



Cone Beam Computed Tomography Evaluation of Two Rotary Systems with and without XP-Endo Finisher for Retreatability of Canals Obturated with Bioceramic Sealer.

Ahmed S. Mahmmod*, Nawal A. Al-Sabawi

Department of Conservative Dentistry, College of Dentistry, University of Mosul.

Article information

Received: 7 July, 2021

Accepted: 22 August 2021

Available online: 5 September, 2022

Keywords

EdgefileXR
Retreatment
Sure-Seal Root™
R-Endo
XP-Endo Finisher.

*Correspondence:

E-mail:

ahmed.slahalden76@gmail.com

Abstract

Aims: To evaluate volumetric amount of endodontic obturating materials remnants after endodontic retreatment using two retreatment rotary systems (R-Endo and EdgefileXR) with and without supplementary retreatment (XP-Endo Finisher), in teeth obturated by Sure-Seal Root TM (Bioceramic sealer). **Materials and Methods:** Twenty human mandibular premolars with single straight root canals were prepared using a 2Shape endodontic rotary system with a file size of 25/0.04. All teeth were obturated using gutta-percha and Sure-Seal Root TM (Bioceramic sealer) using the single cone technique. The samples were then divided into two groups according to the retreatment system used (n=10). After retreating all samples with different rotary systems, the samples were evaluated using CBCT images. CBCT images of each sample were taken and evaluated in axial, coronal and sagittal planes to determine the obturating material remnants after retreatment. Then, all samples retreated with two retreatment systems (R-Endo and EdgefileXR) underwent supplementary retreatment with XP-Endo Finisher. Second CBCT images for each sample were taken and the volume of the remnant material inside the canal walls was analyzed. Data were analyzed statistically using one-way ANOVA analysis of variance, Duncan's multiple analysis rang test and independent t-test. **Results:** EdgeFileXR and R-Endo were significantly different and XP-Endo Finisher improved the removal of obturating materials in both groups. **Conclusions:** The retreatment system had a significant effect on the amount of endodontic obturating material remnants after endodontic retreatment and XP-Endo Finisher had a supplementary removal effect.

الخلاصة

الاهداف: تقييم الكمية الحجمية لبقايا مواد السدادة اللبية بعد اعادة المعالجة اللبية باستخدام نظامين مع او بدون استخدام وحدة الانهاء اللبية اكس بي (EdgefileXR and R-Endo) دوارين في الاسنان المملوءة بواسطة بايوسيراميك سيلر. **المواد وطرائق العمل:** استخدمت الدراسة عشرين سن بشري ضاحك سفلي حيث تم تحضير قنوات الجذر بواسطة نظام ثنائي الشكل وملئها بواسطة البايوسيراميك سيلر , بعدها تم تقسيمها الى مجموعتين كل مجموعة عشرة اسنان حيث تم استعمال نظام اعادة معالجة دوار مختلف مع كل مجموعة. بعدها تم اخذ صورة لكل عينة بواسطة التصوير الشعاعي المخروط المحوسب لاحتساب الكمية الحجمية لبقايا مواد السدادة اللبية وبعد ذلك تم استخدام وحدة الانهاء اللبية اكس بي مع كل العينات في كلتا المجموعتين واحتساب الكمية الحجمية لبقايا مواد السدادة اللبية تم تحليل البيانات باستخدام اختبار تي المستقل وتحليل التباين احادي الاتجاه واختبار دنكن. **النتائج:** نظامين اعادة المعالجة اللبية المستخدممين في البحث يوجد بينهم فرق معنوي بالإضافة الى ان استخدام وحدة الانهاء اللبية اكس بي سيدعم عملية ازالة بقايا مواد السدادة اللبية في المجموعتين. **الاستنتاجات:** نوعية نظام اعادة المعالجة اللبية له تأثير على كمية بقايا مواد السدادة اللبية ووحدة الانهاء اللبية اكس بي تكون كنظام تكميلي لإعادة المعالجة اللبية.

DOI: [10.33899/rdenj.2021.130773.1114](https://doi.org/10.33899/rdenj.2021.130773.1114) , © 2022, College of Dentistry, University of Mosul.

This is an open access article under the CC BY 4.0 license (<http://creativecommons.org/licenses/by/4.0/>)

INTRODUCTION

The success of an endodontic therapy depends on the achievement of the endodontic triad of debridement, disinfection, and three-dimensional obturation. The clinical success rate of endodontic treatment ranges from 50% and 90%. The preferred treatment for failing endodontic cases is nonsurgical retreatment. This treatment usually results in successful outcomes ⁽¹⁾.

Non-surgical root canal retreatment is often reported as the initial treatment option to resolve or decrease microbial infection. The purpose of retreatment is to eject the filling material from the root canal to allow effective shaping, cleaning and filling of the root canal. Only if the gutta-percha and sealer can be removed entirely and the canal reached to the apical foramen, an appropriate retreatment procedure can be applied ⁽²⁾.

Many techniques and materials have been proposed for the proper removal of root canal filling, including hand files, heat-carrying instruments, chemical solvents, ultrasonic devices, lasers and engine-driven instruments such as Gates Glidden drills and nickel-titanium (NiTi) rotary instruments. Recently, rotary instruments have been developed for retreatment procedures. A few examples of these systems are R-Endo, Mtwo R, ProTaper Universal, D-RaCe, and more recently EdgefileXR ⁽³⁾.

XP-Endo Finisher has recently been introduced in endodontics as a new concept of anatomical instrument, originally designed to be used following root canal system preparation and retreatment to enhance cleaning. The XP-Endo Finisher has a small core size (ISO 25 in diameter), zero taper (25/.00) and triangular cross section ⁽⁴⁾.

Evaluation methods for residual obturation material remaining in root canal after retreatment include tooth sectioning, radiography, clearing method, micro-computed tomography, and cone beam computed tomography ⁽⁵⁻⁸⁾. In recent years, the cone beam computed tomography (CBCT) technique has been used to evaluate the residual volume of the filling material present in the inner walls of the root canals after retreatment. The CBCT images provided by the CBCT technique are in sagittal, coronal, and axial cross-sections and can decrease the superimposition of adjacent tissues. In addition, the patient radiation dose with CBCT techniques is less than that with conventional CT technique ⁽⁹⁻¹¹⁾.

Therefore, this study aimed to evaluate and compare the volumetric amount of endodontically obturating material remnants after endodontic retreatment using two retreatment rotary systems (R-Endo and EdgefileXR) with and without XP-Endo Finisher, in teeth obturated by Sure-Seal Root TM (bioceramic-based sealer)

The null hypothesis of this study, was that there are no significant differences between two retreatment systems regarding the amount of filling remnants in the root canals obturated by Sure-Seal Root™ (bioceramic-based sealer). Moreover, XP-Endo Finisher has no significant effect on the amount of remnants inside the canals.

MATERIALS AND METHODS

Ethical Statement:

The present study was approved by Research Ethics Committee board (University of Mosul, College of Dentistry, REC reference No. UoM.Dent/DM.H.L.50/21).

Samples Preparation:

Twenty human mandibular bicuspid with single straight canals and mature apices extracted for orthodontic purpose had been chosen, and were stored in 0.1% thymol solution (BDH Chemical Ltd, England) at 4°C⁽¹²⁾. Teeth cleaned by removing plaque, calculus and debris remnant. Then, preoperative radiographs were taken to check the criteria for teeth selected which must be included: completely formed apices and no calcified canal, no internal resorption, no caries or previous endodontic treatment⁽¹³⁾. Then all teeth decoronated to a length of 15mm from the apex as determined by digital vernia (China) using diamond disc bur (KG Sorensen SP, Brazil) for standardization⁽¹⁴⁾. K-file size 10 (Dentsply Maillefer, Switzerland) passed to apex of all canals to

ensure apical patency of the canals. The same file re-entered into the canal until being seen by eye at the apical foremen and the working length (WL) was recorded⁽¹⁵⁾. Then, all teeth fixed in a blocks of acrylic resin material (W 1.5*L 1.5*H 2cm) in order to provide more control and standardization of instrumentation and obturation technique⁽¹⁶⁾. Preparation of root canals was done with the Rotary 2 shape System (MicroMega, Besancon, France) by contra-angled rotary hand piece (E connect, China). The speed and torque of endo motor maintained at 350 (rpm) and 2(N/cm) with single file size TS1 (25/.04) according to manufacture instruction Sodium hypochlorite (2.5%, 5ml/1min) was used as irrigating solution following the use of each file⁽¹⁷⁾. Each file was discarded after preparation of five specimens⁽¹⁸⁾. After completion of canal preparation, the canals were rinsed with (17%, 2ml/1min) ethylenediamine tetraacetic acid (EDTA). A final rinse of 5ml/1min normal saline was used to remove any remnant of the irrigating solution. Then the canal was dried using 2 shape paper points (25/.04)⁽¹⁹⁾. Single cone size TS1 (25/.04) 2 shape gutta percha fitted into the root canal to the full WL and tug-back tested. The syringe tip of Bioceramic sealer (Sure-Seal Root™) was inserted into canal till it reach apical part, applying the sealer inside the canal was continued smoothly till filling the whole of the canal. The cone was also coated with sealer and introduced into the canal and the

excess filling material was removed with a heated spoon excavator⁽²⁰⁾. After obturations, all the samples were sealed coronally with tetric N-ceram composite resin (Ivoclar Vivadent, Liechtenstein), this procedure done like direct veneer, and were incubated for one month at 37C⁰ in 100% humidity by placing them in gauze moisten with distilled water to simulate the clinical procedure as possible⁽²¹⁾.

Samples Grouping:

All the samples were divided randomly into two groups according to the type of retreatment system used with 10 samples for each as follow:

- ❖ **Group A:** R-Endo retreatment files (MicroMega, Besancon, France) were used. It consists of three files: R1 (25/0.08) till cervical third, R2 (25/0.06) till middle third, R3 (25/0.04) to full working length. Retreatment conducted at a speed of 300 rpm and a torque of 1.2 N/cm⁽²²⁾.
- ❖ **Group B:** EdgefileXR retreatment files (EdgeEndo, USA) were used. It employed with following sequences R1 (25/0.12), R2 (25/0.08), R3 (25/0.06), and R4 (25/0.04) till reach to full working length. Retreatment performed at speed 400 rpm and a torque of 3 N/cm⁽²³⁾.

Sodium hypochlorite (2.5%, 12ml/6min for each sample) used as irrigating solution following the use of each file. After completion of canal retreatment, the canals rinsed with 5ml/1min normal saline and then rinsed with (17%, 2ml/1min) EDTA. A final rinse of 5ml/1min normal saline used to remove any remnant of the irrigating solution⁽²⁴⁾.

Cone Beam Computed Tomography Evaluation after Retreatment with Two Rotary Systems:

After retreatment of all samples by different rotary system, the samples evaluated by CBCT image which was taken with CS8100 equipment (Carestream, Healthcare, France) at 87 kilo volt (KV), 2.00 millie amber (mA). CBCT images of each sample were taken and evaluated in axial, coronal and sagittal plans to determined obturating material remnant after retreatment as in (Figure 1, 2). Moreover, CBCT provided 0.5mm thickness of slice by slice sections for each view. The CS 3D Imaging program was used to inspect each view, which was then saved in DICOM format (Digital Image Communication of Medicine). With the aid of AutoCAD software (Sketchup, Startup company, USA), the volume of filling material was measured^(25, 26).

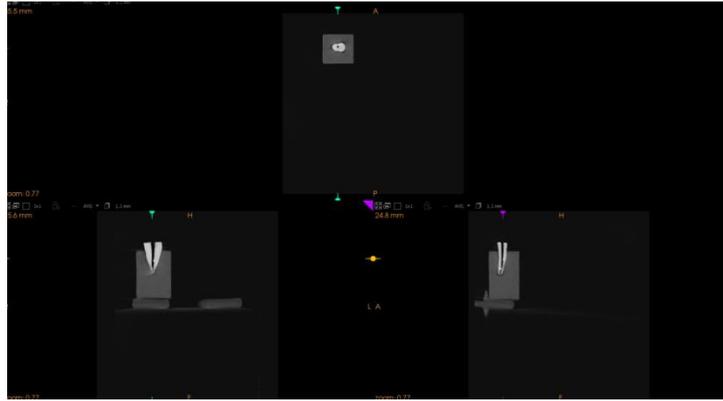


Figure (1): CBCT image of sample after retreatment with EdgefileXR Files



Figure (2): CBCT image of sample after retreatment with R-Endo Files.

Supplementary Retreatments with XP-Endo Finisher:

All samples retreated by two retreatment systems (R-Endo and EdgefileXR) underwent supplementary retreatment by XP-Endo Finisher (FKG Dentaire, Switzerland). The XP-Endo Finisher has a 25 ISO size, zero taper, and triangular cross section. It operated at 800 rpm and 1 N/cm torque. In order to hold the XP-Endo Finisher straight when setting the WL measurement, it cooled with Endo-Ice spray⁽²⁷⁾. The XP-endo Finisher instrument was placed in a contra-angle hand piece (E connect, China), cooled by ice spray, removed from the plastic tube, and inserted without rotation into the canal. The rotation

was then initiated, and the instrument was activated for 1 minute by making slow and gentle 7-8 mm lengthwise movements up to the WL. During the instrumentation, the instrument was brushed against the canal sidewalls. This cycle was carried out three times (total time 3 minute). After each cycle, the canal was irrigated with 5 mL of 2.5 percent NaOCl. Then rinsing the canal with 2 mL of 17% EDTA for 3 min followed by 5 mL of 2.5% NaOCl. Finally, a 3 mL rinse with by normal saline was used in the final irrigation to flush out the NaOCl⁽²⁸⁾.

Cone Beam Computed Tomography Evaluation after Retreatments with XP-Endo Finisher:

Second CBCT images for each sample was taken and the volume of the remnant material inside the canal walls was

analyze as mentioned before as in (Figure 3).

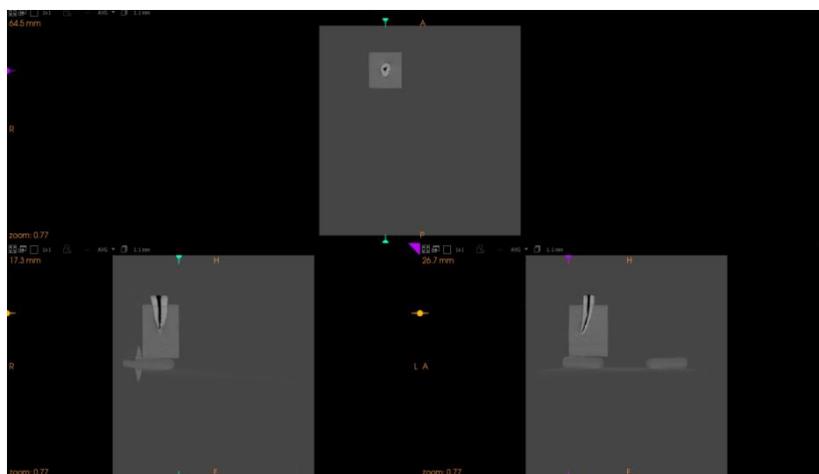


Figure (3): CBCT image of sample retreated by R-Endo after supplementary retreatment with XP-Endo Finisher.

Statistical analysis:

The data were collected and analyzed using SPSS version 25 (IBM,USA) using normality test that detect data parametric and then using descriptive statistic, independent t-test, one way ANOVA and Duncan's multiple analysis rang test . *P* value ≤ 0.05 was considered statistically significant.

RESULTS

Descriptive statistics for the volume of residual obturating material that remained inside the canal after using two

rotary retreatment systems are shown in Table (1). It revealed that the samples retreated by EdgefileXR retreatment files had less mean volume of remaining filling materials in root canal than samples retreated by R-Endo retreatment files. Independent t-test was used to compare the volume of remnant filling material for each retreatment system. Results showed that there was significant difference for the same sealer retreated by two retreatment systems (Table 2).

Table (1): Descriptive statistics of volume of remaining obturating material after using two retreatment systems.

	Retreatment Systems	No.	Minimum mm ³	Maximum mm ³	Mean mm ³	Std. Deviation
Sure-Seal Root™	R-Endo	10	3.90	4.20	4.0257	0.09120
	EdgefileXR	10	3.21	3.48	3.3623	0.08262

Table (2): Independent t-test for volume of remnant filling material for each retreatment system.

Retreatment systems		Mean(mm ³)±SD ⁺	P-value**
Sure-Seal Root TM	R-Endo	4.0257±0.09120	0.000
	EdgefileXR	3.3623±0.08262	

+ Standard deviation. ** $P \leq 0.05$ mean significant variation exist. Highly sig. at $p \leq 0.01$.

Descriptive statistics for the volume of remaining obturating material after supplementary retreatment with XP-Endo Finisher are presented in (Table 3). It is shown that the samples retreated by EdgefileXR retreatment files and underwent supplementary retreatment by XP-Endo Finisher had less mean volume of remaining filling materials in root canal than samples retreated by R-Endo retreatment files and underwent supplementary retreatment by XP-Endo Finisher. Independent t-test was used to compare the volume of remnant filling material after supplementary retreatment that there was significant difference for the Sure-Seal RootTM sealer retreated by different retreatment systems as in (Table 4).

To investigate if there is any difference exist in the mean volume of remnant filling material. ANOVA and Duncan Multiple Analysis Rang test were performed. Result showed a significant difference ($P\text{-value} \leq 0.05$) among groups that retreated by two retreatment systems before and after supplementary retreatment by XP-Endo Finisher. There was significant difference among retreatment files that used in canals obturated by single cone with and without supplementary retreatment as in (Table 5). Duncan Multiple Analysis Rang test revealed that there was significant difference between groups before and after using of XP-Endo Finisher but after supplementary retreatment there was no significant difference as in (Table 6).

Table (3): Descriptive statistics of volume of remaining obturating material after supplementary retreatment with XP-Endo Finisher.

Retreatment Systems+ supplementary		No.	Minimum mm ³	Maximum mm ³	Mean mm ³	Std. Deviation
Sure-Seal Root TM	R-Endo+XP-Endo	10	0.32	0.47	0.3879	0.04291
	EdgefileXR+XP-Endo	10	0.28	0.39	0.3270	0.03577

Table (4): Independent t-test for volume of remnant filling material for each retreatment system in same obturating sealer after supplementary retreatment.

	Retreatment systems + Supplementary	Mean(mm³)±SD⁺	P-value**
(Sure-Seal Root™)	R-Endo+XP-Endo	0.3879±0.04291	0.003
	EdgefileXR+XP-Endo	0.3270±0.03577	

+ Standard deviation. ** $P \leq 0.05$ mean significant variation exist.

Table (5): ANOVA test for volume of remaining obturating material before and after supplementary retreatment.

	Sum of Squares	Df⁺	Mean Squares	F-value	P-value**
Between Groups	113.545	3	37.848	8289.201	0.000
Within Groups	0.164	36	0.005		
Total	113.709	39			

⁺df= degree of freedom. ** $P \leq 0.05$ mean significant variation exist. Highly sig. at $p \leq 0.01$.

Table (6): Duncan Multiple Analysis Rang for mean of remaining obturating material before and after supplementary retreatment.

	Retreatment systems with and without Supplementary	Mean(mm³)±SD	Duncan Grouping
Sure-Seal Root™	R-Endo	4.0257±0.09120	A
	EdgefileXR	3.3623±0.08262	B
	R-Endo+XP-Endo	0.3878±0.04291	C
	EdgefileXR+XP-Endo	0.3270±0.03577	C

The variable letters mean significant difference exist. ** Standard deviation.

DISCUSSION

The endodontic retreatment intends to remove completely the root canal filling materials (gutta-percha, sealer). However, remnants of filling material are a constant concern. Among the remnants gutta-percha and sealer, some necrotic tissue or bacteria might be present, potentially causing persistent inflammation and pain⁽²⁹⁾.

The removal of the entire gutta-percha and sealer without remnants from the root canal system is very important for the success of the

retreatment technique. Therefore, the most effective retreatment system must be identified that can result in a clean root canal wall without remnants, in various sealers used for obturation, in order to achieve a successful endodontic retreatment⁽³⁰⁾. Therefore, this study was conducted to evaluate and compare the efficacy of two rotary retreatment systems (Edgefile-XR and R-Endo) with and without supplementary cleaning by XP-Endo Finisher for canals

obtured by Sure-Seal Root TM (bioceramic-based sealer), which was evaluated by CBCT.

Some studies have shown that the use of solvents in the removal of filling material (gutta percha and sealer) might make root filling material removal more difficult, as it could make the structure of the material viscous and highly adhesive, resulting in the formation of films of softened gutta percha on the root canal surface, and alteration of material properties in response to the use of solvents may even make the retreatment procedure longer or more difficult. Therefore, the use of instrumentation techniques (manual or mechanical) is more effective and easier than using a solvent for retreatment ^(31, 32).

The use of NiTi rotary files has recently become popular in endodontic retreatments. NiTi rotary instruments have numerous advantages, including reduced working time and dental fatigue ⁽³³⁾. Therefore, the NiTi rotary retreatment systems were used in this study.

In this study, cone-beam computed tomography was used to evaluate the volume of the remaining filling materials. In view of the importance of accurate determination of the exact location and volume of the residual filling material during retreatment procedures, the use of CBCT images may provide useful information for clinicians in the volumetric assessment of the amount of residual filling material in root canals ⁽³⁴⁾.

The results of this study revealed that two rotary retreatment systems (R-Endo and EdgefileXR) left filling materials in the canal after retreatment, especially in the apical third of the canal because of the complexity of the

apical area of the root canal (intracanal isthmuses, constriction, and apical delta) ⁽³⁵⁾. In the current study, the results revealed that the EdgefileXR retreatment system was more effective than the R-Endo retreatment system in removing obturating materials. The superior effectiveness of EdgefileXR may be related to the fact that it is made of an annealed heat-treated nickel titanium alloy called Fire-Wire TM, which may improve strength and mechanical qualities of the files. In addition, because of the cutting edges of the R-Endo instruments do not have radial land and the tip is inactive which reduced its cutting efficiency. In addition, the number of files in the Edgefile XR system is four while the R-Endo system has three files, that influenced the efficacy of the system in removing obturating materials ⁽³⁶⁾.

The results revealed that the samples retreated by EdgefileXR files and then underwent supplementary retreatment by XP-Endo Finisher had volume of remaining filling material less than the volume of remaining filling material in samples retreated by R-Endo files and then underwent supplementary retreatment by XP-Endo Finisher, this may be due to the effectiveness of EdgefileXR file in removing of filling material reinforced by using of XP-Endo Finisher.

According to the current study, we confirmed that the retreatment was enhanced by using XP-Endo Finisher in the samples retreated by two retreatment systems (R-Endo and EdgefileXR). Therefore, it may be advisable to use a supplementary XP-Endo finisher after retreatment systems in endodontic failure treatments.

CONCLUSIONS

Within the limitations of this study the following conclusions could be drawn

- The two systems R-Endo and EdgefileXR retreatment files, left obturating materials in root canal after retreatment.
- The EdgefileXRretreatment files more effective than R_Endo retreatment files in removal of filling materials (gutta-percha and Bioceramic sealer)
- The use of XP-Endo Finisher as supplementary approach show better results in removing the filling materials (gp and sealer).

REFERENCES

1. Azim, A.A., Wang, H.H., Tarrosh, M., Azim, K.A., and Piasecki, L. Comparison between single-file rotary systems: part 1- efficiency, effectiveness, and adverse effects in endodontic retreatment. *J Endod.* (2018); 44(11):1720-1724.
2. Gokturk, H., Yucel, A.C., and sisman, A. Effectiveness of four rotary retreatment instruments during root canal retreatment. *Cum Dent J.* (2015); 18(1):25-36.
3. Niemi, T.K., Marcbesan, M.A., Lloyd, A., and Seltzer, R.J. Design and access outlines on the removal of root canal obturation effect of instrument materials in oval-shaped canals. *J Endod.* (2016); 42(10):1550-1554.
4. Valente, N.F., de Oliveira, J.Z.P., Valoura, A.V.M., Hecksher, M., Moreira, E.J.L., and da Silva, E.J.N. A new instrument for root canal system finishing after chemomechanical preparation: XP-Endo Finisher. *Rev Bras Odontol.* (2017); 74(4):305-308.
5. Kumar, M., Shanavas, M., Sidappa, A., and Kiran, M. Cone beam computed tomography-know its secrets. *J Int Oral Health.* (2015); 7(2):64-68.
6. Colaco, A.S., and Pai, V.A.R. Comparative evaluation of the efficiency of manual and rotary gutta-percha removal techniques. *J Endod.* (2015); 41(11):1871-1874.
7. Giudice, R.L., Nicita, F., Puleio, F., Alibrandi, A., Cervino, G., Lizio, A.S., and Pantaleo, G. Accuracy of periapical radiography and CBCT in endodontic evaluation. *Int J Dent.* (2018); 10(18):1-7
8. Patel, S., Brown, J., Pimentel, T., Kelly, R.D., Abella, F., and Durack, C. Cone beam computed tomography in Endodontics-a review of the literature. *Int Endod J.* (2019); 52(8):1138-1152.
9. Khademi, A., Mahdizadeh, M., Sanei, M., Sadeqnejad, H., and Khazaei, S. Comparative evaluation of root canal morphology of mandibular premolars using clearing and cone beam computed tomography. *Dent Res J.* (2017); 14(5):321-325.
10. Basaiwala, A.K., Mala, K., Ahmed, J., Shetty, N., and Gupta, A. Comparison of the diagnostic accuracy of cone-beam computed tomography and periapical radiography in determining endodontic working length: An in vitro study. *Saudi Endod J.* (2020); 10(3):208-214.
11. Kataia, E.M., and Kataia, M.M. Micro-computed tomographic evaluation of the

- apical seal of endodontically treated teeth by two obturating techniques and two post space preparation techniques. *J Int Oral Health*. (2020); 12(1):41-45.
12. Al-Sabawi, N.A., Mohammed, F.A., and Shehab, N.F. Residual antibacterial effect of calcium hydroxide combined with chlorhexidine gel as an intracanal medicament. *Ind J Dent Res*. (2021); 31(6):846-851.
13. Prasad, A., Nair, R.S, Angelo, J.M.C, Mathai, V., Vineet, R., and Christopher, S.R. A comparative evaluation retrievability of Guttapercha, Resilon and CPoints for retreatment, using two different rotary retrieval systems- An ex vivo study. *Saudi Endod J*. (2018); 8(2):87-92.
14. Kamil, S.S. and Al-Sabawi, N.A. Comparative evaluation of three rotary retreatment systems for apical extrusion of root canals obturated with different techniques. *Tikrit J Dent Sci*. (2020); 8(2):38-46.
15. Singh, R., Chaudhary, S., Manuja, N., Chaitra, T., and Sinha, A. Evaluation of Different Root Canal Obturation Methods in Primary Teeth Using Cone Beam Computerized Tomography. *Clin Ped Dent J*. (2015); 39(5):462-469.
16. Zaazou, A., and Sherif, R.A. Efficacy of D-Race and protaper retreatment files in removing gutta percha from curved canals using cone beam computed tomography. *Eygp Dent J*. (2015); 61(3): 2-8.
17. Vangala, A.,Hegde, V., Sathe, S., Dixit, M., and Jain, P. Effect of irrigating solutions used for postspace treatment on the push-out bond strength of glass fiber posts. *J Conserv Dent*. (2016); 19(1):82-86.
18. Usla, G., Ozyurek, T., Gundogar, M., and Yilmaz, K. Cyclic fatigue resistance of 2shape, twisted file and endosquence xpress nickel-titanium rotary files at intracanal temperature. *J Dent Res Dent Clin Den.Prospect*.(2018);12(4):283-287.
19. Khdairah, H.R., and Al-Gharrawi, H.A.The Effect of Canal Preparation using 2Shape, ProTaper GOLD and ProTaper Next File Systems on the Fracture Resistance of Obturated Roots. *J Int Dent Med Res*. (2020); 13(1): 42-45.
20. Toursavadkahi, S., Zamani, F., and Afkar, M.Comparison of Tubular Penetration of AH26, EasySeal, and SureSeal Root Canal Sealersin Single-Rooted Teeth Using Scanning Electron Microscopy. *J Res Dent Sci*. (2018); 3(3): 27-32.
21. Yuruker, S., Gorduysus, M., Kucukkaya, S., Uzunoglu, E., Ilgin, C., Gulen, O., Tuncel, B., and Gorduysus, M.O. Efficacy of Combined Use of Different Nickel-Titanium Files on Removing Root Canal Filling Materials. *J Endod*. (2016); 42(3): 487-492.
22. Garg, A., Nagpal, A., Shetty, S., Kumar, S., Singh, K.K., and Garg, A. Comparison of Time Required by D-RaCe, R-Endo and Mtwo Instruments for Retreatment: An in vitro Study. *J Clin Diag Res*. (2015); 7(2): 47-49.
23. Tomer, A.K., Kumari, S., Rastogi, D., Ramachandran, M., Mushtaq, H., Cecilia, L.L., Tyagi, A., and Poonia, S. Evaluation

- of Gutta Percha removal from different NITI rotary file system: An in vitro study. *Int J App Dent Sci.* (2021); 7(2): 1-4.
24. Donnermeyer, D., Bunne, S., Schafer, E., and Dammaschke, T. Retreatability of three calcium silicate-containing sealers and one epoxy resin-based root canal sealer with four different root canal instruments. *Clin Oral Invest.* (2018); 22(2):811-817.
25. Madani, Z.S., Simdar, N., Moudi, E., and Bijani, A. CBCT evaluation of the root canal filling removal using D-RaCe, ProTaper retreatment kit and hand files in curved canals. *Iran Endod J.* (2015); 10(1):69-74.
26. Donyavi, Z., Shokri, A., Pakseresht, Z., Tapak, L., Falahi, A., and Abbaspourrokni, H. Comparative evaluation of retreatability of endodontically treated teeth using AH 26, fluoride varnish and mineral trioxide aggregate-based endodontic sealers. *Open Dent J.* (2019); 13(5):183-189.
27. Sliva, E.J., Belladonna, F.G., Zuolo, A.S., Rodrigues, E., Ehrhardt, I.C., Souza, E.M., and De-Deus, G. Effectiveness of XP-endo Finisher and XP-endo Finisher R in removing root filling remnants: a micro-CT study. *Int Dent J.* (2017); 51(1): 86-91.
28. Rodrigues, E., Belladonna, F., De-Deus, G., and Silva, E. Endodontic management of type II dens invaginatus with open apex and large periradicular lesion using the XP-endo Finisher: A case report. *J Clin Exp Dent.* (2019); 10(10): 1040-1044.
29. Fariniuk, L.F., Azevedo, M.A.D., Carniero, E., Westphalen, V.P.D., Piasecki, L., and Neto, U.X.D.S. Efficacy of protaper instruments during endodontic retreatment. *Ind J Dent Res.* (2017); 28(4): 400-405.
30. Gordon, M.P.J. The removal of gutta percha and root canal sealers from root canals. *New Zealand Dent J.* (2005); 101(2):44-52.
31. Bhagavaldas, M.C., Diwan, A., Kusumvalli, S., Pasha, S., Devale, M., and Chava., D.C. Efficacy of two rotary retreatment systems in removing Gutta-percha and sealer with or without solvent:A comparative in vitro study. *J Conserv Dent.* (2017); 20(1):6-12.
32. Dotto, L., Sarkis-Onofre, R., Bacchi. A., and Pereira, G.K.R. The use of solvents for gutta-percha dissolution/removal during endodontic retreatments: A scoping review. *J Biomed Mater Res.* (2020);109(6):1-12.
33. Hammad, M., Qualtrough, A., and Silikas, N. Three-dimensional Evaluation of Effectiveness of Hand and Rotary Instrumentation for Retreatment of Canals Filled with Different Materials. *J Endod.* (2008);34(11):1370-1373.
34. Yilmaz, F., sonmez, G., Kamburoglu, K., Koc, C., and celik, H. Accuracy of CBCT images in the volumetric assessment of residual root canal filling material: effect of voxel size. *Nig J Clin Pra.* (2019);22(8): 1091-1098.

35. Bago, I., Plotino, G., Katic, M., Rocan, M., Batinic, M., and Anic, I. Evaluation of filling material remnants after basic preparation , apical enlargement and final irrigation in retreatment of severely curved root canals in extracted teeth. *Int Endod J.* (2020);53(7): 962-973.
36. Tomer, A., Miglani, A., Sahni, S., Goud, B.V., Vaidya, S., and Kumari, A. Comparison of Efficacy of Three Ni-Ti Instruments in Removal of Gutta-Percha from Root Canal during Retreatments- An In Vitro Study. *J Dent Med Sci.* (2017);16(4): 32-37.