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A comparative study of the efficacies of continuous rotation vs reciprocation motion on the remaining dentin thickness after the removal of bio-ceramic-based root canal filling samples obturated with two different techniques (an in vitro study)

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Abstract

To measure remaining mesial and distal dentin thicknesses following removal of root canal filling material using continuous rotational and reciprocative motion. Fifty-six extracted human mandibular premolars were selected for the study. All samples were prepared till fill (F4) and were divided into two experimental groups (n=28) according to obturation technique used, then each group was further sub-divided into two subgroups (n=14) according to kinematics of the file system used in filling material removal. Changes in mesial and distal dentine thicknesses were calculated using CBCT before obturation and after filling material removal. Measurements were evaluated at three standard points (3, 6, 9 mm) from the apex. For all studied regions coronal, middle, and apical thirds there was no statistically significant difference between percentage changes in dentin thickness at different root levels with different kinematics used. As regards the overall percentage change in dentin thickness, single cone technique showed statistically significantly lower percentage change than lateral compaction technique. Reciprocation motion showed a no significance difference on the remaining dentin thickness when compared to continuous rotational instruments.

Keywords: Retreatment, Cone-beam computed tomography, Remaining dentin thickess, Reciproc, Continuous rotational.

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1. Introduction

Despite having a high success rate, root canal treatment may not provide the expected results and may even fail [1]. Even with the strictest adherence to the most exacting treatment protocols, endodontic failures can still occur [2]. Re-treatment is considered the primary procedural option when the tooth exhibits inadequate initial root canal treatment, has a localized swelling, percussion and palpation sensitivity, recurrent caries and missing coronal restorations. The ultimate goal of retreatment is to remove all remnants of necrotic tissue, complete removal or root canal filling (gutta-percha and sealer), proper canals disinfection with adequate obturation and coronal seal to reach the highest success rate. The key factor that determines the success of this procedure is to remove the originally obturated material completely from the canal in order to access the resistant residual bacteria [3]. Several manners have been introduced to remove root canal filling material from the root canal system whether manual as endodontic hand files (K-files or H-files), Micro-debriders or micro-openers, gutta-percha solvents, rotary instruments as (Gates-glidden drills- Ni-Ti rotary instruments), ultra-sonics and laser with adjunctive use of solvent or not with considering minimal debris extrusion. Removal of root canal filling by hand files is time consuming especially in well compacted canals. Now the use of rotary instruments is more effective, faster and easier; Furthermore, to this date, there is no manual or rotary files can completely remove the root canal filling material [4]. The residual dentin thickness change (RDTC) is significant. Retreatment may result in further changes to the root canal wall since it necessitates more mechanical adjustments and root canal preparations [5]. While there have been a number of approaches used in the past to evaluate RDTC after retreatment, cone-beam computed tomography (CBCT) is a non-destructive technology that has recently gained popularity and offers extremely precise, high-resolution, and completely quantitative three-dimensional images [6]. The present study aimed to evaluate the changes produced by

Pro-taper Next file and Reciproc file according to the amount of dentine removed after retreatment samples obturated with two different obturation techniques [7].

2.Materials and Methods

2.1. Ethical committee approval

This study was approved as an in-vitro study by the institutional ethical committee, faculty of dentistry, Misr International University (registration no. MIU-IRB-2122-154).

2.2. Samples selection

Fifty-six human-extracted mandibular first permanent premolars were selected for the present study. The teeth were selected to be of average length (22 mm, ±1 mm). Each tooth was examined under dental microscope 8X magnification to exclude teeth with root caries, cracks and vertical root fracture. The teeth were assessed radiographically in a bucco-lingually and mesio-distally aspects to exclude the presence of calcifications, pulp stones, and internal or external root resorption and to confirm the existence of a mature single straight canal.

2.2.1. Inclusion Criteria

Single rooted mandibular premolars with mature single canal each.

2.2.2. Exclusion Criteria

- Teeth with Multiple roots and canals.
- Teeth with root fracture, root caries or cracks.
- Teeth with resorption (internal or external).
- Teeth with open apex.
- Teeth with calcified canals.

2.3. Samples Preparation

The access cavity in each tooth was prepared using a contra-angle, high-speed handpiece, round bur No. 3, and tapered stone with a rounded end with a continuous water coolant. The round bur was used to gain access to and remove the pulp chamber's roof. Using DG16 Explorer, the canal orifices were detected. The tapered stone was then used for flaring and smoothing the axial walls in order to assure a direct access and convenience.

2.4. Samples embedding

Two standardized custom-made wax housing blocks were made (10cm x 12 cm) such that 28 samples were embedded in each block. Each tooth was embedded into the wax block so that its long axis was parallel to long axis of the wax container with the labial surface of all samples facing the same direction designated by a piece of gutta-percha embedded at the mesio-labial side to achieve standardization of the specimens for the CBCT images before obturation and after root canal retreatment (Figure 1).

2.5. Root canal instrumentation and irrigation

In each tooth glide path was established, and working length was determined by measuring length of K-File #15 flushing with apex and subtracting 1 mm from this length. Cleaning and shaping were done using (Pro-taper Universal Rotary files). Each canal was prepared till F4-File (#40, 0.06 taper) according to manufacturer instructions. 3ml of 2.5 % Sodium hypochlorite (NaOCl) were used between file sizes using a 30 gauge plastic needle 1mm short of the working length such that not bind into the canal. Final irrigation protocol was carried out using 5ml NaOCl then distilled water followed by 5ml EDTA 17 % for 1 minute to eliminate smear layer, this was followed by final irrigation with distilled water. Each canal was dried using paper points. CBCT was taken for each tooth before obturation of the canal to measure mesial and distal dentin thicknesses.

2.6. Samples obturation

Samples were classified randomly into two groups (n=28) according to obturation technique used;

2.6.1. Group I: Single cone technique

The bio-ceramic sealer (Ceraseal) was injected inside the canal using a plastic intra-canal tip for injection. Corresponding to the master apical file, master cone length in each canal was verified visually and radiographically and tug-back action was checked. Obturation in the canals was done using Pro-taper gutta-percha master cone size #40 (F4) with taper 0.06, this aided in an even distribution of the sealant throughout the canal. A hot condenser was used to remove the excess gutta percha up to the canal orifice.

2.6.2. Group II: Lateral compaction technique

The master gutta-percha cone size #40/taper 0.02 was inserted inside the canal to the working length. A spreader size #30 was fitted deeply into the canal 1-2 mm short of the working length to insert auxiliary gutta-percha cones size #25/taper 0.02. After complete compaction auxiliary cones, a hot condenser was used to remove the excess gutta percha up to the canal orifice. Following obturation, all-access cavities in all samples were sealed using temporary filling. The teeth were then scanned in 3D image using the CBCT, to assess the quality of the obturation and the apical extent of the root canal fillings. The quality of obturation was estimated satisfactory when no voids could be found on the postoperative CBCT radiograph. The samples were stored at 37°C and 100% humidity environment for one week to ensure complete setting of the sealer at incubator.

2.7. Samples Classification

Samples in the present study were classified randomly into two groups (n=28) as previously mentioned, according to obturation technique used.

•Group I: (n= 28) Root canal obturated by Single cone technique.

•Group II: (n= 28) Root canal obturated by Lateral compaction technique.

Then each group was further subdivided into two subgroups (n=14) according to kinematics of the file system used in filling material removal.

•Subgroup A: Bio-ceramic filling material was removed by using continuous rotation motion (Pro-taper Next file system).

•Subgroup B: Bio-ceramic filling material was removed by using reciprocation motion (Reciproc file system).

2.8 Retreatment procedures:

In subgroups IA and IIA (n=14), Continuous rotation motion was employed by using Pro-taper next X4 file system. Files of size and taper (#40/.06) were selected. Each file was inserted up to the working length in a gentle inward continuous rotation motion at speed 300 rpm without pressure, with short 1-2 mm amplitude strokes, at torque 2 Ncm according to the manufacturer's recommendations. A gentle apical pressure was carried out with a lateral brushing movement along the canal walls. After every three pecks of the Pro-taper next X4 file, adherent debris were cleaned from the flutes of the file using sterile gauze. Irrigation of the canal was carried out using 2 ml of 2.5% NaOCL in a side-vented 30-gauge needle. When the Pro-taper next X4 file reached the full working length and debris of filling material were no more seen on flutes nor the file in the received irrigant solution, the retreatment procedure was considered completed. Each file was discarded after use in three canals. In order to prevent file separation, any file showing signs of distortion was replaced with a new one. In subgroups IB and IIB (n=14), Reciprocation motion was employed by using Reciproc (R40) file system. Files of Size and taper (#40/.06) were selected. Retreatment was done in the same manner as the previous subgroups. Mesial and Distal dentine thicknesses were measured using CBCT before obturation and after filling material removal. Measurements of dentinal thickness were evaluated from the axial view. Dentin thickness was measured from mesial and distal sides of the canal space. Measurements were taken at three standard points; 3, 6, 9 mm from the apex. For each sample in each subgroup an average was calculated for both mesial and distal dentin thicknesses to evaluate the percent of change before obturation and after re-treatment. Fusion of the primary image (before obturation) to the secondary image (after filling material removal) was then carried out by first using manual registration through different points along the root of the samples. Superimposition was completed automatically using software allowing the best possible accuracy. Each image (primary and secondary) was given a color code for identification. First measurements were recorded on the primary image. Then the measurement on the primary image was left and the primary image itself was cancelled leaving the secondary image. A new measurement was recorded on the secondary image on the same plane direction and cut of the primary image ensuring standardization (Figure 2,3,4,5,6,7).

3. Results

3.1. Percentage change in dentin thickness

3.1.1. Comparison between obturation techniques

With rotation motion at the coronal root level, single cone technique showed statistically significantly lower percentage change in dentin thickness than lateral compaction technique (P-value = 0.027, Effect size = 0.917). At the middle and apical root levels, there was no statistically significant difference between the two obturation techniques (P-value = 0.270, Effect size = 0.426) and (P-value = 0.073, Effect size = 0.72), respectively. As regards the overall percentage change in dentin thickness, single cone technique showed statistically significantly lower percentage change in dentin thickness than lateral compaction technique (P-value = 0.035, Effect size = 0.871). With reciprocation at the coronal and middle root levels, there was no statistically significant difference between the two obturation techniques (P-value = 0.129, Effect size = 0.598) and (P-value = 0.395, Effect size = 0.326), respectively. At the apical root level, single cone technique showed statistically significantly lower percentage change in dentin thickness than lateral compaction technique (P-value = 0.043, Effect size = 0.827). As regards the overall percentage change in dentin thickness, single cone technique showed statistically significantly lower percentage change in dentin thickness than lateral compaction technique (P-value = 0.015, Effect size = 1.037).

3.1.2. Comparison between motions

With single cone obturation technique at the coronal, middle as well as apical root levels, there was no statistically significant difference between the two motions (*P*-value = 0.520, Effect size = 0.245), (*P*-value = 0.383, Effect size = 0.335) and (*P*-value = 0.520, Effect size = 0.245), respectively. As regards the overall percentage change in dentin thickness, there was also no statistically significant difference between the two motions (*P*-value = 0.491, Effect size = 0.263). With lateral compaction technique at the coronal, middle as well as apical root levels, there was no statistically significant difference between the two motions (*P*-value = 0.098, Effect size = 0.658), (*P*-value = 0.581, Effect size = 0.21) and (*P*-value = 0.066, Effect size = 0.741), respectively. As regards the overall percentage change in dentin thickness, there was also no statistically significant difference between the two motions (*P*-value = 0.089, Effect size = 0.679).

3.1.3. Comparison between root levels within each group

As regards single cone whether with rotation or reciprocation, there was no statistically significant difference between percentage changes in dentin thickness at different root levels (*P*-value = 0.931, Effect size = 0.005) and (*P*-value = 0.751, Effect size = 0.02), respectively. Similarly for lateral compaction with rotation or reciprocation, there was no statistically significant difference between percentage changes in dentin thickness at different root levels (*P*-value = 0.071, Effect size = 0.189) and (*P*-value = 0.051, Effect size = 0.508), respectively (Table 1).

4. Discussion

The primary objective of an orthograde retreatment is to regain access to the apical foramen by completely removing the root canal filling material to enable thorough cleaning of the root canal system, shaping, and ultimate obturation [8]. Bio-ceramic material is considered one of the most appreciated sealing materials in dentistry [9,10]. It is characterized by dimensional stability and slight expansion upon setting. It is a hydrophilic material which is susceptible to moisture, and possesses anti-microbial properties when unset. It is both biocompatible and bioactive when fully set [11,12,13]. Upon interaction with tissue fluids, bio-ceramic materials release calcium hydroxide, which would combine with the phosphates in the fluids to produce hydroxyapatite, which would explain some of the materials tissue-inductive properties. Bio-ceramics are now the material of choice for root canal fillings in adult teeth with closed apices as well as for the obturation of juvenile teeth with open apices [14]. Therefore, this study was conducted to evaluate and compare the efficacy of continuous rotation versus reciprocation motion in the changes in the remaining mesial and distal dentine thicknesses before obturation and after removal of filling material. Mandibular premolars with mature single root canal each were selected for this study because they are often straight and flattened mesiodistally which would result in more difficultly for endodontic instruments to reach all parts of the root canal with this anatomy [15].

Consequently, it might become more challenging to totally remove the filling material within these canals [16]. In addition, to make the process of standardizing the specimens easier, it has been found that most of the experimental research assessing the effectiveness of retreatment techniques have been carried out using straight root canals [17,18,19]. In the current study, samples were randomly classified into two groups according to the obturation technique used. First group was obturated with single cone technique that has gained popularity in clinical practice as it is reported to be fast and easy [20]. It involves filling the whole canal with a single, tapered gutta-percha cone and a root canal sealant. The single cone obturation method has been reported to allow the preservation of tooth structure, exhibit higher dislodging resistance, and to minimize risk of voids and overfilling [21,22]. The second group was obturated with lateral compaction technique. This technique provides a hermetic seal inside the root canal by combining a sealer with the gutta-percha master cone in addition to some auxiliaries resulting in effective sealing, thermal stability, tapered preparation accommodation, and long-term success rate [23,24]. Rotary instruments were employed in this study in retrieving bio-ceramic sealer owing to their reported easiness and fastness [25,26,27]. Two kinematics were evaluated and compared; continuous rotation and reciprocation [28,29]. Pro-taper Next (X4) file was investigated in this study representing the continuous rotation motion. It is an M-Wire Ni-Ti alloy with an innovative off-centred rectangular cross section, that would give the file a snake-like (swaggering) movement as it moves inside the canal. It would result in optimisation of root canal tracking as only two points of the rectangular cross section touch the canal wall at a time. This reduces engagement and limits undesirable lock during retreatment process [31]. The off-centred cross-section and the unique design of file generate enlarged space for debris hauling [32]. In addition, also the variable helical angle and balanced pitching along the shaft would enhance efficiency in the longitudinal axis [33]. Reciproc (R40) file was also selected in this study to represent the reciprocation motion. It is an M-wire with s- shaped cross-section file, which has been reported to possess a high cyclic fatigue resistance reducing the risk of instrument fracture during retreatment procedure [34]. The Reciprocating file is designed to have alternating cutting edges which would allow it to efficiently remove gutta-percha and any residual material from the previous treatment [35,36]. Reciprocating movement was implemented as it was reported to increase the centralization of the preparation and to minimize canal transportation, hence leading to even contact and cutting of all canal walls and thus a more efficient cleaning ability [37]. In addition, it would result in the relief of torsional and flexural tensions that would occur during retreatment. hence avoiding errors as instrument separation [38,39]. Size #40 was selected for both systems of different kinematics to guarantee sufficient canal cleanliness and avoid significant enlargement [40]. In the current study, efficiency of instruments and the two kinematics in retreatment was measured by percent decrease in mesial and distal dentin thicknesses, time consumed and percent remaining debris. CBCT was used in this study in order to show samples in 3D planes (axial, coronal and sagittal planes) for measuring the dentin thickness [41,42]. The same methodology was used in this study which allowed standardizing samples positioning for acquisition of CBCT images before obturation and after retreatment and hence obtaining precise measurements of mesial and distal dentin thicknesses. This standardization method is known as Fusion. Barmante et al (1987) [43] performed this technique to identify changes detected by superimposing images from sample slices. Re-preparing the root canal is required in retreatment instances in order to create enough space for effective disinfection and to remove infected dentin. However, in order to lessen further root weakness and thus, the danger of vertical root fracture, extensive dentine removal should be avoided [44]. The present study revealed a statistically significantly lower percentage change of dentin thickness at the coronal level in the single cone technique than the lateral compaction technique in the continuous rotation motion. These findings were in agreement with Ozyurek et al., (2016) [45] who found that this could be due to the presence of less amount of compacted gutta-percha in the coronal level in the single cone technique which facilitated the retreatment procedure preventing any excess dentin removal. Moreover, Salloum et al., (2018) [46] and Kumar et al., (2022) [47] reported similar results to ours in the middle and apical levels in the continuous rotation motion, revealing no statistically significant difference. This could be due to the similarity of the oval cross-section in the middle and apical levels of the samples, therefore same dentin thickness in both thirds which gave no significant difference of dentin removal percent change whether with lateral compaction or single cone obturating techniques [48]. The current findings are in conflict with (Deka et al., 2015) [49] who stated that no significant difference between the three thirds in the percent change of dentin thickness along the whole length of the canal obturated whether with single cone or lateral compaction technique. He related his results to the files' design and motion used. With the reciprocation motion at the apical third, single cone obturation technique showed statistically significantly lower percentage change in dentin thickness than the lateral compaction technique. This might be due to the gap between the dentin and the single cone based bio-ceramic sealer that resulted from the micro-air bubbles in the apical third, which are produced as a reaction of sodium hypochlorite and organic gas [50] allowing easier removal of sealer and gutta-percha from the apical third with minimal removal of dentin, whilst this may have not been the case with the lateral compaction technique. Coronal and middle thirds with reciprocation motion showed no significant difference between two obturation techniques in coincidence with (McMichael et al., 2016) [51]. They explained the results that may be due to similar tubular penetration of bio-ceramic sealer in the dentinal tubules especially in the coronal and middle thirds as they contained the largest amount of injected bio-ceramic sealer (169) which confirmed the results of this study (Table 2).

Figure 1: Samples of the study

Figure 2: Samples exposure with CBCT machine

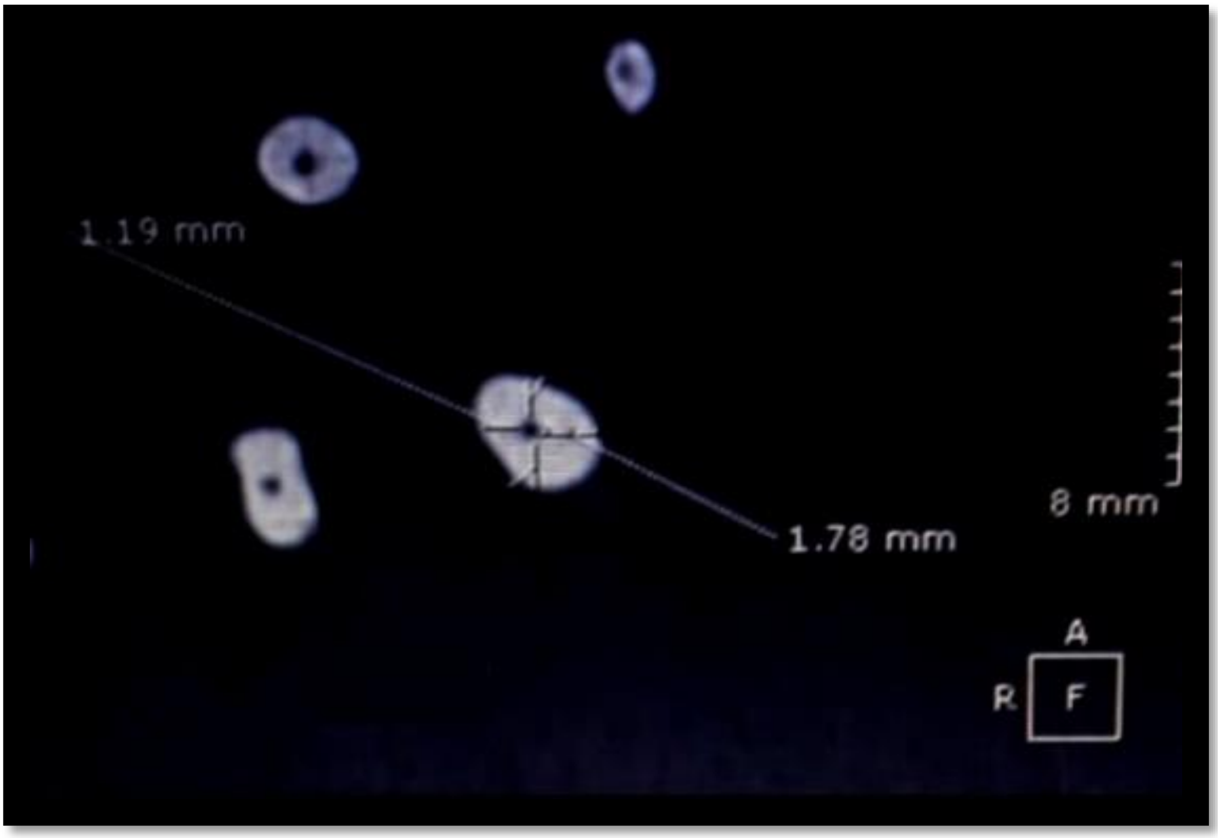

Figure 3: Remaining dentin thickness pre-obturation

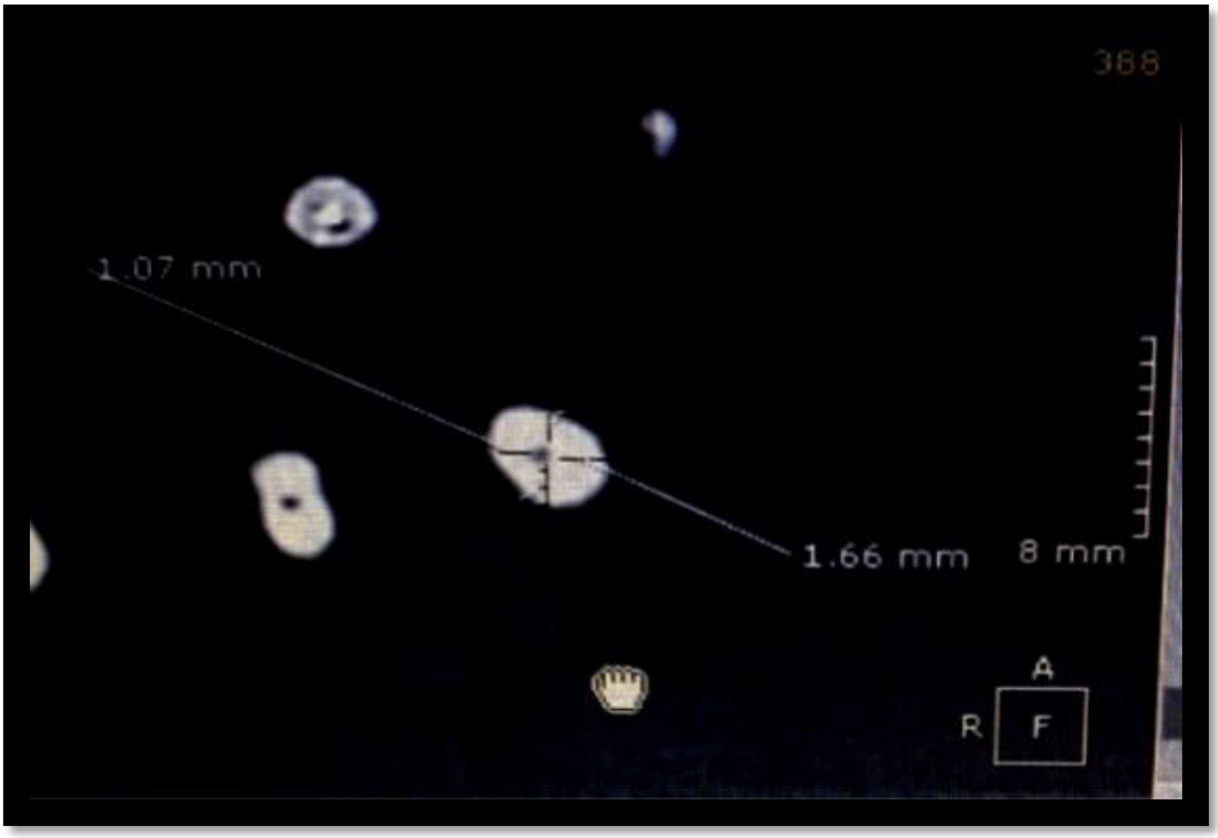

Figure 4: Remaining dentin thickness after retreatment with x4 file.

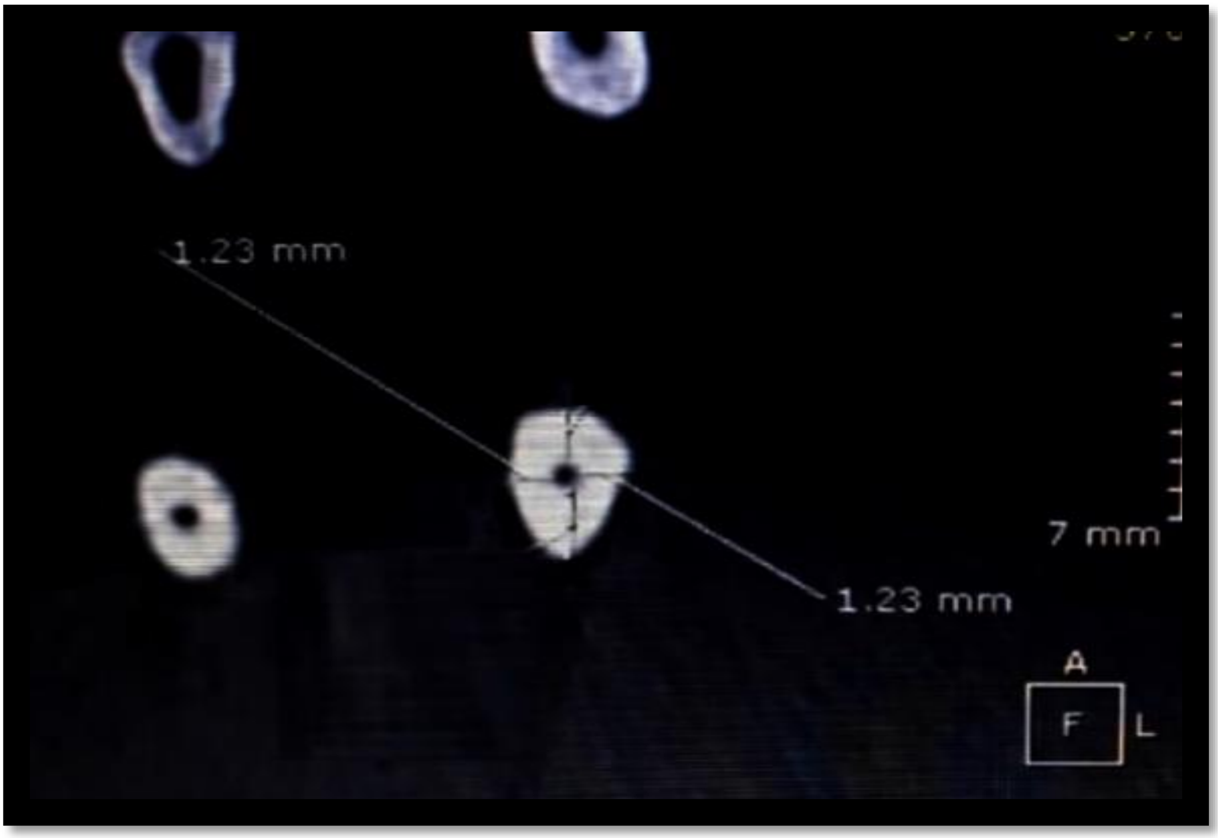

Figure 5: Remaining dentin thickness pre-obturation

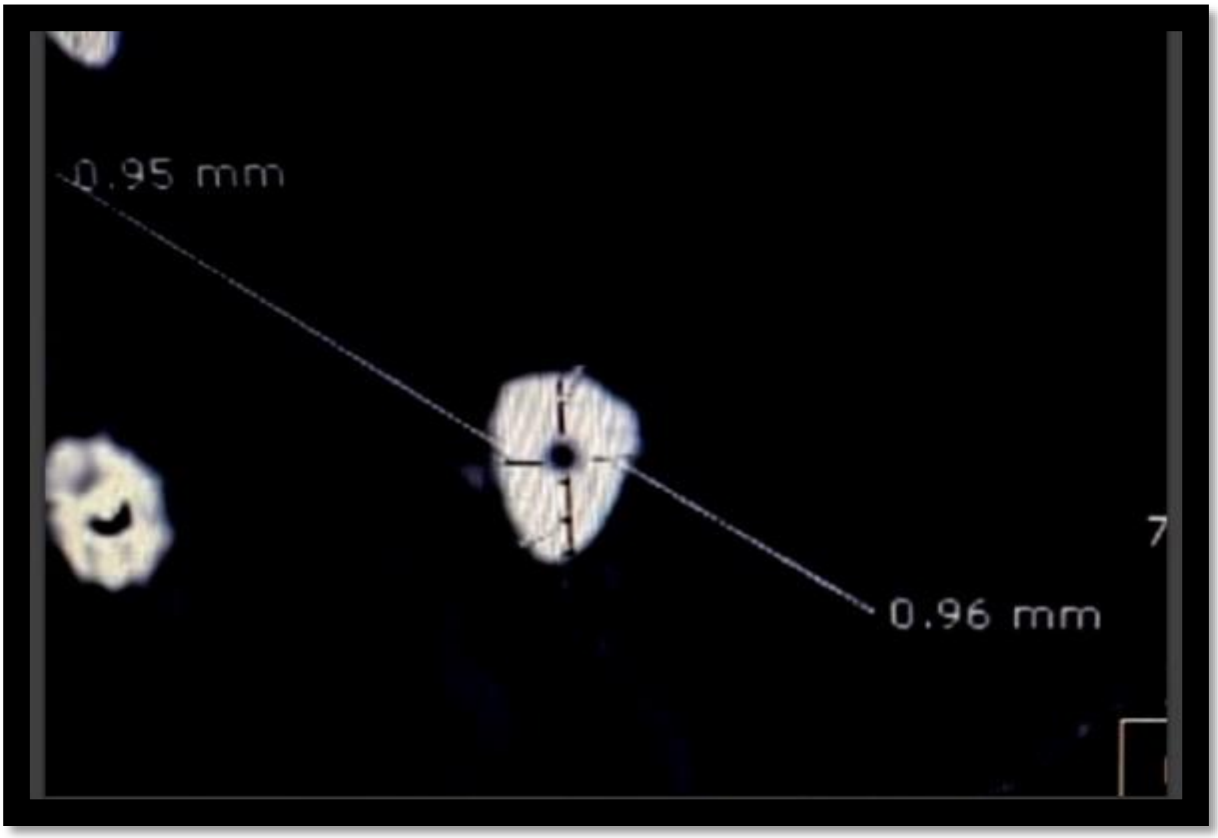

Figure 6: Remaining dentin thickness after retreatment with reciproc file.

Table 1: Descriptive statistics and results of Mann-Whitney U test for comparison between percentage change in dentin thickness after using the two obturation techniques

Motion	Root level	Single cone		Lateral compaction		*P*-value	*Effect size (d)*
		Median (Range)	Mean (SD)	Median (Range)	Mean (SD)		
Rotation	Coronal	16.3 (0-28.1)	15.2 (8.6)	27.6 (8.9-64.5)	30.3 (18.1)	0.027*	0.917
	Middle	13.5 (5.7-23)	13.4 (5.5)	17.3 (2.7-29.8)	16.6 (8.5)	0.270	0.426
	Apical	11.4 (1.4-44.9)	13.4 (12)	17.3 (2.3-38.7)	18.5 (8.6)	0.073	0.72
	Overall	13.3 (6.3-28.8)	14 (6.1)	21.1 (6.1-36.7)	21.8 (10)	0.035*	0.871
Reciprocation	Coronal	12.2 (3.3-43.9)	14.7 (10.8)	17.7 (9-25.4)	17.5 (5.4)	0.129	0.598
	Middle	10.7 (3.6-22.6)	11.5 (5.2)	13.8 (0-44.2)	15.8 (11.5)	0.395	0.326
	Apical	8.8 (0-24.6)	9.7 (6.8)	13.9 (6.4-20.3)	13.8 (4.7)	0.043*	0.827
	Overall	11.5 (7.6-18.9)	12 (3.3)	14.3 (7.5-26.2)	15.7 (5)	0.015*	1.037

**: Significant at $P \leq 0.05$*

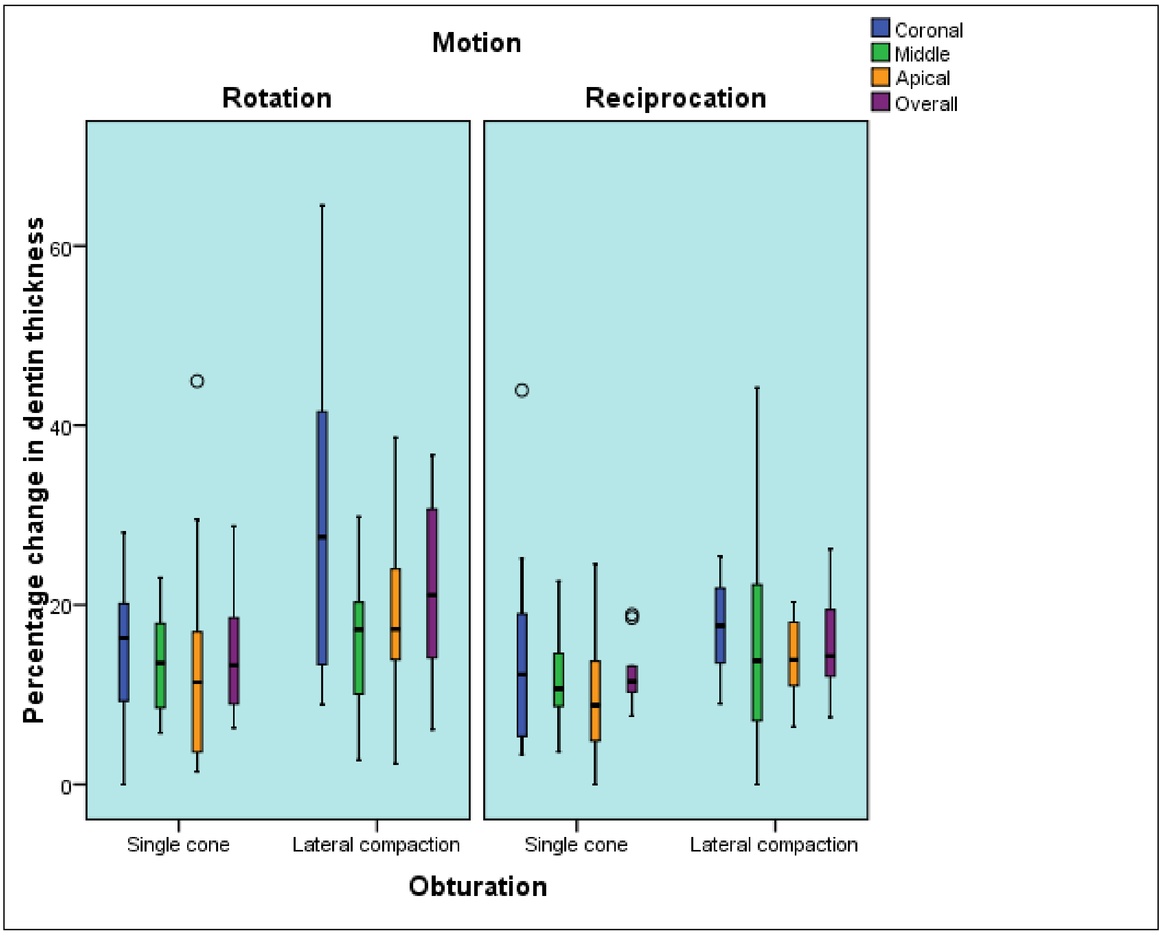

Figure 7: Box plot representing median and range values for percentage change in dentin thickness (Circles represent outliers)

Table 2: Descriptive statistics and results of Mann-Whitney U test for comparison between percentage change in dentin thickness after using the two motions

Obturation technique	Root level	Rotation		Reciprocation		*P*-value	*Effect size (d)*
		Median (Range)	Mean (SD)	Median (Range)	Mean (SD)		
Single cone	Coronal	16.3 (0-28.1)	15.2 (8.6)	12.2 (3.3-43.9)	14.7 (10.8)	0.520	0.245
	Middle	13.5 (5.7-23)	13.4 (5.5)	10.7 (3.6-22.6)	11.5 (5.2)	0.383	0.335
	Apical	11.4 (1.4-44.9)	13.4 (12)	8.8 (0-24.6)	9.7 (6.8)	0.520	0.245
	Overall	13.3 (6.3-28.8)	14 (6.1)	11.5 (7.6-18.9)	12 (3.3)	0.491	0.263
Lateral compaction	Coronal	27.6 (8.9-64.5)	30.3 (18.1)	17.7 (9-25.4)	17.5 (5.4)	0.098	0.658
	Middle	17.3 (2.7-29.8)	16.6 (8.5)	13.8 (0-44.2)	15.8 (11.5)	0.581	0.21
	Apical	17.3 (2.3-38.7)	18.5 (8.6)	13.9 (6.4-20.3)	13.8 (4.7)	0.066	0.741
	Overall	21.1 (6.1-36.7)	21.8 (10)	14.3 (7.5-26.2)	15.7 (5)	0.089	0.679

*: *Significant at P ≤ 0.05*

Table 3: Descriptive statistics and results of Friedman's test for comparison between percentage change in dentin thickness at different root levels within each group

Motion	Root level	Single cone		Lateral compaction	
		Median (Range)	Mean (SD)	Median (Range)	Mean (SD)
Rotation	Coronal	16.3 (0-28.1)	15.2 (8.6)	27.6 (8.9-64.5)	30.3 (18.1)
	Middle	13.5 (5.7-23)	13.4 (5.5)	17.3 (2.7-29.8)	16.6 (8.5)
	Apical	11.4 (1.4-44.9)	13.4 (12)	17.3 (2.3-38.7)	18.5 (8.6)
	P-value	0.931		0.071	
	Effect size (w)	0.005		0.189	
Reciprocation	Coronal	12.2 (3.3-43.9)	14.7 (10.8)	17.7 (9-25.4)	17.5 (5.4)
	Middle	10.7 (3.6-22.6)	11.5 (5.2)	13.8 (0-44.2)	15.8 (11.5)
	Apical	8.8 (0-24.6)	9.7 (6.8)	13.9 (6.4-20.3)	13.8 (4.7)
	P-value	0.751		0.051	
	Effect size (w)	0.02		0.508	

*: *Significant at P ≤ 0.05*

There was no significant difference in the percentage change of dentin thickness between different kinematics along all root levels whether obturation technique was single cone or lateral compaction. This depended mainly on the cross-section and the metallurgy of the files used [53]. Both files Pro-taper Next X4 and Reciproc R40 used in this study are made of M-wire which is flexible and has a high centring ability in the canal that aids in focusing on removal of filling material with minimal removal of dentin thickness [54]. Results in our study were in full agreement with Kansal et al., (2014) [55], where the revealed that the change in the mesial and distal dentin thicknesses depends mainly on the inherent design of the instrument and dynamics used during instrumentation. Reciproc file in our study preserved the tooth structural integrity and dentine thickness with enhanced bio-ceramic filling removal [56]. Pro-taper Next had the same effect on the mesial and distal dentin thickness due to it is swaggering action and offset design, and hence there is less chance of root canal blockage and more ability for cutting with less engagement of the files with the dentin [57]. In the present study Pro-taper Next file representing continuous rotation motion and Reciproc file representing reciprocation motion as the coronal, middle as well as apical levels showed no statistically significant difference in the percentage change in dentin thickness regardless the obturation technique used. This finding comes in agreement with Bonaccorso et al., (2009) [58]. Factors that contributed to this include the features of the instrument design, including the taper, flexibility, cross-section geometry, and tip design. Capar et al., 2014 [59] stated that Pro-taper Next file X4 with an asymmetric motion employed a bigger envelope of motion compared with a similarly sized file Reciproc R40 with centralized mass and rotation axis, although the difference between the kinematics he proved that both files had similar shaping ability. However, most of the statistical interpretation of dentin thickness of all sub-groups appeared to be insignificant. This showed that both Pro-taper Next file and Reciproc file are effective in of removal residual bio-ceramic filling material while conserving dentin thickness (Table 3).

5.Conclusion

Under the conditions of this study, it was concluded that Reciproc instruments showed no significant difference in the remaining dentin thickness when compared to continuous rotational instruments.

6. Source of funding

The study did not receive any financial support.

7. Conflict of interest

The authors deny any conflict of interest.

8. Authorship statement

we confirm that all listed authors meet the authorship criteria and that all authors agree with the manuscript’s content.

References

[1] M. Sartaj, A. Sangra, R. Farooq, A. Rashid, F. Ahmad. (2017). Comparative evaluation of dentinal changes following retreatment by rotary NiTi retreatment files: An ex vivo stereomicroscopic analysis. Indian Journal of Applied Dental Sciences. 3(1): 94-97.

[2] M.V.R. Só, C. Saran, M.L. Magro, F.V. Vier-Pelisser, M. Munhoz. (2008). Efficacy of ProTaper retreatment system in root canals filled with gutta-percha and two endodontic sealers. Journal of Endodontics. 34(10): 1223-1225.

[3] C. Pirani, G.A. Pelliccioni, S. Marchionni, L. Montebugnoli, G. Piana, C. Prati. (2009). Effectiveness of three different retreatment techniques in canals filled with compacted gutta-percha or Thermafil: a scanning electron microscope study. Journal of Endodontics. 35(10): 1433-1440.

[4] S. Kasam, A.B. Mariswamy. (2016). Efficacy of different methods for removing root canal filling material in a retreatment-an in-vitro study. Journal of Clinical and Diagnostic Research: JCDR. 10(6): 11-16.

[5] M. MdlNP, J. Sánchez, F. Elmsmari, F. Durán-Sindreu, P. Salmon, D. Jaramillo, J. Fernández. (2023). Micro-computed tomographic evaluation of 6 NiTi files on the paracervical dentin and the smallest dentin thickness zones in mesial root canals of mandibular molars: An in vitro study. Journal of Clinical and Diagnostic Research: JCDR. 8(4): 13-17.

[6] N.R. Kulkarni, S.B. Kamat, S.I. Hugar, G.S. Nanjannawar, P.D. Patil. (2019). Evaluation of remaining dentin thickness following use of three different rotary nickel–titanium retreatment files: A cone-beam computed tomography study. Journal of Conservative Dentistry. 22(6): 588-592.

[7] M. Tabrizizadeh, J. Reuben, M. Khalesi, M. Mousavinasab, M.G. Ezabadi. (2010). Evaluation of radicular dentin thickness of danger zone in mandibular first molars. Journal of Dentistry (Tehran, Iran). 7(4): 196.

[8] S. Friedman, A. Stabholz, A. Tamse. (1990). Endodontic retreatment—case selection and technique. Part 3. Retreatment techniques. Journal of Endodontics. 16(11): 543-549.

[9] M.G. Gandolfi, F. Iacono, K. Agee, F. Siboni, F. Tay, D.H. Pashley, C. Prati. (2009). Setting time and expansion in different soaking media of experimental accelerated calcium-silicate cements and ProRoot MTA. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 108(6): 39-45.

[10] S.R. Jefferies. (2014). Bioactive and biomimetic restorative materials: a comprehensive review. Part I. Journal of Esthetic and Restorative Dentistry. 26(1): 14-26.

[11] H. Zhang, Y. Shen, N.D. Ruse, M. Haapasalo. (2009). Antibacterial activity of endodontic sealers by modified direct contact test against Enterococcus faecalis. Journal of Endodontics. 35(7): 1051-1055.

[12] Trope M, Bunes A, Debelian G. Root filling materials and techniques: bioceramics a new hope? Endodontic Topics. 2015 May;32(1):86–96.

[13] D. Donnermeyer, S. Bürklein, T. Dammaschke, E. Schäfer. (2019). Endodontic sealers based on calcium silicates: a systematic review. Odontology. 107(4): 421-436.

[14] A. Al-Haddad, Z.A. Che Ab Aziz. (2016). Bioceramic-based root canal sealers: a review. International Journal Of Biomaterials. 2016 4(1) 435-466.

[15] A. Masiero, F. Barletta. (2005). Effectiveness of different techniques for removing gutta-percha during retreatment. International Endodontic Journal. 38(1): 2-7.

[16] A.P.M. Colombo, C.E. Fontana, A. Godoy, A.S. De Martin, A.S. Kato, D.G. Rocha, R.A. Pelegrine, C.E. Bueno. (2016). Efectiveness of the waveone and ProTaper D systems for removing gutta-percha with or without a solvent. Acta Odontológica Latinoamericana. 29(3): 262-267.

[17] T. Roedig, T. Hausdörfer, F. Konietschke, C. Dullin, W. Hahn, M. Huelsmann. (2012). Efficacy of D-RaCe and ProTaper Universal Retreatment NiTi instruments and hand files in removing gutta-percha from curved root canals–a micro-computed tomography study. International Endodontic Journal. 45(6): 580-589.

[18] M. de Azevêdo Rios, A.M. Villela, R.S. Cunha, R.C. Velasco, A.S. De Martin, A.S. Kato, C.E. da Silveira Bueno. (2014). Efficacy of 2 reciprocating systems compared with a rotary retreatment system

for gutta-percha removal. Journal of endodontics. 40(4): 543-546.

[19] N.S. Shojaee, E. Vakilinezhad, M.M. Shokouhi. (2019). In vitro comparison of efficacy of Neolix and ProTaper universal retreatment rotary systems in removal of gutta-percha combined with two different sealers. Journal of Dentistry. 20(4): 285-292

[20] P. Hörsted-Bindslev, M.A. Andersen, M.F. Jensen, J.H. Nilsson, A. Wenzel. (2007). Quality of molar root canal fillings performed with the lateral compaction and the single-cone technique. Journal of Endodontics. 33(4): 468-471.

[21] J. Camilleri. (2015). Sealers and warm gutta-percha obturation techniques. Journal of Endodontics. 41(1): 72-78.

[22] A. Nouroloyouni, V. Samadi, A. Salem Milani, S. Noorolouny, H. Valizadeh-Haghi. (2023). Single Cone Obturation versus Cold Lateral Compaction Techniques with Bioceramic and Resin Sealers: Quality of Obturation and Push-Out Bond Strength. International journal of dentistry. 2023 3(4) 233-244.

[23] R. Gupta, A. Dhingra, N.R. Panwar. (2015). Comparative evaluation of three different obturating techniques lateral compaction, Thermafil and Calamus for filling area and voids using cone beam computed tomography: An invitro study. Journal of Clinical and Diagnostic Research: JCDR. 9(8): ZC15.

[24] M. Aminsobhani, A. Ghorbanzadeh, M.R. Sharifian, S. Namjou, M.J. Kharazifard. (2015). Comparison of obturation quality in modified continuous wave compaction, continuous wave compaction, lateral compaction and warm vertical compaction techniques. Journal of Dentistry (Tehran, Iran). 12(2): 99.

[25] M. Garrib, J. Camilleri. (2020). Retreatment efficacy of hydraulic calcium silicate sealers used in single cone obturation. Journal of Dentistry. 98: 10-34.

[26] D.G. Mufti, S.A. Al-Nazhan. (2021). Retreatability of bioceramic sealer using one curve rotary file assessed by microcomputed tomography. The Journal of Contemporary Dental Practice. 22(10): 1176.

[27] V. Chopra, G. Davis, A. Baysan. (2022). Clinical and radiographic outcome of non-surgical endodontic treatment using calcium silicate-based versus resin-based sealers—A systematic review and meta-analysis of clinical studies. Journal of Functional Biomaterials. 13(2): 38-47.

[28] M. Rajda, I. Miletić, G. Baršić, S.J. Krmek, D. Šnjarić, A. Baraba. (2021). Efficacy of reciprocating instruments in the removal of bioceramic and epoxy resin-based sealers: Micro-CT analysis. Materials. 14(21): 6670-6688.

[29] H.C. Baranwal, N. Mittal, R. Garg, J. Yadav, P. Rani. (2021). Comparative evaluation of retreatability of bioceramic sealer (BioRoot RCS) and epoxy resin (AH Plus) sealer with two different retreatment files: An: in vitro: study. Journal of Conservative Dentistry and Endodontics. 24(1): 88-93.

[30] T. Özyürek, E.Ö. Demiryürek. (2017). Efficacy of pro taper next and proper universal retreatment systems in removing gutta-percha in curved root canals during root canal retreatment. Journal of Istanbul University Faculty of Dentistry. 51(2): 7-13.

[31] M.C. Matta, R.P.C. de Araújo, E.L.A. Dantas, F.L.C. D'Assunção, F.B. de Sousa. (2021). Comparative Analysis of Continuous versus Reciprocating Instruments in Retreatment of Flat-oval Root Canals. Iranian Endodontic Journal. 16(4): 217-231.

[32] M.P. Martins, M.A.H. Duarte, B.C. Cavenago, A.S. Kato, C.E. da Silveira Bueno. (2017). Effectiveness of the ProTaper Next and Reciproc systems in removing root canal filling material with sonic or ultrasonic irrigation: a micro–computed tomographic study. Journal of Endodontics. 43(3): 467-471.

[33] R.A.d. Rosa, M.F. Santini, B.C. Cavenago, J.R. Pereira, M.A.H. Duarte, M.V.R. Só. (2015). Micro-CT evaluation of root filling removal after three stages of retreatment procedure. Brazilian Dental Journal. 26(3): 612-618.

[34] S. Bürklein, K. Hinschitza, T. Dammaschke, E. Schäfer. (2012). Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals of extracted teeth: Reciproc and WaveOne versus Mtwo and ProTaper. International Endodontic Journal. 45(5): 449-461.

[35] K. Romeiro, A. de Almeida, M. Cassimiro, L. Gominho, E. Dantas, N. Chagas, C. Velozo, L. Freire, D. Albuquerque. (2020). Reciproc and Reciproc Blue in the removal of bioceramic and resin-based sealers in retreatment procedures. Clinical Oral Investigations. 24: 405-416.

[36] A.A. Madarati, A.A. Al-Nazzawi, A.M. Sammani, M.A. Alkayyal. (2018). The efficacy of retreatment and new reciprocating systems in removing a gutta-percha-based filling material. Journal of Taibah University Medical Sciences. 13(5): 452-458.

[37] S. Elsaka, A. Elnaghy, A. Badr. (2017). Torsional and bending resistance of WaveOne Gold, Reciproc and twisted file adaptive instruments. International Endodontic Journal. 50(11): 1077-1083.

[38] G. De-Deus, E.J.N.L. Silva, V.T.L. Vieira, F.G. Belladonna, C.N. Elias, G. Plotino, N.M. Grande. (2017). Blue thermomechanical treatment optimizes fatigue resistance and flexibility of the Reciproc files. Journal of Endodontics. 43(3): 462-466.

[39] B. Tantiwanichpun, S. Kulvitit. (2023). 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(1): 871.

[40] D. Delai, D. Boijink, C.B. Hoppe, P.M.P. Kopper. (2018). Apically extruded debris in filling removal

of curved canals using 3 NiTi systems and hand files. Brazilian Dental Journal. 2(9): 54-59.
[41] N.R. Chaudhary, D.J. Singh, R. Somani, S. Jaidka. (2018). Comparative Evaluation of Efficiency of Different File Systems in Terms of Remaining Dentin Thickness Using Cone-Beam Computed Tomography: An: In vitro: Study. Contemporary clinical dentistry. 9(3): 367-371.
[42] A. Nouroloyouni, A. Salem Milani, A. Etminan, S. Noorolouny, E. Tavakkol, H. Mikaieli Xiavi, N. Ghoreishi Amin. (2023). Cone-beam computed tomography assessment of the quality of endodontic treatment and prevalence of procedural errors in mandibular molars. International Journal of Clinical Practice. 2023 4(2) 23-33.
[43] C.M. Bramante, A. Berbert, R.P. Borges. (1987). A methodology for evaluation of root canal instrumentation. Journal of Endodontics and Restorative Dentistry. 243-5.
[44] M. Hülsmann, S. Drebenstedt, C. Holscher. (2008). Shaping and filling root canals during root canal re-treatment. Endodontic Topics. 19(1): 74-124.
[45] T. Özyürek, K. Yılmaz, G. Uslu. (2017). Shaping ability of Reciproc, WaveOne GOLD, and HyFlex EDM single-file systems in simulated S-shaped canals. Journal of Endodontics. 43(5): 805-809.
[46] S. Salloum, C. Torbey, S. Bassam, C. Dib. (2018). Reciprocal and continuous rotation are two sides of the same coin. Journal of Dental Health, Oral Disorders & Therapy. 9(3): 210-3.
[47] M. Kumari, S. Taneja, S. Bansal. (2017). Comparison of apical sealing ability of lateral compaction and single cone gutta percha techniques using different sealers: An in vitro study. Journal of Pierre Fauchard Academy (India Section). 31(2-4): 67-72.
[48] P.F. de Souza, L.C.O. Goncalves, A.A.F. Marques, E.C.S. Junior, L.d.F.R. Garcia, F.M.A. de Carvalho. (2015). Root canal retreatment using reciprocating and continuous rotary nickel-titanium instruments. European Journal of Dentistry. 9(02): 234-239.
[49] A. Deka, A. Bhuyan, D. Bhuyan. (2015). A comparative evaluation of root canal area increase using three different nickel-titanium rotary systems: An: ex vivo: cone-beam computed tomographic analysis. Contemporary Clinical Dentistry. 6(1): 79-83.
[50] H. Abada, A. Farag, H. Alhadainy, A. Darrag. (2015). Push-out bond strength of different root canal obturation systems to root canal dentin. Tanta Dental Journal. 12(3): 185-191.
[51] G.E. McMichael, C.M. Primus, L.A. Opperman. (2016). Dentinal tubule penetration of tricalcium silicate sealers. Journal of Endodontics. 42(4): 632-636.
[52] C. DeLong, J. He, K.F. Woodmansey. (2015). The effect of the obturation technique on the push-out bond strength of calcium silicate sealers. Journal of Endodontics. 41(3): 385-388.
[53] P. Jaggi, S. Mulay, A. Tandale, R. Jadhao, P. Joshi, S. Aras, K. Krishnakumar, V. Krishna. (2023). Comparative Evaluation of Debris Extrusion, Remaining Dentin Thickness and Fracture Resistance of Endodontically Treated Teeth Using Rotary and Reciprocating Endodontic File Systems: An In Vitro Study. Cureus. 15(7) 34-56.
[54] G. Nevares, D.S. de Albuquerque, L.G. Freire, K. Romeiro, H.M. Fogel, M. Dos Santos, R.S. Cunha. (2016). Efficacy of ProTaper NEXT compared with Reciproc in removing obturation material from severely curved root canals: a micro-computed tomography study. Journal of Endodontics. 42(5): 803-808.
[55] R. Kansal, A. Rajput, S. Talwar, R. Roongta, M. Verma. (2014). Assessment of dentinal damage during canal preparation using reciprocating and rotary files. Journal of Endodontics. 40(9): 1443-1446.
[56] E. Khoshbin, Z. Donyavi, E.A. Atibeh, G. Roshanaei, F. Amani. (2018). The effect of canal preparation with four different rotary systems on the formation of dentinal cracks: An in vitro evaluation. Iranian Endodontic Journal. 13(2): 163.
[57] S. Saber, M. Nagy, E. Schäfer. (2015). Comparative evaluation of the shaping ability of ProTaper Next, iRaC e and Hyflex CM rotary NiTi files in severely curved root canals. International Endodontic Journal. 48(2): 131-136.
[58] A. Bonaccorso, G. Cantatore, G.G. Condorelli, E. Schäfer, T.R. Tripi. (2009). Shaping ability of four nickel-titanium rotary instruments in simulated S-shaped canals. Journal of Endodontics. 35(6): 883-886.
[59] I.D. Capar, H. Ertas, E. Ok, H. Arslan, E.T. Ertas. (2014). Comparative study of different novel nickel-titanium rotary systems for root canal preparation in severely curved root canals. Journal of Endodontics. 40(6): 852-856.