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COMPARATIVE EVALUATION OF IMPACT OF ONE RECI AND WAVE ONE GOLD RECIPROCATING NITI FILES ON REMAINING DENTIN THICKNESS AND VOLUME: A CONE BEAM COMPUTED TOMOGRAPHY STUDY (IN-VITRO STUDY)

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ABSTRACT

Objective: This study was designed to assess influence of instumentation with One RECI(*Micro Mega, Besancon, France*) on dentin volume and remaining dentin thickness relative to Wave One Gold(Dentsply Maillefer, Ballaigues, Switzerland) utilizing Cone-beam computed tomography.

Materials and methods: 16 human permanent mandibular first molar with two independent mesial canals were chosen randomly and splited into two equal groups 8 each based on root canal preparation system; Wave One group and One RECI group.All the specimens underwent imaging utilizing cone-beam computed tomography (CBCT) to detect dentin thickness and volume before instrumentation. After instrumentation the mesio-buccal canals were scanned using CBCT for evaluation of dentin volume and remaining dentin thickness after instrumentation.

Results: Regarding remaining dentin thickness, For 2 and 3 mm from the furcation level, the change in remaining thickness measured in Wave One Gold group was significantly higher than in One RECI. Regarding dentin volume, The change in volume post-instrumentation measured in Wave One Gold group was significantly greater than that of One RECI group

Conclusion: Within the study's constraints ; One RECI preserve more dentin than Wave One Gold.

KEYWORDS: Wave One Gold , One RECI, remaining dentin thickness , dentin volume , Cone-beam computed tomography.

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INTRODUCTION

Root canal treatment aims to eliminate intra-radicular pathogens, creating a conducive environment for periapical healing through appropriate shaping, cleaning, and adequate root canal filling. (1)

Minimal invasive endodontics is a new philosophy that prioritizes preserving tooth structure during root canal treatment to ensure long-term tooth survival. (2)

Pericervical dentin (PCD), defined as the dentin located 4 mm above and below the crestal bone, plays a crucial role in transmitting occlusal forces to the root and ferrule, particularly in molars(3,4). This region is irreplaceable, even when the coronal portion is restored or the apex is compromised. Preservation of PCD enhances fracture resistance, reduces catastrophic failures, and improves the longevity of restored teeth. Conversely, dentin loss leads to higher stress concentrations and significantly compromises fracture strength. During root canal therapy, removal of dentin affects the biomechanical response of the tooth and increases susceptibility to vertical root fractures. As PCD is essential for distributing occlusal forces along the long axis of the tooth,conserving. This structure should be a primary goal of endodontic treatment.(5)

In 2008, The single file concept for preparation of the root canal was introduced reducing the number of instruments required and reducing working time. (6)

Wave One Gold (Dentsply Sirona, Ballaigues, Switzerland) rotary file system based on the revolutionary Wave One concept of a single file, reciprocating shaping approach that uses asymmetrical clockwise and counterclockwise angles for better safety and reducing time over employing numerous rotary files to obtain the same final shape (7).

One RECI (Micro-Mega, Besançon, France) is a single reciprocating instrument for shaping of the root canal is made of nickel titanium. It features C.Wire heat treatment and variable cutting cross-section design, resulting in a great balance of flexibility and cutting efficiency. Based on the manufacturer, the reciprocating action of the One RECI provides safety, resistance to cycle fatigue, and comfort of use. Its 1mm wire diameter maintains the integrity of the peri-cervical region of the canal and the adjacent tooth structure.(8)

The impact of the One RECI system on remaining dentin thickness and canal volume has not been previously investigated. Therefore, the present study was designed to compare the influence of root canal instrumentation using One RECI and Wave One Gold systems on the remaining dentin thickness and canal volume. The null hypothesis was that there would be no statistically significant difference between two instrumentation systems with respect to remaining dentin and the volume of the root canal following preparation.

MATERIALS AND METHODS

The Ethics Committee at the Faculty of Dentistry, Minia University, approved the proposal for this in-vitro study. (no. 98) and registered with recording code (REC code \783).

Sample size calculation

According to Vorster et al (2023) (9) 16 extracted mandibular first molars were included in the study, a sample size deemed sufficient to detect an effect size of 1.53 with a statistical power of 80% at a significance level of 5% ($p < 0.05$). The specimens were allocated into two test groups, each comprising 8 teeth. The sample size estimation was undertaken using R statistical software (version 4.4.2 for Windows), employing the following parameters: effect size = 1.53, $\alpha = 0.05$, $\beta = 0.2$, and statistical power = $1 - \beta = 0.8$.

Samples selection and preparation

Sixteen human permanent mandibular first molars, freshly extracted, with intact mature apices that were obtained following extraction for purposes not associated with this research this study were selected. Teeth were radiographed, and only mesial roots of teeth with curvature ranging between 15° – 20° were included in the study. After immersion in a sodium hypochlorite solution for 30 minutes to eliminate residual soft tissue, the samples were thoroughly rinsed and then maintained in saline solution at ambient temperature to preserve their hydration until further use.

For standardization working length in all samples, All samples had their mesiobuccal cusp tips reduced with a diamond stone (Mani Inc., Tochigi-kan, Japan) while coolant was applied.

Working length determination was achieved by advancing a size 10 K-file into the root canal until its tip emerged at the apical foramen; the final working length was calculated by subtracting 1 mm from this measurement.

Grouping of Samples

16 permenant molars were randomly distributed by a computer software (random. Org)into two groups in accordance with the type of instrument used as follows :

1- Group I: samples were prepared by using the Wave One Gold primary (25/07)

(Dentsply Maillefer, Ballaigues, Switzerland)

2- Group II: samples were prepared with using One RECI files 25/06 (*Micro Mega, Besancon, France*)

Pre-instrumentation Samples scanning

All specimens included in the study underwent cone-beam computed tomography (CBCT) scanning. CBCT scans were performed utilizing a Planmeca ProMax scanner**.** Prior to image acquisition, a scout view was taken to confirm proper alignment of each sample using the scanner's light beam guide. The imaging system is equipped with an amorphous silicon flat-panel detector incorporating a cesium iodide (CsI) scintillator, a focal spot size of 0.5 mm, and a 14-bit grayscale resolution. For the purposes of this study, the exposure parameters were set at 90 kV and 11 mA. The field of view (FOV) was 4 cm in diameter and 4 cm in height, with a voxel size of 0.75 mm.**,** and the scanning time was established at 26.9 seconds**.**

To standardize both preoperative and postoperative imaging, each sample was vertically embedded in a transparent chemically cured acrylic resin mold**,** ensuring that each specimen was positioned perpendicularly to the X-ray beam, with the buccal surface consistently oriented in the same direction**.** Wax was applied to the root apices to avoid acrylic resin intrusion, and a gutta-percha marker was positioned on the buccal surface of each mold to aid in standardized canal orientation during image evaluation.

After image acquisition, the scan files were exported in DICOM format, recorded onto a compact disc (CD), and then imported into a personal computer with a radiology-grade monitor (Barco Nio MDNC-3421 3MP 21, Houston, USA) for further analysis. Multiple specialized software programs were used to perform the image measurements.

Root canal preparation

The glide path for the mesiobuccal (MB) canal was determined utilizing a size #15 K-file. For standardization across all specimens, each file system employed in this study had a tip size of 0.25. A size #10 hand K-file was employed to preserve apical patency throughout the procedure. Root canal preparation of the mesiobuccal canals in both experimental groups was carried out to the established working length, adhering to the

manufacturers' guidelines and utilizing a torque-regulated endodontic motor to ensure controlled instrumentation.

Group I: Wave One Gold files(25/07) were utilized with controlled in-and-out pecking motion at a specified speed 350 RPM , Reciprocation angles 170° counter clockwise, 50° clockwise and torque of 2Ncm.

Group II: One RECI files were used (size 25/06) operated by Wismy endodontic motor using pre-set mode with speed 400 RPM and torque of 3Ncm, with a gentle pecking motion with Reciprocation angles170 °counter clockwise, 60 ° clockwise.

Throughout root canal instrumentation, irrigation was conducted with 3 ml of 2.5% sodium hypochlorite (NaOCl) following the use of each file. After completing the mechanical preparation, a sequential irrigation protocol was employed, consisting of 5ml 17% ethylenediaminetetraacetic acid (EDTA), followed by 5 ml of distilled water, and finalized with a 5 ml rinse of 2.5% NaOCl. A 27-gauge side-vented needle affixed to a plastic syringe was used for the application of irrigants within the root canal system, introduced 1–2 mm short of the working length to ensure effective canal debridement while minimizing the potential for apical extrusion.

The canals were then thoroughly dried with sterile absorbent paper points. Post-instrumentation cone-beam computed tomography (CBCT) scans were subsequently performed for all specimens, employing the same acquisition parameters as those used in the preoperative scans to enable accurate comparative evaluation.

Image analysis

Image analysis was performed by another operator who was blinded to samples

For dentin thickness, Invivo software (Version 5.5, Anatomage, USA) was employed for image analysis.Prior to and following instrumentation CBCT scans were superimposed to ensure precise alignment, thereby facilitating accurate evaluation of dentin thickness at corresponding anatomical levels.

The remaining dentin thickness was measured at levels 4 mm apical to the cementoenamel junction (CEJ), corresponding anatomically to the furcation region. The measurements, expressed in millimeters, represented the shortest linear distance between the canal wall and the adjacent external surface of the root. Quantitative assessments were carried out at 1 mm intervals specifically at 1 mm, 2 mm, 3 mm, and 4 mm levels on both the mesial and distal surfaces of each root.[10]

Change in thickness was calculated as percentage[11] as follows

$$\frac{\text{Dentin thickness before instrumentation - dentin thickness after instrumentation}}{\text{Dentin thickness before instrumentation}} \times 100$$

The collected data were systematically compiled and tabulated for subsequent statistical analysis.

Dentin volume measurement:

Volumetric assessment was carried out using Mimics software (Version 21.0, Materialise, Leuven, Belgium). The mesiobuccal canal of each specimen was digitally segmented, allowing for precise volume calculations both prior to and following instrumentation. The amount of dentin removed was determined by computing the difference between the initial (pre-instrumentation) canal volume and the final (post-instrumentation) shaped canal volume. All volumetric data were recorded in cubic millimeters (mm^3).

The change in dentin volume was calculated as percentage [12] as follows :

$$\frac{\text{Dentin volume before instrumentation-Dentin volume after instrumentation}}{\text{Dentin volume before instrumentation}} \times 100$$

The collected data were systematically compiled and tabulated for subsequent statistical analysis.

Statistical analysis

Statistical analysis was conducted using R statistical software (Version 4.4.2 for Windows). Differences in canal volume were evaluated using an independent t-test. Changes in dentin thickness were analyzed through a two-way mixed-model ANOVA, followed by simple effects comparisons to assess interaction effects.

To mitigate the risk of Type I error arising from multiple statistical comparisons, p-values were adjusted using the False Discovery Rate (FDR) method. Statistical significance was considered at a threshold of $p < 0.05$ following correction.

RESULTS

Change in remaining dentin thickness

At 2 mm and 3 mm apical to the furcation, The results revealed a statistically significant difference betwwen the two groups, with the Wave One group demonstrating significantly greater changes in remaining dentin thickness relative to the One RECI group ($p < 0.001$ and $p = 0.007$, respectively). However, at 1 mm and 4 mm from the furcation, no statistically significant differences were noted between the groups in terms of dentin thickness changes following instrumentation ($p = 0.766$ and $p = 0.458$, respectively).

Change in dentin volume

Group I (Wave One Gold) showed significantly higher change in dentin volume than group II (One RECI) ($p<0.001$).

Comparisons and summary statistics of change in root canal volume (%) for different file types are presented in Table (2)

TABLE (1) Comparisons and summary statistics of change in dentine thickness (%) for different variables.

Distance from the furcation		Change in dentine thickness (%) (Mean±SD)		p-value	Effect size	
		Group (I)	Group (II)		PES (95% CI)	Magnitude
	1 mm	11.84±5.83^{B}	10.82±5.14^{A}	**0.766ns**	**0.02 (0.00 to 0.05)**	**Very small**
	2 mm	33.18±11.23^{A}	11.38±5.50^{A}	**<0.001***	**0.42 (0.26 to 0.54)**	**Large**
	3 mm	19.56±7.68^{B}	10.14±7.00^{A}	**0.007***	**0.12 (0.02 to 0.26)**	**Small**
	4 mm	11.63±5.31^{B}	9.09±4.03^{A}	**0.458ns**	**0.01 (0.00 to 0.09)**	**Very small**
	p-value	**<0.001***	**0.917ns**			
Effect size	**PES (95% CI)**	**0.56 (0.35 to 0.65)**	**0.01 (0.00 to 0.02)**			
	Magnitude	**Large**	**Very small**			

Values with different superscripts within the same vertical column are significantly different; * significant (p<0.05); ns: not significant; PES: Partial Eta Squared; CI: Confidence Interval.

TABLE (2) Comparisons and summary statistics of change in root canal volume (%) for different file types.

Change in root canal volume (%) (Mean±SD)		p-value	Effect size	
Group (I)	Group (II)		Cohen's d (95% CI)	Magnitude
79.57±11.11	47.13±11.34	**<0.001***	**2.89 (1.42 to 4.31)**	**Large**

: Significant (p<0.05); CI: Confidence Interval.

DISCUSSION

The current study aim was to asses impact of instrumentation with One RECI on dentin volume and remaining dentin thickness in comparison to Wave One Gold utilizing Cone-beam computed tomograph.

Mandibular first molars were chosen for this study due to their high incidence of endodontic treatment among posterior teeth and their frequent requirement for cuspal coverage.[13]

The teeth were embedded in acrylic resin blocks to secure consistent positioning prior to and following instrumentation scans. Additionally, the radiodensity of the acrylic resin was selected to avoid obscuring root canal details [14] . For canal orientation during scanning, a piece of gutta-percha was inserted into the resin.. [15]

A manual glide path was established prior to initiating root canal instrumentation, following the approach outlined by Saber and Berutti et al., who reported that establishing a glide path with #10 and #15 K-files substantially lowers the likelihood of instrumentation-related complications and contributes to the preservation of the canal's original morphology during root canal preparation.[16,17]

No coronal flaring was done to preserve peri-cervical dentin.[10]

In the current study, cone-beam computed tomography (CBCT) was utilized for radiographic evaluation, as it allows for reliable and replicable assessment of morphological alterations in the root canal system prior to and following instrumentation [16,18,19] . CBCT provide distinct benefits as enhanced precision and resolution, shorter image acquisition and exposure times, and the preservation of specimens during analysis [18,20,21]. Moreover, it overcomes the limitation of superimposition commonly associated with two-dimensional conventional radiography [22] and assists in accurate measurement of root curvature [23].

Invivo software (V 5.5, Anatomage, USA) and Mimics software (V21.0, Materliase, Luuven, Belgium) used have the advantage of performing first manual registration followed by automatic registration of the secondary post-instrumentation image to the primary pre-instrumentation image [24,25], by this way the two images were superimposed over each other at any section allowing for standardization. [26,27]

Two parameters were assessed for the tested instruments in this study: **The change in dentin thickness before and after instrumentation and also change in dentin volume before and after instrumentation**

The remaining dentin thickness was measured at levels 4 mm apical to the cementoenamel junction (CEJ), corresponding anatomically to the furcation region. The measurements, expressed in millimeters, represented the shortest linear distance between the canal wall and the adjacent external surface of the root. Quantitative assessments were carried out at 1 mm intervals specifically at 1 mm, 2 mm, 3 mm, and 4 mm levels on both the mesial and distal surfaces of each root. [11]

The danger zone within the mesial root of mandibular molars may be located on either the mesial or distal surfaces. According to Abou-Rass et al. and De-Deus et al, the mesial aspect of the mesial canals exhibits a predisposition to structural weakening, with an incidence rate of approximately 40% [28]. In a seminal study conducted in 1980, Abou-Rass et al. highlighted the distal surface of the mesial roots in mandibular molars as a critical 'danger zone,' attributing its vulnerability to a heightened risk of strip perforation [29] . Subsequent investigations, including those by De-Deus et al, have further examined these anatomically vulnerable areas using methodologies consistent with the original approach outlined by Abou-Rass et al. [30,31] .

Change in thickness was calculated as percentage[11] as follows ×100

$$\frac{\text{Dentin thickness before instrumentation - dentin thickness after instrumentation}}{\text{Dentin thickness before instrumentation}} \times 100$$

Dentin volume was calculated by subtracting the pre-instrumentation

(uninstrumented) canal volume from the post-instrumentation (instrumented) volume, with all values expressed in cubic millimeters (mm^3).

The change in dentin volume was calculated as percentage [12] as follows :

$$\frac{\text{Dentin volume before instrumentation - Dentin volume after instrumentation}}{\text{Dentin volume before instrumentation}} \times 100$$

The present study identified statistically significant differences in dentin thickness changes at 2 mm and 3 mm beneath the furcation, along with a distinct variation in dentin volume change between the two experimental groups. These findings warranted the rejection of the null hypothesis.

The change in dentin thickness at 2 mm and 3 mm apical to the furcation level was markedly greater in the WaveOne Gold group than in the One RECI group. This distinction may be explained by the design of the One RECI system, which incorporates a reduced maximum instrument diameter (1 mm wire)[8] promoting a more conservative shaping approach in the cervical third of the canal, particularly 2–3 mm apical to the cementoenamel junction (CEJ). Instrument cross-sectional geometry is a critical factor influencing dentin preservation [32] .One RECI file's triple-helix and S-shaped, off-centered configuration [33,34] may enhance its ability to conserve dentin, as opposed to the parallelogram-shaped, off-centered cross-section characteristic of the Wave One Gold system [35]. Furthermore, One RECI file is manufactured from C-wire alloy and features a variable off-centered design .Based on the manufacturer's data, these instruments are designed to offer superior mechanical properties, including elevated flexibility, efficient cutting action, and reliable canal-centering performance. [8]

With respect to volumetric changes, the results also indicated that the WaveOne Gold group exhibited a significantly greater change in dentin volume compared to the One RECI group.

These findings align with those of a previous study in which WaveOne Gold system exhibited a significantly superior change in dentin volume relative to TruNatomy system [9], which, in another investigation, displayed performance comparable to that of One RECI file [36].

To date, no studies in the existing literature had directly assessed the impact of One RECI system on remaining dentin thickness and volume in comparison with WaveOne Gold, thus precluding direct comparisons of the current results with prior research.

The main limitation of the present study was its ex vivo design, which, although it allowed for controlled experimental conditions, did not fully replicate the complex biological and functional environment of the oral cavity. Additionally, the small sample size limited the generalizability of the findings.

Future studies should include larger sample sizes to improve the reliability of the findings and allow for subgroup analyses. Additionally, it is recommended to investigate the effect of remaining dentin thickness on the fracture resistance of endodontically treated teeth. To further validate the clinical applicability of these findings, well-designed clinical trials are warranted to assess the long-term outcomes of One RECi files .

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