Micro CT Evaluation of the Cleaning Effectiveness of Ultra sonic Efficiency VS the XP-endo Finisher R in Cleaning the Dentinal Wall After Filling Material Removal

Mohammed E. Rokaya [1], Fahd M. Hadhoud [2], Karam Hamada Ahmed Khalaf [3], Mohamed Ahmed Mahmoud Hamed [4], Mahmoud Abdellah Ahmed Refaei [5], Safwat S Elwaseef [6].

Article History: Received: 21.06.2023 **Revised:**04.07.2023 **Accepted:** 16.07.2023

Abstract:

Aim: To contrast the efficiency of cleaning of Ultra sonic efficiency versus the XP-endo Finisher R in cleaning the dentinal wall after obturating material removal with Micro CT. **Method:** 30 human lower premolars have one straight canal and fully developed apex were used in this study. In order to standardize, every tooth has decoronated to a distance of 15 mm from the apex. Revo-S files were used to prepare the canals. Gutta percha cones sized #25 were used to fill the canals, along with resin sealer. Retreatment procedures were done using EdgefileXR retreatment files. The premolars were subsequently randomized split into 3 identical groups of 10 premolars each in accordance with the additional cleaning technique. **Group 1:** Control group (No additional ultimate cleaning), **Group 2:** Ultra sonic activation, and **Group 3:** XP-endo Finisher R. Micro CT was used three time for every specimen for building 3D volumetric models by mm^3 of the remaining material (after obturation, after filling material removal, and after using the additional cleaning methods). **Results:** The XP-endo Finisher R demonstrated the best efficacy (reducing remaining filling material by 79%), followed by Ultra sonic (reducing remaining filling material by 70%) in comparing with the control group (reducing remaining filling material by 0%). **Conclusion: XP-endo Finisher R** and **Ultrasonic** are both advised to be used as additional methods for cleaning the dentinal wall after removal the filling materials.

[1] Associate Professor of Endodontics, Endodontic Department, Faculty of Dental Medicine Al-Azhar University, Assiut Branch, Egypt. E-mail: mrokaya@azhar.edu.eg.

[2] Assistant Professor of Endodontics, Endodontic Department, Faculty of Dental Medicine Al-Azhar University, Assiut Branch, Egypt. E-mail: Dr.fahdmhadhoud@gmail.com

[3] Lecturer of Endodontics, Endodontic Department, Faculty of Dental Medicine Al-Azhar University, Assiut Branch, Egypt. E-mail: KaramKhalaf.46@azhar.edu.eg

[4] Lecturer of Endodontics, Endodontic Department, Faculty of Dental Medicine Al-Azhar University, Assiut Branch, Egypt. E-mail: Mohamedhamed@azhar.edu.eg

[5] Lecturer in Dental Materials Department, Faculty of Dental Medicine Al-Azhar University, Assiut Branch, Egypt. E-mail: mahmoudabdellah14@yahoo.com

[6] Al-Azhar University, Faculty of Dental Medicine, Endodontic Department, Assiut, Egypt.
E-mail: safwatelwaseef@azhar.edu.eg

DOI: 10.53555/ecb/2023.12.1175

Introduction:

The purpose of endodontic re-treatment is to remove old, contamination filling substances from the root canal and clean and shape it. Eliminating intracanal infection will aid in the body's peri radicular pathosis recovery process [(1)].

One of the main objectives of re-treatment is the complete removal of filling material, which might be difficult. The most effective method for restoring healthy periapical tissues following a second infection or ineffective therapy of a tooth that was earlier obturated because of apical or coronal leaking is non-surgical re-treatment[(2)]. It demands removing the initial root canal filling, further cleaning, and ultimately re-obturation[(3)].

Re-treatment has an approximate success rate of 60% to 85%. The subsequent factors are probably connected to the reduced healing rate in comparison to the first therapy: restricted access to the remaining microorganisms which might become more difficult to deal with as the old filling material needs to be removed entirely; remaining microorganisms that are resistant to treatment; and are spread out in locations other than the primary canal lumen [(4)].

The substance presents a resistance which renders removal challenging and raises the possibility of procedural mishaps including fractured instruments, ledges, and perforations. Moreover, the endodontic sealer has the potential to permeate the dentinal tubules, in contrast to gutta-percha, which is often limited to the primary canal. Canal re-treatment may be made more difficult by the degree of sealer infiltration and dentinal tubule obstruction, even though this is necessary for a fluid-tight seal. It is technically difficult to completely remove the sealer through re-treatment after it has entered dentinal tubules [(5)].

For eliminating endodontic restorative material, a variety of tools and methods are accessible, including manual files, rotary tools, ultrasonic cleaners, and lasers. Nevertheless, none of these methods can completely eradicate the filler ingredients [(6-9)].

For ideal elimination of any leftover root filling material, the goal of present investigation was to compare the cleaning effectiveness of Ultra sonic efficiency versus the XP-endo Finisher R in cleaning the dentinal wall after obturating material removal by 3D volumetric Micro CT scan.

Materials and methods:

Samples Preparation:

30 human lower premolars have one straight canal and fully developed apex extracted for orthodontic purposes were selected. After premolars were thoroughly cleansed to remove any tissue or calculus deposits, isotonic saline was used to keep them.

All premolars were examined under a magnification lens to check for cracks. To guarantee uniform canal shape, radiographs of every tooth were taken in the buccolingual and mesiodistal orientations.

The included criteria of the selected teeth:

The teeth were fully developed apex without interior resorption, decay, calcification of the canal, or history of endodontic therapy.

In order to standardize, every tooth has decoronated to a distance of 15 mm from the apex using diamond disc bur for standardization [(10)]. To guarantee the apical patency of the canals, a K-file size 10 (Dentsply Maillefer, Switzerland) was transferred to the apex of each canal. The identical file was reinserted into the canal till it was observed through the apical foremen, at which point the working length (WL) was noted [(11)].

Utilizing EDTA gel and Revo-S files (Micro-Mega, Besancon, France), canals were prepared until last preparation of SU file size #25 taper 6% was achieved. Employing a 27-gauge needle syringe, 10 millilitres of 17%

EDTA solution and 10 millilitres of sodium hypochlorite were flushed into the canals. A final flush of 5 millilitres of distilled water was applied. Paper points of size #25 were used to dry the canals. Next, gutta percha cones of size #25 and resin sealer (ADSEAL - Root Canal Sealer META BIOMED) were used for filling the canals via the lateral condensation method. X-rays were obtained upon obturation.

Following obturations, tetric N-ceram composite resin (Ivoclar Vivadent, Liechtenstein) was used to seal the specimens occlusally, this process is carried out similarly to direct veneer. They were kept in gauze moistened via distilled water for thirty days at 37C0 and 100% humidity in an attempt to replicate the clinical process as closely as feasible [(12)].

Retreatment procedures were done using Edge file XR retreatment files (EdgeEndo, USA) with the following order R1 (25/0.12), R2 (25/0.08), R3 (25/0.06), and R4 (25/0.04) until the entire working length. Re-treatment was done with a torque of 3 N/cm at a speed of 400 rpm. After using every file, 12. millilitres of 2.5% sodium hypochlorite was utilized as an irrigating solution for six minutes for every specimen. Following finishing canal retreatment, the canals were washed using five millilitres of normal saline for one minute, followed by washing using 17% EDTA for five minutes. Finally, a washing using five millilitres of normal saline for one minute was employed [(13)]. The premolars were subsequently randomized split into 3 identical groups of 10 premolars each in accordance with the additional cleaning technique.

Group 1: Control group (No additional ultimate cleaning).

Group 2: Ultra sonic: In accordance with the instructions provided by the supplier, the Ultra X (Eighteeth, Changzhou Sifary Medical Technology Co., Ltd, Changzhou City, China) has a flexible X Silvertip (#25, 0.02).

Group 3: XP-endo Finisher R. (FKG Dentaire, La Chaux de Fonds, Switzerland).

Ran at 800 rpm with a torque setting of one Ncm in accordance with the instructions provided by the supplier.

For every canal, a total of 5ml of 2.5% NaOCl was utilized for one minute of activation period. Next 5 ml of distilled water was flushed, and finally 5 ml of 17% EDTA with the same motion. The tip was positioned 2 mm shorter than the WL, in an upward and downward direction avoiding contacting the walls. The canal specimens were then washed with 5 ml of distilled water. All methodology steps were done by the same experienced operator to reduce inter-operator variability.

Evaluation method (3D volumetric Micro CT scan):

A cotton pellet was placed inside the coronal opening of each sample to prevent any object from entering the canal specimens.

To ensure an identical location for each scan, each specimen was set in a silicone root socket that was specially created for it.

a Sky scan 1173 micro - CT scanner (Bruker Micro CT, Kontich, Belgium) was used was used three time for every specimen (after obturation, after filling material removal, and after using the final cleaning methods) for construction of 3D volumetric models by mm^3 of the remaining material.

For picture capture, the Sky scan 1173 employs a cone beam X-ray geometry. The item may be rotated 180° or 360° in predetermined stages while data is being collected. Every step is documented with a picture. The scanned images were stored in Tag Image File Format (TIFF) in 16-bit files. The scanning device can work with an adjustable current between 30 and 130 kV and a highest power of 8 W. Following the collection procedure, an FDK algorithm is used to rebuild the acquired picture. N Recon, edition 1.6.9.4, is used for the rebuilding of images, whereas Sky Scan 1173 is used for

data collecting. Versions 3.0.0r1114 and 1.16.4.1 of CT Vox and CT were used for qualitative and quantitative analysis, correspondingly. Every photograph was analysed by a single examiner. The ideal voltage and current settings for scanning samples were energy 70 kV, current 114 µA, and pixel size 8.5 µm.

Statistical Analyses:

The data were analysed using IBM SPSS Statistics version 23 (SPSS Armonk, NY: IBM Corp.). The Shapiro-Wilk test was used to determine the data's normal distribution. One-way ANOVA was used to compare the initial volume of remaining filler material in the preoperative photographs across the groups in order to assess how comparable the specimens were to one another. One-way ANOVA was used to analyse the volume of root canal filling materials eliminated at every root level and in the overall volume in order to look for significant variations between the groups.

Results:

The groups were similar as evidenced by the initial volumes of remaining root canal filling materials in each group not being substantially different (P>0.05) as presented in **Table 1** while the remaining filling material in coronal segment in all groups showed high significantly different residual value in comparison with middle and apical segments in each group (p<0.05).

The average volume of remaining root canal filling material after using additional cleaning methods (**Ultra sonic, and XP-endo Finisher R)** are listed in **Table 2** while **Table 3** shows the proportion of the reduction in root canal filling materials. In all groups, significant varying volumes of root canal filling materials were eliminated. The **XP-endo Finisher R** demonstrated the best efficacy with **79 %** reduction of residual filling material**,** followed by **Ultra sonic** with **70%** reduction of residual filling material in comparing with the **control group 0 %** reduction of residual filling material**.** These results are represented in **figures 1,2,3.**

Table (1): The mean volume value by mm^3 and stander deviation (SD) of the remaining material after removal by Edge file XR

Groups	Coronal	Middle	Apical	Total	P-Value
Group 1: Control group (No additional final cleaning).	**1.35 ± 0.20^{B}**	**0.40 ± 0.19^{C}**	**0.30 ± 0.21^{C}**	**2.05 ± 0.60^{A}**	**$P = 0.001^{*}$**
Group 2: Ultra sonic	**1.34 ± 0.21^{B}**	**0.42 ± 0.21^{C}**	**0.32 ± 0.21^{C}**	**2.08 ± 0.82^{A}**	
Group 3: XP-endo Finisher R.	**1.45 ± 0.21^{B}**	**0.45 ± 0.21^{C}**	**0.29 ± 0.21^{C}**	**2.19 ± 0.75^{A}**	
P-Value	**$p = 0.18^{NS}$**				

NS: non-significant (p > 0.05). *Significant (p<0.05). Different letters indicate a significant difference.

Table (2): The mean volume value by mm^3 and stander deviation (SD) of the remaining material after Additional cleaning methods.

Groups	Coronal	Middle	Apical	Total	P-Value
Group 1: Control group (No additional final cleaning).	**1.35 ± 0.20**	**0.40 ± 0.19**	**0.30 ± 0.21**	**2.05 ± 0.60^{A}**	**P = 0.001***
Group 2: Ultra sonic	**0.83 ± 0.21**	**0.31 ± 0.21**	**0.20 ± 0.21**	**1.34 ± 0.58 ^{B}**	
Group 3: XP-endo Finisher R.	**0.75 ± 0.21**	**0.29 ± 0.21**	**0.18± 0.21**	**1.22 ± .52 ^{B}**	
P-Value	**P = 0.15**			**P = 0.001***	

*Significant ($p<0.05$). Different letters indicate a significant difference between the groups in the same column ($P<0.05$).

Table (3): The percentage the of the remaining material reduction after Additional cleaning methods.

Groups	The percentage of residual filling material reduction %
Group 1: Control group (No additional final cleaning).	**0 % ^{B}**
Group 2: Ultra sonic	**70% ^{A}**
Group 3: XP-endo Finisher R.	**79 % ^{A}**
P-Value	**p = 0.004**

Different letters indicate statistical difference ($P < 0.05$).

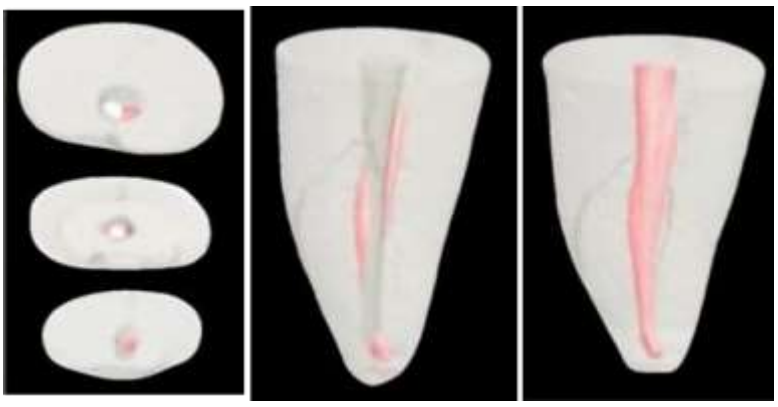

Figure (1): A Photograph of 3D volumetric of Micro CT in group 1 (control group).

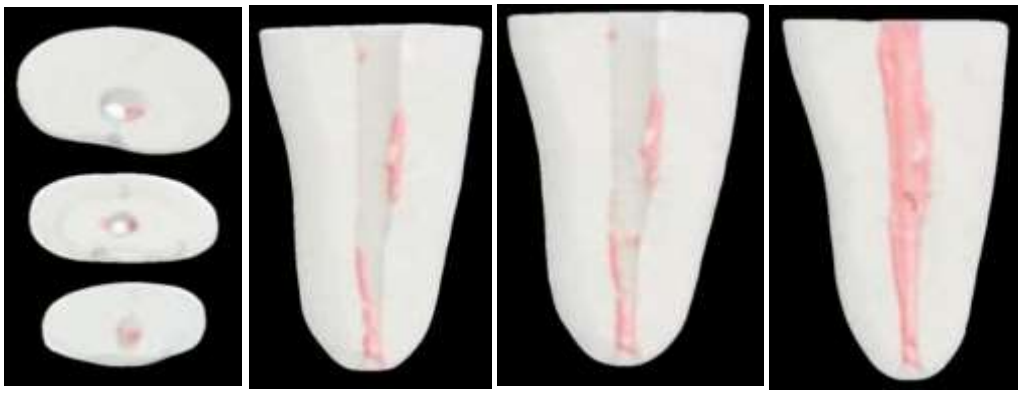

Figure (2): A Photograph of 3D volumetric of Micro CT in group 2 (Ultra sonic) post obturation, post filling material removal, post using **Ultra sonic**, and cross section of the root (from right to left).

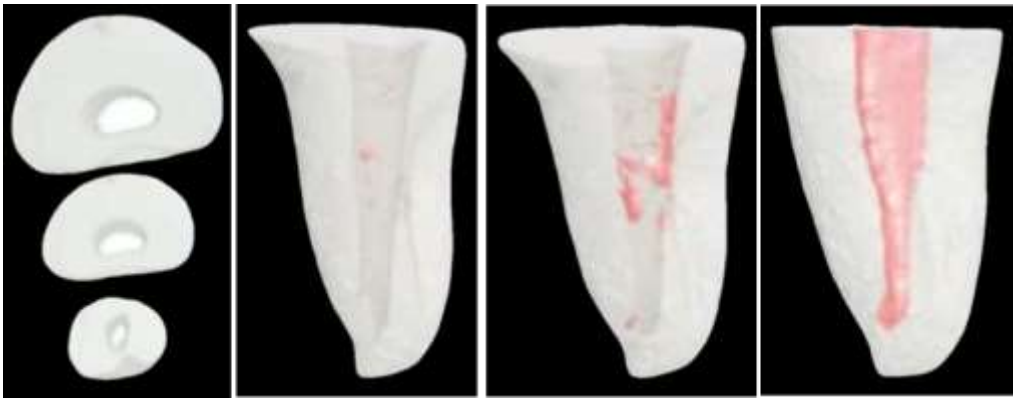

Figure (3): A Photograph of 3D volumetric of Micro CT in group 3 (XP-endo Finisher R.) post obturation, post filling material removal, post using **XP-endo Finisher R**, and cross section of the root (from right to left).

Discussion:

Many studies show that there are no suitable methods to completely take out the materials used for root canal fillings through the root canal system following re-treatment without surgery [14-17], on other hand the failure may be accompanied to non-surgical retreatment due to the trapped bacteria in dentinal tubules[18]. Therefore, others advocated mandatory use of new tools and additional methods for eliminating the residual filling material stacked to the dentinal wall [19-21].

For ideal elimination of any leftover root filling material, the goal of present investigation was to compare the cleaning effectiveness of **Ultra sonic** efficiency versus the **XP-endo Finisher R** in cleaning the dentinal wall after obturating material removal by 3D volumetric of Micro CT.

In this study, EdgefileXR retreatment files (EdgeEndo, USA) with the subsequent order R1 (25/0.12), R2 (25/0.08), R3 (25/0.06), and R4 (25/0.04) were used to facilitate the filling materials removal for all specimens before specimens grouping moreover, equal controls were applied to irrigation amount, time, and specimen preparation.

Our results of initial volumes of remaining filling for root canals following the use of **EdgefileXR** re-treatment files in the groups were found to be equivalent ($P>0.05$), suggesting that they were not significantly variation for standardization of specimens.

On other hand our results concerning the volume of remaining filling for root canals following the use of additional cleaning methods (**Ultra sonic, and XP-endo Finisher**

R), and the percentage of the root canal filling materials reduction where in all groups, significant varying volumes of root canal filling materials were eliminated. The **XP-endo Finisher R** demonstrated the best efficacy (reducing remaining filling material by 79%)**,** followed by **Ultra sonic** (reducing remaining filling material by 70%), in comparing with the **control group** (reducing remaining filling material by 0%).

Our findings are entirely consistent with those of **Alves et al.** [22], **Machado et al.** [23], **Campello et al.** [24], and **Silva et al.** [25] who similarly demonstrated a noteworthy decrease in the amount of intracanal filling material that remained after employing XP-FR. This may be explained by the file expansion at the temperature of the oral cavity and by its spiral motion inside the canal, which encourages the moving of the residual filling material [22].

However, **XP-FR** has been tested on resin-based sealers and gutta percha in these investigations. Utilizing a resin-based sealer as our study's subject, Silva et al. demonstrated that **XP-FR** reduced the overall volume of residual intracanal filling material by 59.4%.

on other way our results are contradicted to **Bassem *et al.*** [26] study who used bio ceramic sealer and found the percentage of material reduction with **XP-FR** was 43.83%. This is a logical conclusion given that bio ceramic sealers have a stronger chemical connection via hydroxyapatite than resin-based sealers, making them more challenging to eliminate [27,28].

In more details our study result concerning **Ultra sonic** showed that percentage reduction of the residual filling materials but less than **XP-FR.** This might be linked to the vibration of the tip, which encourages sonic conduction and causes the residual filling material to fracture and move out of the root canal walls. Additionally, it may encourage a rise in temperature, which might change the structure of the filler material and make it easier to remove with continuous irrigation [29].

Conclusion:

XP-endo Finisher R and **ultrasonic** are both advised to be used as additional methods for cleaning the dentinal wall after removal the filling materials.

References:

1) Matoso FB, Quintana RM, Jardine AP, Dela D, Fontanella VRC, Grazziotin-Soares R, Kopper PM. XP Endo Finisher-R and PUI as supplementary methods to remove root filling materials from curved canals. Braz. Oral Res. 2022;36: e053.

2) Yadav P, Bharath MJ, Sahadev CK, Makonahalli Ramachandra PK, Rao Y, Ali A, et al. An in vitro CT comparison of gutta-percha removal with two rotary systems and hedstrom files. Iran Endod J. 2013; 8:59–64.

3) Mali S, Patil A, Hegde D, Jaiswal H, Saoji H, Edake DN. Efficacy of rotary and hand instrument in removing gutta-percha and sealer from root canals of endodontically treated teeth. J Contemp Dent Pract. 2018; 19:964–8.

4) De Chevigny, C.; Dao, T.T.; Basrani, B.R.; Marquis, V.; Farzaneh, M.; Abitbol, S.; Friedman, S. Treatment outcome in endodontics: The Toronto study–phases 3 and 4: Orthograde retreatment. J. Endod. 2008, 34, 131–137.

5) Kim, H.; Kim, E.; Lee, S.J.; Shin, S.J. Comparisons of the Retreatment Efficacy of Calcium Silicate and Epoxy Resin-based Sealers and Residual Sealer in Dentinal Tubules. J. Endod. 2015, 41, 2025–2030.

6) Bedier MM, Hashem AAR, Hassan YM. Improved dentin disinfection by combining different-geometry rotary nickel-titanium files in preparing root canals. Restor Dent Endod. 2018; 43:46.

7) De-Deus G, Belladonna FG, Zuolo AS, Cavalcante DM, Carvalhal JCA, Simões-

Carvalho M, et al. XP-endo Finisher R instrument optimizes the removal of root filling remnants in oval-shaped canals. Int Endod J. 2019; 52:899–907.

8) Donmez ozkan H, Kaval M, Ozkan G, Ozer S. Efficacy of two different nickel-titanium rotary systems in retreatment procedure with or without laser-activated irrigation: An in vitro study. Photomed Laser Surg. 2019; 37:495-9.

9) Nair U, Natera M, Koscso K, Pillai P, Varella C, Pileggi R. Comparative evaluation of three different irrigation activation on debris removal from root canal systems. J. Dent. Sci. 2011;57.

10) 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.

11) 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.

12) 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.

13) 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.

14) Crozeta BM, Silva-Sousa YT, Leoni GB, Mazzi-Chaves JF, Fantinato T, Baratto-Filho F, Sousa-Neto MD. Micro - computed tomography study of filling material removal from oval-shaped canals by using rotary, reciprocating, and adaptive motion systems. J Endod 2016; 42:793–797.

15) Martins MP, Duarte MA, Cavenago BC, Kato AS, da Silveira Bueno CE. Effectiveness of the ProTaper next and reciproc systems in removing root canal filling material with sonic or ultrasonic irrigation: a micro-computed tomographic study. J Endod 2017;43: 467–471.

16) Akbulut MB, Akman M, Terlemez A, Magat G, Sener S, Shetty H.Efficacy of twisted file adaptive, Reciproc and ProTaper universal retreatment instruments for root-canal-filling removal: a cone-beam computed tomography study. Dent Mater J 2016; 35:126–131.

17) Monguilhott Crozeta B, Damiao de Sousa-Neto M, Bianchi Leoni G, Francisco Mazzi-Chaves J, Terezinha Correa Silva-Sousa Y, Baratto-Filho F. A micro-computed tomography assessment of the efficacy of rotary and reciprocating techniques for filling material removal in root canal retreatment. Clin Oral Investig 2016;20: 235–240.

18) Ricucci D, Siqueira JF Jr, Bate AL, Pitt Ford TR. Histologic investigation of root canal-treated teeth with apical periodontitis: a retrospective study from twenty-four patients. J Endod 2009; 35:493–502.

19) Bernardes RA, Duarte MA, Vivan RR, Alcalde MP, Vasconcelos BC, Bramante CM. Comparison of three retreatment techniques with ultrasonic activation in flattened canals using micro - computed tomography and scanning electron microscopy. Int Endod J 2015; 49:890–897.

20) Silva E, Belladonna FG, Zuolo AS, Rodrigues E, Ehrhardt IC, Souza EM, De-Deus G. Effectiveness of XP-endo

Finisher and XP-endo Finisher R in removing root filling remnants: a micro-CT study. Int Endod J 2018; 51:86–91 14.

21) Keles A, Arslan H, Kamalak A, Akcay M, Sousa-Neto MD, Versiani MA Removal of filling materials from oval shaped canals using laser irradiation: a micro-computed tomo-graphic study. J Endod 2015; 41:219–224.

22) Alves FRF, Ribeiro TO, Moreno JO, Lopes HP. Comparison of the efficacy of nickel-titanium rotary systems with or without the retreatment instruments in the removal of gutta-percha in the apical third. BMC Oral Health. 2014;14(1):1-5. 27.

23) Machado AG, Guilherme BPS, Provenzano JC, Marceliano-Alves MF, Gonçalves LS, Siqueira JF, et al. Effects of preparation with the Self-Adjusting File, TRUShape and XP-endo Shaper systems, and a supplementary step with XP-endo Finisher R on filling material removal during retreatment of mandibular molar canals. Int Endod J 2021;52(5):709-15.

24) Campello AF, Almeida BM, Franzoni MA, Alves FRF, Marceliano-Alves MF, Rôças IN, et al. Influence of solvent and a supplementary step with a finishing instrument on filling material removal from canals connected by an isthmus. Int Endod J 2021;52(5):716-24.

25) Silva EJNL, Belladonna FG, Zuolo AS, Rodrigues E, Ehrhardt IC, Souza EM, et al. Effectiveness of XP-en - do Finisher and XP-endo Finisher R in removing root filling remnants: a micro-CT study. Int Endod J. 2018;51(1):86-91.

26) Eid, B. M., Abdel Maksoud, H. B., Elsewify, T. M. Efficacy of XP-endo Finisher-R in enhancing removal of bioceramic sealer from oval root canal: a micro-CT study. Giornale Italiano Di Endodonzia 2021;35(1).

27) Koch KA, Brave D, Nasseh A. Bioceramic Technology: Closing the Endo-Restorative Circle, Part I. Dentistry Today 2021 Mar 30.

28) Ersev H, Yilmaz B, Dinçol ME, Daglaroglu R. The efficacy of ProTaper Universal rotary retreatment instrumentation to remove single gutta-percha cones cemented with several endodontic sealers. Int Endod J. 2012;45(8):756-62.

29) Wiesse PEB, Silva-Sousa YT, Pereira RD, Estrela C, Domingues LM, Pecora JD, Sousa-Neto MD. Effect of ultrasonic and sonic activation of root canal sealers on the push-out bond strength and interfacial adaptation to root canal dentine. Int Endod J 2018; 51:102– 111.