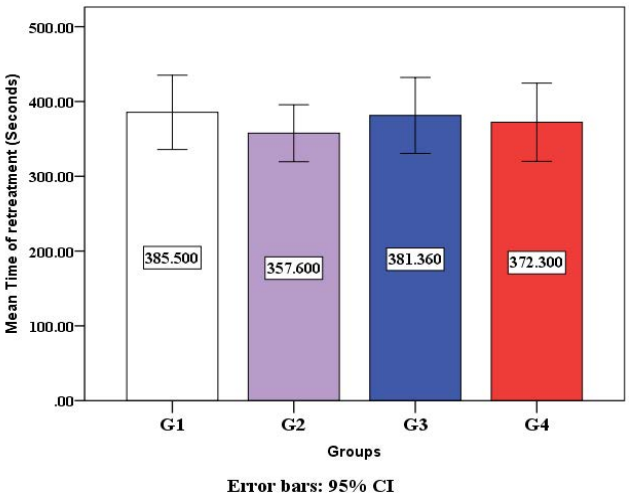

Figure 3: Allocation of retreatment time needed for samples among groups.

In the time needed for the removal of gutta-percha and calcium silicate-based sealer, One Way ANOVA test showed there was no significant difference at (P=0.798) among 4 tested systems as shown in Figure 3.

DISCUSSION

The present study evaluated the effectiveness of different systems with two type of kinematic movements, continuous rotation (ProTaper Universal retreatment system, XP-endo Retreatment system) and reciprocation (Reciproc Blue, WaveOne Gold) in removing gutta-percha and calcium silicate-based sealer from the root canal during endodontic retreatment procedure. The results showed all four assessed systems demonstrated similar performance in removing obturating materials at the coronal and middle thirds but in the apical third XP-endo Retreatment system was the most effective in the retreatment ability. Thus, the null hypothesis was accepted except in the apical third of the canal [11,12].

The present SEM evaluation showed that only 4 samples were completely free from the remnants of root canal filling materials after endodontic retreatment. In line with previous research, these findings indicate that gutta-percha and sealer residues are practically impossible to remove residual materials was contained in the apical thirds, the similar result demonstrated by Ersev et al. [13] and Hegde et al. [14].

This finding can be explained by the fact that anatomical complexities are greater in the apical third [15]. In addition, the middle and apical thirds of the canal had more compaction and penetration of the obturating materials, resulting in more debris may be deposited in the dentinal tubules [14]. Another explanation is the variations in tip sizes and tapers between instruments used in the initial preparation and canal retreatment instruments [9].

The PTU files were able to remove the obturating materials from the coronal third of root canal due to its convex triangular cross section, constantly changing helical angle, and spirals that run around the instruments [14]. But it was less effective in the middle and apical thirds, it may be referred to the last instrument used (D3 20/07) most likely did not allow for full cleaning of the root canal walls that was initially prepared up to size (30/07), in agreement with a previous study [11].

In the samples retreated with using XP-endo retreatment system. The results showed considerable removal of filling materials. This may be due to the performance of three files involved in this system. DR1 which has a cutting tip to help with initial filling material penetration [16]. In addition, the special design of XP-endo Shaper with high speed of rotation may provide easier removal of gutta-percha from the canal [12]. Moreover, the innovative alloy of XP-endo Finisher R and instrument expansion inside the canal may allow the semiactive tip of the file to contact and dislodge obturating root materials from the walls of the canal, which may be eliminated during canal irrigation [17]. This result is consistent with other studies [4-18].

Retreatment ability of RB is most likely due to the S-shaped cross-section with sharp cutting edges and a wide chip space [19]. However, RB showed less efficiency in the apical third this may be attributed to the size of file used (R 25/ 08), as suggested by Romeiro, de Almeida [9] higher percentage of obturation materials removal may have resulted from the two-size apical enlargement after initial preparation.

For WOG system, which is made of a flexible NiTi Gold wire with a parallelogram cross section, it showed similar retreating potential to the other tested systems in the coronal and middle thirds. In contrast to apical third associated with a greater number of residual materials. It can explain by the size of system used (25/07), which may be need additional apical enlargement in accordance to recent study [20], stated improved in the effectiveness of WOG with larger tip size file (35) in curved root canals. Furthermore, WOG's design cannot provide enough space for debris to be displaced, reducing its cutting performance [21].

In the apical third of the canal, XP-endo Retreatment system had less amount of the remnants. It may be due to the larger diameter of the XP-endo files provide better cleaning in the apical region [1]. In addition, mechanical action of XP-endo Finisher R may improve the removal of the residual filling materials from the root canal [17].

In the term of retreatment time, the present study showed that the performance of continuous rotation and reciprocation systems were similar, which consistent with the previous studies [22-23]. However, other study has shown that reciprocating single file take substantially less time than multi files rotary retreatment system [24], and the opposing findings reported by other study, which attributed the differences in the results to several factors associated with operator and time recording method [25].

PTU system characterized with active tip, allowing for more effective cutting performance, which provide rapid instrument penetration into the filling materials. However, the longer instrument sequences of the system (D1, D2, and D3) as well as, shaping of the canal was difficult with this system need more time for complete cleaning [5].

In contrast with the single file reciprocating systems, where RB and WOG the longer periods of time was needed for obtaining patency into obturating materials attributed to greater flexibility of these files [5-9].

The operation time for XP-endo Retreatment was the shortest among all tested systems, as the active tip on the DR1 aids in simple and fast penetration of gutta-percha [26]. XP-endo shaper has a slim design, a narrow taper, and a booster tip, with the plasticization of gutta-percha at the high speed of rotation which may make gutta-percha removal easier [27]. Furthermore, mechanical action of the XP-endo Finisher R might produce faster removal of root filling materials [17]. Based on the findings of this research, regardless of the system used, it was impossible to eliminate the root canal filling materials. XP-endo Retreatment system was the most effective system in removing gutta-perch point and calcium silicate-based sealer from the root canals.

CONCLUSIONS

- ✓ None of the tested systems were able to remove residual filling materials completely from the walls of the root canals.
- ✓ Regarding the amount of residual filling materials, in the apical third, there was significantly more remaining filling materials in comparison to coronal and middle thirds.
- ✓ There was no significant difference among 4 tested systems (PTU, XP-endo Retreatment, RB, and WOG) in the efficacy of gutta-percha and calcium silicate- based sealer removal from the coronal and middle thirds of the straight oval canals. Whereas in the apical third, XP-endo Retreatment system was significantly more effective than PTU and WOG.
- ✓ There was no significant difference among groups in the term of retreatment time.

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