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Comparative Evaluation of Gutta-percha Removal Using Different Kinematics and Surface Changes in Reciproc Blue and ProTaper Rotary as Retreatment Files (In Vitro Study).

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Abstract

Aim of the study: The aim of the present study is to compare between Reciprocating file (Reciproc Blue) and rotating files (Protaper Universal Retreatment System) in retreatment of endodontically treated teeth concerning: 1. Removal of obturating material. 2. Surface changes of the File. **Material and Method:** 32 single-rooted human maxillary central incisors were collected. the specimens were randomly allocated into two groups,16 teeth decoronated and retreated by ReciprocBlue file ,16 teeth decoronated and retreated by ProTaper Universal Retreatment files. The selected teeth were decoronated using diamond disc to standardize the working length to 15 mm for each specimen. Root canal of each tooth was slightly dried with paper points #40 and obturated with cold lateral.
Technique: Specimens randomly divided into two experimental groups, with 16 specimens each, retreatment performed using two different Rotary systems without using Gutta-percha solvent. Canals were irrigated in all the specimens with 5.25% sodium hypochlorite during obturation material removal. The obturation removal done using one of the following systems: Group 1: Reciproc Blue one file shaping, Group 2: ProTaper Universal Retreatment Ni–Ti rotary**. Results :** No examined retreatment technology can completely remove root canal obturation material, particularly at the apical third. The ProTaper Retreatment Rotary Instruments remove somewhat more obturation material as compared to reciproc blue. Reciproc blue files had a higher percentage of fractures and cracks compared to PTUR files.
Conclusion: Continuous rotation is somewhat more effective and efficient than reciprocating motion. Instrument failure can be influenced by several parameters such as speed, force, kinematics, and torque values. Reciproc blue files had a higher percentage of fractures and cracks compared to PTUR files.
Keyword: *ProTaper, Reciproc Blue, Retreatment, Surface change, Reciprocation, Rotation*

Introduction.

The primary goal of root canal therapy is to form and cleanse the root canal system before sealing it in three dimensions to avoid reinfection of the tooth.
The purpose of an efficient obturation is to eliminate any possible space for germs to thrive.
Obturate the canal from apex to orifice with gutta percha and plug any holes.
The success of endodontic treatment is decided by the short-term quality of root canal therapy and the long-term quality of the coronal restoration that follows.
Endodontic success is dependent on the appropriate cleansing, shape, and obturation of the root-canal system. This is due to the fact that endodontic therapy may effectively eradicate germs from the root-canal area during treatment, preventing recontamination of the region.

The aim of retreatment is to perform an endodontic treatment that can render the treated tooth functional and comfortable again, allowing complete repair of the supporting structures.

The objectives of nonsurgical retreatment are to eliminate materials from the root canal space and, to cure imperfections or fix iatrogenic or pathologic abnormalities. Confirm any mechanical issues, missed canals in the past, or fractures in the radicular subcrestal area.

Surface changes in Ni-Ti rotary instruments play a significant role in failure or fracture start , Ni-Ti instrument fracture may happen with little to no obvious plastic deformation; this would be impossible to see without magnification.

Several techniques have been proposed for removing filling materials from the root canal system, including the use of endodontic hand files, Nickel Titanium rotary tools, Gates Glidden burs, heated instruments, ultrasonic instruments, lasers, and supplementary solvents. Traditionally, removing gutta percha with hand files with or without solvent can be a difficult and time-consuming operation, especially when the root filling material is tightly compacted.
Endodontic practitioners have developed many generations of rotary Ni-Ti files to improve fracture resistance and cutting performance. These generations enhance design features, metallurgical qualities, and motions.
The ProTaper Universal Retreatment System (PTUR) is a rotating system built specifically for

retreatment. It comprises of three instruments used in continuous rotation and has a convex triangular cross section.

The Nickel-Titanium alloy "Ni-Ti" has several benefits over ordinary files, including superior elasticity, form memory, and reduced modulus of elasticity.

Reciprocation means mechanical radicular endodontic shaping using unequal bidirectional clockwise/counterclockwise (CW/CCW) directions.

Reciproc Blue (RB) (VDW, Munich, Germany) is a single reciprocating file system that shares the same design features as the M-wire Reciproc with an S-shaped horizontal cross-section and 2 cutting edges,

IV-Materials and Methods

Sample selection:

The collected teeth were examined to ensure the absence of caries, root resorption or fractures by periapical x-ray. Before starting the experiment a pre-operative radiograph was taken for each tooth to evaluate the root canal anatomy of the extracted teeth before their inclusion in the study. The teeth with calcified canals, internal or external root resorption were excluded and replaced with another incisors. The 32 extracted, single-rooted human maxillary incisors were stored in distilled water until further use.

Methodology:

This study was approved by the ethics committee, Faculty of Dentistry, October 6 University, Cairo, Egypt.

Grouping:

Group 1 : 16 teeth decoronated and retreated by Reciproc Blue file

Group 2 : 16 teeth decoronated and retreated by ProTaper Universal Retreatment files

32 single-rooted human maxillary central incisors were collected

Specimen preparation: The selected teeth were decoronated using diamond disc to standardize the working length to 15 mm for each specimen . A size 10 K-type file was inserted into the canal until its appearance from the apical foramen to ensure the canal patency. The file was retrieved until it was flushed with root apex then the working length was established 1mm shorter than this length. The specimens engaged at their working length (14 mm) by size 25 K file, while the unengaged incisors were replaced by other teeth to standardize the initial file for all specimens. Canal instrumentation was performed using ProTaper Next rotary files system to a final size of 40/0.06. Apical patency maintained with 10 K-file. The canals were irrigated with 10 ml (NaOCl) 5.25% during the root canal preparation and 1 ml of 17% EDTA for 5 min before root canal obturation

Root canal obturation: Root canal of each tooth was slightly dried with paper points #40 and obturated with cold lateral technique. Gutta-percha cone size 40/0.04 and Ceraseal Sealer were used for canal obturation. The master Gutta-percha cone size 40 selected and tug-back was justified, then Ceraseal Sealer was injected inside the canal. The master cone was inserted to the full working length and pumping motion was performed to spread the sealer on the canal walls. A gutta- percha point was inserted, and root canal obturation was performed by using the cold lateral condensation technique. Accessory gutta-percha cones were placed into the space created by the spreader penetrated no more than 1–2 mm from the root canal orifice. The process was repeated until the spreader penetrated only into the coronal one-third of the root canal space. Excess gutta-percha was removed with a heated plugger, the remaining was condensed vertically with a cold plugger and the pulp chamber was cleaned. The obturated teeth were radiographed to confirm the length of root filling . All specimens stored at 37°C for 1 weeks at 100% humidity to allow complete setting of the sealer.

Retreatment

Canals were irrigated in all the specimens with 5.25% sodium hypochlorite during obturation material removal. The obturation removal done using one of the following systems:

Group 1: Reciproc Blue :one file shaping. produced with Nickel-Titanium (NiTi) Figure(1) that goes through an innovative heat treatment, modifying its molecular structure to give it increased resistance to cyclic fatigue and additional flexibility as well as its characteristic blue color. Thus,

a root canal can be completely prepared with only one Reciprocating instrument – without creating a glide path in the majority of cases.

The retreatment technique was carried out with the Reciproc Blue (RB) R40 file (tip size 40; variable taper; VDW) and the Xsmart plus Endomotor set to reciprocation RECIPROC ALL mode. The device was advanced apically using an in-and-out pecking motion with an amplitude of about 3 mm, as directed by the manufacturer; light apical pressure was exerted with a brushing action on the lateral walls. After three pecks, the tool was withdrawn from the canal and cleaned with sterile gauze. The canal was then irrigated with 2.5% NaOCl. The operation was repeated until the instrument reached WL

Figure(1)

Group 2: ProTaper Universal Retreatment Ni–Ti rotary instrumentation system Figure(2). ProTaper Retreatment files will be used in crown-down technique in a brushing motion at constant speed of 500 rpm as per manufacturer's recommendation. D1 (size 30; 9% taper) was used in the coronal third, D2 (size 25; 8% taper) in the middle third, and D3 (size 20; 7% taper) in the apical third as specified by the manufacturer.

The PTU Retreatment system was used as per the manufacturer's instructions, with a speed of 500 rpm and torque of 2.5 N cm−2. The D1 file was used to remove material from the canal's coronal, while the D2 and D3 files were utilized to remove material from the middle and apical thirds. Following the usage of each file, root canals were irrigated with 2.5% NaOCl

Figure(2).

Gutta-percha removal evaluation

Roots grooved longitudinally, in buccolingual direction, into two halves with diamond disc such that the groove done in proximity of the root canal wall but not cutting through the wall of the canal . The root split using a chisel and mallet . After tooth splitting, each half of every specimen separately imaged .Amount of Gutta-percha and sealer on canal walls was imaged in standardized way in both sections of the tooth and measured in square millimeters using the feature of image analyzer software (imageJ 1,6,0_20, image software, USA) connected to Stereomicroscope at 150x magnification (Technival 2 carl zeiss, Jena, Germany) Figure (3) ProTaper, Figure (3) ReciprocBlue.

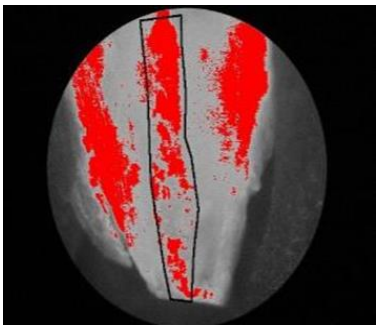

Figure 3

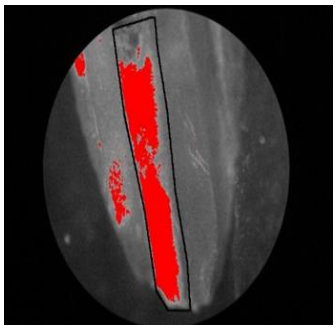

Figure 4

Determination of the files surface changes

Analyzing the surface changes of the Reciproc Blue Figure(5) and the D3 Figure(6) (size 20; 7% taper)

We took the last file of every system and analyze the surface change of the master file of ProTaper Retreatment kit after use it in 4 canals as manufacture instructions in Dentsply paper or fracture happened (https://www.dentsplysirona.com)

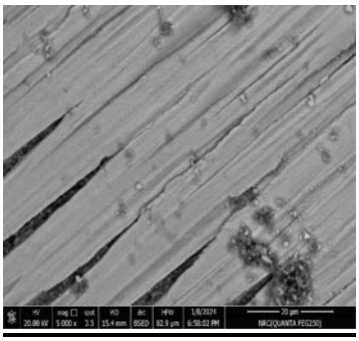

Figure 5

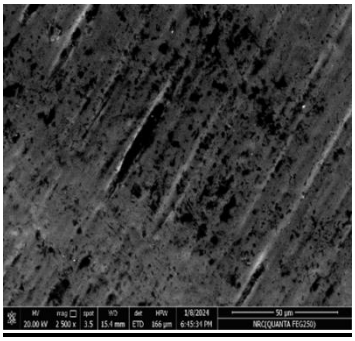

Figure 6

Scanning electron microscope (SEM)

Last instrument of each brand was examined under a scanning electron microscope (SEM) (Inspect S50, PT Multi Teknindo Infotronika, Jakarta, Indonesia) to assess any fractures or cracks (initial evaluation)]

instruments were cleaned with absolute alcohol for 3 min and fixed in a metal stub and examined at magnification (100×, 200×, 500×, 1000×, 2000× and 5000×). After the initial evaluation, the topographic features of the surfaces of these instruments were evaluated after three more times after each instrumentation and autoclave sterilization cycle

Stereo microscope results for remaining GuttaPercha :

The roots were split longitudinally, and the canals were marked into three thirds (coronal, middle and apical) of 3 mm each.

The canals were viewed under a stereomicroscope (Technival 2 Carl Zeiss, Jena, Germany) at 50X magnification, and images were taken for each third using a 4 megapixels digital camera mounted to the microscope (Canon Powershot A520, Canon Inc., USA)

Technival-2 stereomicroscope* at 150x magnification. Photographs were taken using a 4 Megapixel digital camera† and transferred to a computer to be manipulated by image

Images were then transferred to an image manipulation software (ImageJ 1,6,0_20, Image ware, USA) to calculate the percentage of root canal surface area occupied by remnants of the obturation material (% of remnants). The remnants in each canal were traced and the total number of pixels occupied by the remnants was compared to the total surace area of the traced canal. Percentage of remnants was calculated for coronal, middle and apical thirds, through the following equation:

% of remnants = (Total surface area of the remnants / Total surface area of the canal) * 100

Table 1: Mean and standard deviation of group 1 and 2 and comparison between them using Independent t test:

Section	Group 1		Group 2		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		P value
	Mean	Std. Deviation	Mean	Std. Deviation			Lower	Upper	
Apical	3.56	0.18	4.23	0.21	-0.671	0.069	-0.81	-0.53	0.0001*
Middle	3.77	0.19	5.03	0.25	-1.261	0.078	-1.42	-1.10	0.0001*

Coronal	8.45	0.42	5.33	0.27	3.120	0.124	2.86	3.37	0.0001*

**Significant difference as P<0.05.*

Means with the same superscript letters were insignificantly different as P>0.05. Means with different superscript letters were significantly different as P<0.05.

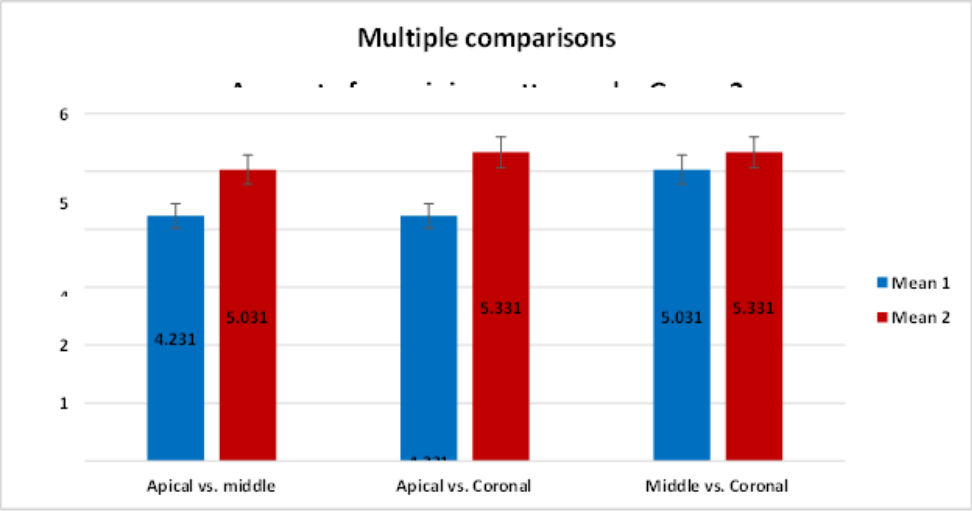

Figure 5: Multiple comparisons of amount of remaining gutta percha between group 1,2

Discussion

The main aim of root canal treatment is to disinfect and shape the root canal system and seal it in three dimensions to prevent reinfection of the tooth. Lack of healing is due to persistent intraradicular infection residing in previously instrumented canals, dentinal tubules or in the complex irregularities of the root canal system. The present study evaluated the effectiveness of different systems with two type of kinematic movements, continuous rotation (ProTaper Universal retreatment system, and reciprocation (Reciproc Blue, WaveOne Gold) in removing gutta-percha. The main advantage of using engine-driven file systems over hand files is the reduction in the time required for filling removal(4,8,9).

Previous research has revealed that continuous rotation is a more appropriate cutting motion for retreatment instances (1,2). Furthermore, the single-file reciprocating WO files are designed to work with proprietary kinematics software that needs a particular motor. According to recent and previous assessments (5), no current retreatment methodology can entirely eliminate root filling materials. with the current study, the ProTaper Universal rotary devices left a less fraction of the area covered with GP/sealer remains than those treated with alternative techniques. The better performance of ProTaper Universal retreatment equipment might be attributed to its design.

D1, D2, and D3 have escalating tapers and lengths. These qualities may allow the retreatment tools to remove not only the GP but also the superficial layer of dentine during root filling extraction. Furthermore, the ProTaper Universal retreatment instruments' unique flute shape and rotating motion tend to draw GP into the file flutes and send it toward the crown ,this result agreed with (2,9,14,15).

In this investigation, results showed that reciprocating motions showed less fatigue resistance than continuous rotation agreed with (15) .but there was a fracture in the tip of last file of protaper universal after using in three teeth. There was no significant variation in the mean length of the broken pieces across the equipment evaluated.(34,43).

Conclusion

1- No examined retreatment technology can completely remove root canal obturation material, specially at the apical third.
2- The ProTaper Retreatment Rotary Instruments remove somewhat more obturation material than reciproc blue.
3- Continuous rotation is somewhat more effective than reciprocating motion. Single file retreatment is cost-effective, and time-saving method for retreatment .
4- Instrument failure can be influenced by several parameters such as speed, force, kinematics, and torque values.
5- Reciproc blue files had a higher percentage of fractures and cracks than PTUR files.

Refrences

1- Reddy N, Admala SR, Dinapadu S, Pasari S, Reddy MP, Rao MS. Comparative analysis of efficacy and cleaning ability of hand and rotary devices for gutta-percha removal in root canal retreatment: an in vitro study. J Contemp Dent Pract. 2013 Jul 1;14(4):635-43.

2- Capar ID, Arslan H, Ertas H, Gök T, Saygılı G. Effectiveness of ProTaper Universal retreatment instruments used with rotary or reciprocating adaptive motion in the removal of root canal filling material. Int Endod J. 2015 Jan;48(1):79-83.

3- Kasam S, Mariswamy AB. Efficacy of Different Methods for Removing Root Canal Filling Material in Retreatment - An In-vitro Study. J Clin Diagn Res. 2016 Jun;10(6):ZC06-1

4- Topçuoğlu HS, Topçuoğlu G, Aktı A. Comparative evaluation of cyclic fatigue resistance of D-RaCe and ProTaper retreatment instruments in curved artificial canals. Int Endod J. 2016 Jun;49(6):604-9.

5- Khedmat S, Azari A, Shamshiri AR, Fadae M, Bashizadeh Fakhar H. Efficacy of ProTaper and Mtwo Retreatment Files in Removal of Gutta-percha and GuttaFlow from Root Canals. Iran Endod J. 2016 Summer;11(3):184-7

6- Ozyurek T, Ozsezer-Demiryurek E. Efficacy of protaper next and protaper universal retreatment systems in removing gutta-percha in curved root canals during root canal retreatment. J Istanb Univ Fac Dent. 2017 Apr 3;51(2):7-13

7- Fariniuk LF, Azevedo MAD, Carneiro E, Westphalen VPD, Piasecki L, da Silva Neto UX. Efficacy of protaper instruments during endodontic retreatment. Indian J Dent Res. 2017 Jul-Aug;28(4):400-405.

8- Das S, De Ida A, Das S, Nair V, Saha N, Chattopadhyay S. Comparative evaluation of three different rotary instrumentation systems for removal of gutta-percha from root canal during endodontic retreatment: An *in vitro* study. J Conserv Dent. 2017

9- Raj PKT, Mudrakola DP, Baby D, Govindankutty RK, Davis D, Sasikumar TP, Ealla KKR. Evaluation of Effectiveness of Two Different Endodontic Retreatment Systems in Removal of Gutta-percha: An in vitro Study. J Contemp Dent Pract. 2018 Jun1;19(6):726-731. PMID: 29959303.

10- Fatima K, Nair R, Khasnis S, Vallabhaneni S, Patil JD. Efficacy of rotary and reciprocating single-file systems on different access outlines for gutta-percha removal in retreatment: An in vitro study. J Conserv Dent. 2018 Jul-Aug;21(4):354-358.

11- Madarati AA, Al-Nazzawi AA, Sammani AMN, Alkayyal MA. The efficacy of retreatment and new reciprocating systems in removing a gutta-percha-based filling material. J Taibah Univ Med Sci. 2018 Jun 27;13(5):452-458.

12- De-Deus G, Belladonna FG, Zuolo AS, SimoesCarvalho M, Santos CB,Oliveira DS, Cavalcante DM, Silva EJNL. Effectiveness of ReciprocBlue in removing canal filling material and regaining apical patency. International Endodontic Journal, 52, 250–257, 2018.

13- Plotino G, Grande NM, Testarelli L, Gambarini G, Castagnola R, Rossetti A, Özyürek T, Cordaro M, Fortunato L. Cyclic Fatigue of Reciproc and Reciproc Blue Nickel-titanium Reciprocating Files at Different Environmental Temperatures. J Endod. 2018

14- Bago I, Suk M, Katić M, Gabrić D, Anić I. Comparison of the effectiveness of various rotary and reciprocating systems with different surface treatments to remove gutta-percha and an epoxy resin-based sealer from straight root canals. Int Endod J. 2019 Jan;

15- Silva EJNL. Effectiveness of Reciproc Blue in removing canal filling material and regaining apical patency. Int Endod J. 2019 Feb;52(2):250-257.

16- Khalil WA, Natto ZS. Cyclic fatigue, bending resistance, and surface roughness of ProTaper Gold and EdgeEvolve files in canals with single- and double-curvature. Restor Dent Endod. 2019 Apr 26;44(2):e19.

17- Mukhtar, A., Mushtaq, M., Sartaj, M., Farooq, R., Rashid, A., & Ahmad, F. (2019). Evaluation Of Surface Changes In Protaper Universal Rotary Files After Single And Multiple Uses In Semi Curved Canals With Different Irrigating Solutions: A Sem Analysis

18- Galal, Sara & Kamel, Wael & din, mohsen. (2019). The Efficacy of Reciprocating Instruments Versus Continuous Rotary Nickel-Titanium Instruments in Root Canal Retreatment with Different Filling Materials.. Al-Azhar Dental Journal for Girls. 10.21608/adjg.2019.5563.1013.

19- Dönmez Özkan H, Kaval ME, Özkan G, Yiğit Özer S. Efficacy of Two Different Nickel-Titanium Rotary Systems in Retreatment Procedure With or Without Laser-Activated Irrigation: An *In Vitro* Study. Photobiomodul Photomed Laser Surg. 2019 Aug;37(8):495-499.

20- Gündoğar M, Özyürek T, Yılmaz K, Uslu G. Cyclic fatigue resistance of HyFlex EDM, Reciproc Blue, WaveOne Gold, and Twisted File Adaptive rotary files under different temperatures and ambient conditions. J Dent Res Dent Clin Dent Prospects. 2019 Summer;13(3):166-171.

21- Uygun AD, Unal M, Falakaloglu S, Guven Y. Comparison of the cyclic fatigue resistance of hyflex EDM, vortex blue, protaper gold, and onecurve nickel-Titanium instruments. Niger J Clin Pract. 2020 Jan;23(1):41-45.

22- Romeiro K, de Almeida A, Cassimiro M, Gominho L, Dantas E, Chagas N, Velozo C, Freire L, Albuquerque D. Reciproc and Reciproc Blue in the removal of bioceramic and resin-based sealers in retreatment procedures. Clin Oral Investig. 2020 Jan;24(1):405-416

23- Serefoglu B, Miçooğulları Kurt S, Kaval ME, Güneri P, Kandemir Demirci G, Çalışkan MK. Cyclic Fatigue Resistance of Multiused Reciproc Blue Instruments during Retreatment Procedure. J Endod. 2020 Feb;46(2):277-282.

24- Burcu Serefoglu, Seniha Miçooğulları Kurt, Mehmet Emin Kaval, Pelin Güneri, Gözde Kandemir Demirci, Mehmet Kemal Çalışkan,Cyclic Fatigue Resistance of Multiused Reciproc Blue Instruments during Retreatment Procedure,Journal of Endodontics,Volume 46, Issue 2,2020

25- Faus-Matoses V, Pasarín-Linares C, Faus-Matoses I, Foschi F, Sauro S, Faus-Llácer VJ. Comparison of Obturation Removal Efficiency from Straight Root Canals with ProTaper Gold or Reciproc Blue: A Micro-Computed Tomography Study. J Clin Med. 2020 Apr 18;9(4):1164.

26- Alakabani TF, Faus-Llácer V, Faus-Matoses I, Ruiz-Sánchez C, Zubizarreta-Macho Á, Sauro S, Faus-Matoses V. The Efficacy of Rotary, Reciprocating, and Combined Non-Surgical Endodontic Retreatment Techniques in Removing a Carrier-Based Root Canal Filling Material from Straight Root Canal Systems: A Micro-Computed Tomography Analysis. J Clin Med. 2020 Jun 25;9(6):1989.

27- Nasiri K, Wrbas KT. Comparison of the efficacy of different Ni-Ti instruments in the removal of gutta-percha and sealer in root canal retreatment. Indian J Dent Res. 2020 Jul-Aug;31(4):579-584.

28- Aly, A., Abdallah, A., El Backly, R. (2020). EFFICACY OF THREE DIFFERENT RETREATMENT FILE SYSTEMS FOR GUTTA-PERCHA REMOVAL USING CONE BEAM COMPUTED TOMOGRAPHY. *Alexandria Dental Journal*, 45(3), 23-28.

29- Uygun AD. Cyclic fatigue resistance of VDW.ROTATE and Reciproc Blue nickel-titanium files at root canal temperature. J Dent Res Dent Clin Dent Prospects. 2020 Summer;14(3):177-180. doi: 10.34172/joddd.2020.032. Epub 2020 Sep 21

30- Howait, Mohammed. (2021). Reciproc Endodontic File Surface Defects After Single Use: An SEM Analysis. Journal of International Society of Preventive & Community Dentistry. 11. 98-103. 10.4103/jispcd.JISPCD_412_20.

31- Aly, A., Abdallah, A., El Backly, R. (2020). EFFICACY OF THREE DIFFERENT RETREATMENT FILE SYSTEMS FOR GUTTA-PERCHA REMOVAL USING CONE BEAM COMPUTED TOMOGRAPHY. *Alexandria Dental Journal*, 45(3), 23-28.

32- Furlan RD, Alcalde MP, Duarte MAH, Bramante CM, Piasecki L, Vivan RR. Cyclic and Torsional Fatigue Resistance of Seven Rotary Systems. Iran Endod J. 2021;16(2):78-84.

33- Baranwal HC, Mittal N, Garg R, Yadav J, Rani P. Comparative evaluation of retreatability of bioceramic sealer (BioRoot RCS) and epoxy resin (AH Plus) sealer with two different retreatment files: An *in vitro* study. J Conserv Dent. 2021 Jan-Feb;24(1):88-93.

34- Howait M. Reciproc Endodontic File Surface Defects After Single Use: An SEM Analysis. J Int Soc Prev Community Dent. 2021 Jan 30;11(1):98-103.

35- Özdemir ÖS, Toplu D. Comparing the cyclic fatigue resistances of Reciproc Blue and Rotate instruments in simulated severe apical curvature. Turk Endod J 2021;6:71-75.

36- Mohd Nazrin Isa, Aws Hashim Ali Al-Kadhim, & Azlan Jaafar. (2021). The Efficacy of Reciproc Blue® For Canal Cleanliness Following the Retreatment of Maxillary First Molar: In Vitro Analysis. *Malaysian Journal of Science Health & Technology*, *7*(1), 22–27.

37- Boetto AC, Arce-Brisson G, Zmener O, Pameijer C, Della-Porta R, Picca M. Ability of two reciprocating Nickel-Titanium instruments for guttapercha/ sealer removal in simulated curved root canals. Acta Odontol Latinoam. 2022 Apr 30;35(1):39-44

38- Buranade AT, Algarni YA, Alobaid ASN, Kader MA, Baba SM, Mohamed Ali AB. Comparative Evaluation of Efficacy of Protaper Universal Retreatment System, R-Endo System and Hedstrom File in Gutta Percha Removal During Root Canal Retreatment- An *In Vitro* Study. J Pharm Bioallied Sci. 2022 Jul;14(Suppl 1):S507-S510

39- Jurić Kaćunić D, Tadin A, Dijanić P, Katunarić A, Matijević J, Trutina-Gavran M, Galić N. Efficacy of Reciprocating Instruments in Retreatment of Bioactive and Resin-Based Root Canal Sealers. Acta Stomatol Croat. 2022 Dec;56(4):338-350.

40- Adel M, Tofangchiha M, Rashvand E, Moutabha I, Roohi N, Reda R, Testarelli L. Comparison of the Efficacy of NeoNiTi, ProTaper, and Reciproc Files in the Retreatment of Curved Root Canals: a CBCT Assessment. Acta Stomatol Croat. 2022 Dec;56(4):351-362.

41- Madarati AA, Sammani AMN, Alnazzawi AA, Alrahlah A. Efficiency of the new reciprocating and rotary systems with or without ultrasonics in removing root-canals filling with calcium silicate-based sealer (MTA). BMC Oral Health. 2023 Jan 3;23(1):5.

42- Farrayeh A, Akil S, Eid A, Macaluso V, Mancino D, Haïkel Y, Kharouf N. Effectiveness of Two Endodontic Instruments in Calcium Silicate-Based Sealer Retreatment. Bioengineering (Basel). 2023 Mar 15;10(3):362.

43- Ciftcioglu E, Sungur Guzel R, Akbal Dincer G, Karakaya G, Kucukay ES. Efficiency of ProTaper Universal Retreatment, Reciproc Blue and XP-endo Shaper in the removal of a bioceramicbased root canal filling. Eur Oral Res 2023; 57(3): 159-16

44- Jamleh, A., Nassar, M., Alfadley, A. *et al.* Retreatment of oval-shaped root canals filled with TotalFill bioceramic or AH plus sealer. *Sci Rep* **13**, 9357 (2023

45- Akshay VA, Srirekha A, Reddy J, Champa C, Shetty A, Srinivasan A. Evaluation of the efficacy of TruNatomy, ProTaper retreatment, and RaCe file systems in retreatment of moderately curved mandibular molars: An *in vitro* study. J Conserv Dent. 2023 Jul-Aug;26(4):383-387

46- dos Reis, F.A.S., Abu Hasna, A., Ragozzini, G. *et al.* Assessing the cyclic fatigue resistance and sterilization effects on replica-like endodontic instruments compared to Reciproc Blue. *Sci Rep* **13**, 22956 (2023)

47- ÇİFTÇİOĞLU E, SUNGUR GÜZEL R, AKBAL DİNÇER G, KARAKAYA G, KÜÇÜKAY ES (September 1, 2023) Efficiency of ProTaper Universal Retreatment, Reciproc Blue and XP-endo Shaper in the removal of a bioceramic-based root canal filling. European Oral Research 57 3 159–164.

48- Abdelnaby P, Ibrahim M, ElBackly R. In vitro evaluation of filling material removal and apical debris extrusion after retreatment using Reciproc blue, Hyflex EDM and ProTaper retreatment files. BMC Oral Health. 2023 Nov 21;23(1):902.

49- Tantiwanichpun, B., Kulvitit, S. Efficiency and complications in root canal retreatment using nickel titanium rotary file with continuous rotation, reciprocating, or adaptive motion in curved root canals: a laboratory investigation. *BMC Oral Health* 23, 871 (2023).