Tikrit Journal for Dental Sciences 13(2) (2025) 297-305
https://doi.org/10.25130/tjds.13.2.1

Tikrit Journal
for
Dental Sciences

https://tjds.tu.edu.iq
Print ISSN:2073-1213
Online ISSN:3105-9384

IRAQI Academic Scientific Journals

A Comparative Evaluation of Two Different Shaping Systems on the Preparation of Mesial Canals for Mandibular First Molars:(A Micro-Computed Tomography Study)

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Keywords:
Comparative, Evaluation, Micro CT, Mesial canals

Article Info.:

Article History:
Received: 17/5/2025
Received in revised form: 22/6/2025.
Accepted: 29/6/2025
Final Proofreading: 29/6/2025
Available Online: 1/12/2025

Citation: AL-Muteery GW, AL-Nuaimi AM, Suliman AA. A Comparative Evaluation of Two Different Shaping Systems on the Preparation of Mesial Canals for Mandibular First Molars:(A Micro-Computed Tomography Study). Tikrit Journal for Dental Sciences 2025; 13(2): 297-305
https://doi.org/10.25130/tjds.13.2.1.

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Abstract

Background: The anatomical complexities and curvature in mesial canal represent the challenges in the shaping and cleaning during canal preparation Aim: The purpose of this in-Vitro study was to evaluate and compare between two different shaping system MicroMega (2S Shape) continuous motion system and Dentsply Wave-One Reciprocate (Dentsply, Sirona) reciprocation motion system during the preparation of mesial root canals for mandibular first molars, including changes of canal volume, canal area, occurred during the preparation using a µ-computed tomography scan (µ-CT). Materials and method the mesial canals of thirty extracted mandibular first molars with a root curvature of < 25 degrees according to Schneider's method, were randomly divided into two groups (Group I:2S Shape; Group II: Wave-One Reciprocate), with a total sample size of n = 30. All coronal segments were respected at the cement-enamel junction (CEJ) and subsequently evaluated with µ-CT before and after preparation. Statistical analysis: Kolmogorov-Smirnova for normality, paired T test. Results: The results showed increasing in all the tested parameters, significant differences were observed between groups regarding changes in the canals volume and canal area ($p<0.05$). Conclusion: the application of two different shaping systems showed increasing in all canal diameters during the preparation, while WO. Reciprocate showed less canal change compared to continuous motion.

Introduction:

The innovation and development of all these rotary systems aim to meet the requirements for bacteria-free infection canals, ensuring that they preserve the tooth's functionality and aesthetics [1,2].

Working length estimation plays an important role in the shaping procedure to prevent both over-instrumentation and under-instrumentation of the root canal. This step can be performed using various techniques. (Apex locator,X-Radiation, Cone Beam Computed Tomography, Micro Computed Tomography [3].

Cone beam computed tomography (CBCT), which is very efficient in patient treatment due to better visualization, aids in diagnosis for the existence issue so it can be used for clinical and research demands [4]. and high-resolution micro-computed tomography (μ-CT), which provides a nondestructive, repeatable method that allows for the precise investigation of canal architecture, has been more important in dentistry research in recent decades[5].

The primary objective of developing various types of rotary systems is to identify a shaping system that aligns with the criteria of canal preparation and align with canal's structure and reduces errors made by the dentist during the preparation process [6].

Rotational motion includes the continuous circular movement of the endodontic file along its axis. This motion is generally driven by an electric hand-piece that rotates the file at a uniform speed.The system's efficiency depends on its ability to eliminate canal debris and maintain a consistent velocity to optimize cutting efficiency. However, these factors may lead to excessive dentin removal and contribute to over-instrumentation [7]. The reciprocation systems show an effective use in curved canal due to its alternating motion in a particular design of the reciprocating file, which aids in reducing the chance of fracture and minimizing stress on the file; it also exhibits slower preparation compared to other rotary systems.The anticlockwise cutting action of 130 degrees, succeeded by a clockwise releasing movement of 50 degrees are the representing motions in reciprocation system. To achieve a complete 360-degree rotation, it requires three spins [8].

The reciprocation systems show an effective use in curved canal due to its alternating motion in a particular design of the reciprocating file, which aids in reducing the chance of fracture and minimizing stress on the file; it also exhibits slower preparation compared to other rotary systems [9].

Two rotation instrument system 2S shape (Micro-Mega) and the reciprocation rotary system (WaveOne.Reciprocate) will be study in this research, to compare two different motions and cross sections

2 S Shape (MicroMega)

To facilitate the negotiation of the canal curve and reduce the stress during preparation, companies have produced a system with two instruments employing the crown-down root method. The TS1 (25/0.04) and TS2 (25/0.06) t-wire instruments are utilized. The files exhibit circumferential motion, comprising three upward and downward movements with TS1, followed by irrigation, and then the identical three upward and downward movements with TS2 [10].

Wave-ONE Reciprocate

These files implement left-handed threads rather of the conventional right-handed threads and possess a reversed helix, allowing counterclockwise (CCW) rotations to engage the file, while clockwise (CW) rotations disengage it. The tips are modified (non-cutting) to accurately conform to canal curvature. The changeable pitch flutes along the instrument's length considerably enhance safety. Counterclockwise rotation promotes the advancement of the instrument, effectively engaging and severing the dentine. The clockwise rotation disengages the instrument from the dentine prior to the occurrence of taper lock within the canal [11,12].

Materials and Methods

Sample size estimation

The power analysis was conducted (G*Power software V 3.1.9.4, Franz Faul, Universität Kiel, Germany) [13].to calculate the sample size for each group. The input parameters were set as follows: α = 0.05, power of 95% and effect size of dz= 0.62. This analysis resulted in a non-centrality parameter of 3.42, a critical t of 1.69, and a determination of 15 specimens for each group.

Sample selection

The ethics committee at Mosul University, Mosul, Iraq (UoMDent.23/59 on November 14, 2023) granted permission for the procedure. Thirty distinctive permanent mandibular first molars were extracted. The extracted teeth must have mature apices, no history of endodontic therapy, and be free from cracks, fractures, calcifications, or apparent anomalies when examined under a 20X stereomicroscope (Optika, Italy). A root curvature of under 25 degrees, as confirmed by the Schneider method.

A computer-generated sequence made in Microsoft Excel was used to randomize the groups. There was a unique ID number for each tooth, from 1 to 30. Then, a random number table was used to put the specimens into two groups, each with 15 specimens. An independent researcher who was not involved in preparing specimens, using instruments, or evaluating outcomes made the randomization list. This was done to keep the allocation secret and avoid any bias. The 2S Shape rotary system was given to Group A, and the WaveOne Reciprocating system was given to Group B.

Samples Preparation

Disinfection and sterilization of the samples before any preparation of the access cavity: the teeth were immersed for 5 minutes in concentrated sodium hypochlorite (5.25% NaOCl), then sterilized for 40 minutes in an autoclave at 121 °C and 15 psi pressure. The specimens were maintained in normal saline until subsequent use. Then removing the coronal part of all samples using a slow-speed hand tool with a double-sided diamond disc that is 0.2 mm wide (Kimet, Germany), while using plenty of water to keep it cool, at a speed of 8000-12000 rpm. The orientation of the disc was perpendicularly to the long axis of the teeth beneath the cement-enamel junction, standardization and establishing a reference point for the root length at 14 mm, as measured with a digital caliper mounted on the surveyor .Coronal flaring has been performed with Gate-Glidden drills at a velocity of 6000 rpm to attain straight-line access. Subsequently, all samples were examined with a Micro-CT instrument for scanning before processing.

Group 1

2S Shape MicroMega

The preparation for the TS1 three up-down movement was executed in a crown-down sequence, involving the file's movement with gentle apical pressure of approximately 3 mm in a slow in-and-out pecking motion, with extreme torque calibrated at 1.5 N/cm and a continuous clockwise rotational motion set at 300 rpm. The procedure was repeated across all systems until the complete working length was attained. During the operation, TS2 was utilized with identical usage outcomes; the canals were irrigated with 2 mL of 5.25% NaOCl for 1 minute between each file, employing a side-vented, 30-gauge needle. A 10 K-file was employed to ensure apical patency between each rotary file.

Group II

WO.Rec

Glide path was done for mesial canals (mesiobuccal and mesiolingual) by hand instrument No.8.10.WaveOne.Rec was used to prepare the canal in-and-out pecking motion with an amplitude of less than 3 mm, following the manufacturers' instructions. The instrument flutes were purified after three cycles of in-and-out motions (pecks), and the canal was irrigated. Upon successfully reaching the terminus of the canal, the instrument rotated freely, WaveON.rec. A singular file (25/07) was employed extensively over nearly all canals, irrigated with 5 mL of 5.25% NaOCl for 1 minute between

each file, utilizing a side-vented, 27-gauge needle.
The irrigation protocol for all rotary systems
The irrigation protocol for all rotary systems involved irrigating the canals using a disposable double-sided vented irrigation needle (27-gauge) with 5 mL of 5.25% sodium hypochlorite between each file. The needle was positioned 1 mm from the working length. Ultrasonic activation of the irrigant was performed during each irrigation step to enhance cleaning efficacy. After instrumentation, 5 mL of 17% EDTA was used for 1 minute to remove the smear layer, also activated ultrasonically. Finally, the canals were flushed with 4 mL of normal saline and dried with matching-size sterile paper points. [13,14].

µ -CT Evaluation
All samples were scanned by µ-CT after meial canals preparation.A high-resolution µ-CT desktop device (Fig-1) (Bruker Skyscan 1272, Kontich, Belgium) was utilized to scan the samples at Tehran Medical College of Medical Sciences in Iran. The scanning parameters were: 100 kVp, 100 mA beam current, 9.93 µm pixel size, 0.5 mm Al/Cu filter, and a rotation increment of 0.5 degrees (Fig-2). Before each scan, air calibration of the detector was conducted to minimize ring artifacts. Each sample was rotated 360° for a total duration of 5 minutes. The Digital Imaging and Communication in Medicine (DICOM) files were transformed into stereolithography (STL) files for the examination of the un-instrumented region(Fig-3,4), 3D models were generated with color coding, and pre- and post-operative photos were captured utilizing automatic image registration. The prepared regions and stripes of the canals were analyzed using CTVol v. 2.2.1 software (Bruker-microCT) [15].

Statistical analysis
The following parameters were evaluated, and values were calculated to compare the shaping ability of the two file systems: changes in canal volume, changes in canal area untouched canal surface, untouched canal area.
Every observation was recorded, descriptive statistics and analytical statistics were done by SPSS software version 26 (SPSS Inc., Chicago, IL, USA. The mean and standard deviation were all included. Normality and homoscedasticity of data were checked using Shapiro-Wilk and Levene's tests. Since the data was regularly distributed, paired t test, independent Samples T test to reveal if there are any significant differences was present.

Results

Comparison of Canal Area and Volume Changes Following Preparation with Two Systems.
After the completion of this experimental groups by testing the samples first with normality test ,then evaluate the shaping ability of the two system to evaluate the change during canal preparation (Table. 1) Describe paired t test which was done to evaluate and assess the change occurred in pre and post instrumentation during the preparation. The table represent the quantities changes in canal area and canal volume during canal preparation of the two rotary shaping systems (2S Shape and WO.Rec), the results showed (P- value <0.05) which indicate there is significant difference.

- **Group I:** include 15 samples scanned before and after preparation by (2S Shape) to assess the change in canal area and canal volume.
- **Group II:** include 15 samples scanned before and after preparation by (WO.Rec) to assess the change in canal area and canal volume.

Discussion

In the present study, the evaluation of two different shaping systems that each one represent a distinct generation of rotary endodontic systems . The findings reveal that both groups were able to change the canal diameters during canal preparation. These rotary instruments with different kinematics during instrumentation and different cross-sections are manufactured by proprietary heat treatment and use a

single-file nickel titanium system that requires only one instrument [16].

Achieving optimal results in root canal treatment requires comprehensive knowledge and an effective rotary system to exercise dentin without altering the anatomy of the root canal. To evaluate these changes, a dependable nondestructive device is required to scan the samples; thus, μ-CT facilitates the comparison of high-resolution images before and after instrumentation [17]. Upon examining the changes in canal area and canal volume post-instrumentation with 2S Shape and WaveOne.Rec, the findings were observed that there were a statistically significant increase in both the canal area and canal volume after the procedure in both groups.

According to the results in Table (2), when comparing the two systems in the specific parameters (canal area, volume of the canal after preparation showed that the shaping procedure effectively enlarged the canal parameters.($p<.05$) so the null hypothesis was rejected provided that p-value is below the significance threshold (Removed Dr.)

In this study, according to Table (2) $p<0.05$that means highly significant difference between groups in all diameters measured, the total volume of removed dentin and surface area were different between groups, the shaping procedures led to the enlargement of the root canal space, parameters groups when the (group 1) mean of canal area changes from (119.9±47.4 to151.9± 48) and the change of canal area in WO from (86.4680) to (113.7763) which means MicroMega is more lateral shaping which means walls were widened more while for the canal volume the mean for the (group1) from (29.5133 to 33.4273) and (group2) mean from (17.23 ± 7.83 to 24.48 ± 10.05) which means more dentin removal more apical shaping in WO [18].

The main reason for these results is that they mainly depend upon each system function. Each system has specific criteria to meet for performance (torque, speed , cross-section, and design). The cutting ability of root canal instruments is a complex interrelationship of different parameters such as cross-sectional design, chip removal capacity, helical and rake angle, metallurgical properties, and surface treatment of the instruments. The efficiency of the cutting ability of a shaping system is a complex interaction of such factors as metallurgical properties, chip removal capacity, cross section, helical and rake angle, and surface properties [19].

According to 2S shape MicroMega, the mean of this group system showed a significant difference from other groups; the value was greater than WaveOne. Reciprocate in the canal area changes the reason for this result: the 2Shape instrument (TS) system is made from T-wire technology, which enhances the flexibility of instruments and fracture resistance. The instrument consists of two main and one secondary cutting edge and a non-cutting safety tip for better negotiation of canal curvature. The two cutting edges demonstrated an excellent cutting performance, and the secondary cutting edge enhanced the removal of debris, as well as the continuous motion, improving the centering shaping. Due to its 2S shaping instruments, it provides a gradual enlargement so that there is much apical preservation [20].

The WaveOne. Reciprocate showed minimal anatomical changes in the canal area, while it is greater in canal volume compared to the other group. This is because the WaveOne system is a very challenged system because it is composed of one primary file for almost all major canals, but due to its reciprocal motion, it will be similar to manual shaping, but it will preserve the canal diameter more than any other system [21].

To analyze the results of WO, it shows better preservation of root canal anatomy in lateral preparation, which can be described by system criteria when a large rotating angle in the counterclockwise motion determines the instrument advances in the canal and engages dentin to cut it, whereas a smaller angle in the clockwise motion allows the file to be immediately disengaged and safely progress along the canal path while

reducing the effect of a screwing effect and file breakage. These angles are specific to the different instruments. According to the manufacturer, reciproc is 150° counterclockwise then 30° clockwise rotation, while WO is 170° counterclockwise then 50° clockwise rotation. And because it is considered a single file system, clinical and research evidence reveals that no single file is able to fully engage the entire canal wall, leaving a variant range of untouched canal. Eventually, due to its large diameter, it may reduce the penetration of the irrigant, so it will reduce the lubricant action inside the canal and decrease the efficiency of cutting the dentin [22].

A non-destructive imaging device, μ-CT, was used to evaluate the shaping system for the object multiple times due to its high-resolution detectors by capturing magnified projection images of small objects. Preserving its integrity for subsequent experimentation and future scans [23].

Our research confirmed the findings by Singh et al [24]. which looked at how much dentin was removed using 2Shape and Protaper Gold in cases of severe root curvature through CBCT analysis. The results indicated a considerable disparity between the 2Shape and ProTaper Gold systems at the 3 mm, 5 mm, and 7 mm measurements.They determined that the 2Shape file exhibits a less aggressive removal of dentin volume.

Another study that align closely with this research findings is the findings of Nassar et al [25] . align closely with our results, as both studies demonstrate that the 2Shape rotary system exhibits superior centering ability and minimal canal transportation during preparation of curved root canals. Their use of micro-CT analysis to assess canal volume changes and centering confirms our observations of effective canal shaping with preservation of the original anatomy, reinforcing the reliability of 2Shape instruments in clinical and laboratory settings.

The current study's outcomes are consistent with the observations of Özyürek et al. [26]. reinforcing the reliability of the 2Shape system in endodontic canal preparation

(Faisal et al.) Evaluate the shaping ability of of2S Shape and There was no significant difference between the two groups in volume of dentin removed, canal transportation, and centering ability for 25° and 35° canal curvatures at 3, 6, and 9 mm from the apex (coronal, middle, and apical thirds) ($p > 0.05$). This study was contradict our findings [27].

Another study that showed no significant difference in shaping ability which is contradicted to these findings, The study that conducted by Yılmaz et al. [28]. demonstrated no significant difference between the 2Shape and Reciproc Blue rotary systems.

Limitation and Recommendation

Every study has its weakness, and the variation in canal anatomy, curvature, and morphology of the tooth were the main limitations in this study because there was no standardization in teeth diameters.

Eventually with all the previous research results leads us to believe that none of the tested systems were able to abruptly change the trajectory of the root canals. Even so, future studies should be performed evaluating such parameters for the tested systems.

Conclusion

With limitation of the present study, Both 2S Shape and WaveOne showed change in canals parameters during the preparation of mesial canals increasing the total canal surface area and canal volume during canal preparation. Eventually, with all the previous research results leads us to believe that none of the tested systems was able to abruptly change the trajectory of the root canals.

Funding: None

Data availability: upon request from the corresponding author.

Ethics approval and consent to participate: Approval of the ethics research committee at Collage of Dentistry/University of Mosul with code . UoM.Dent. 23/59 on November 14,2023

Competing interests: None.

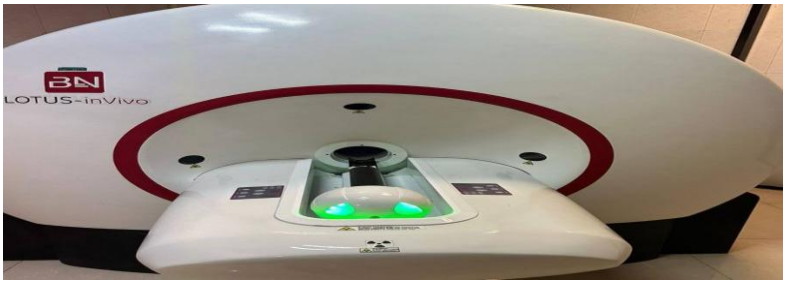

Figure (1):Micro-Computed Tomography Device

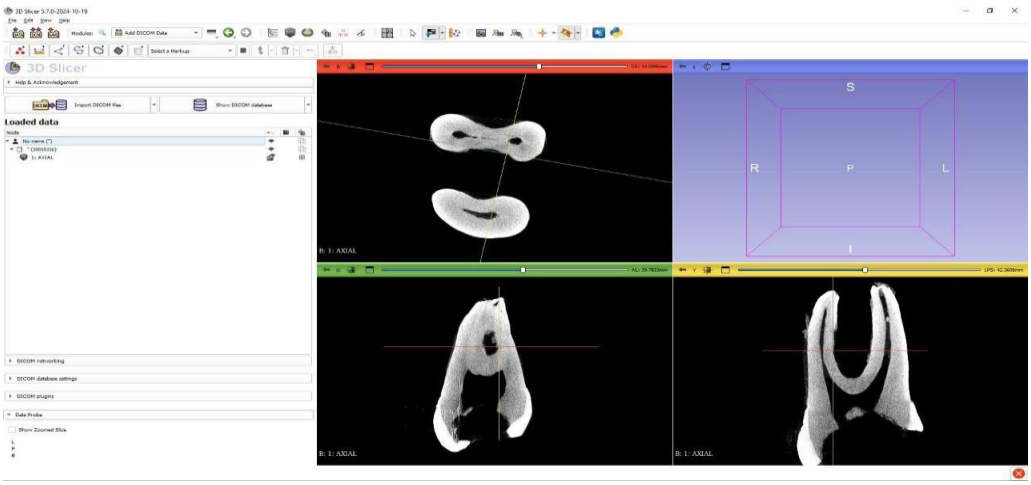

Figure (2):Data Reviewer for parameters measured during µ-CT Scanning

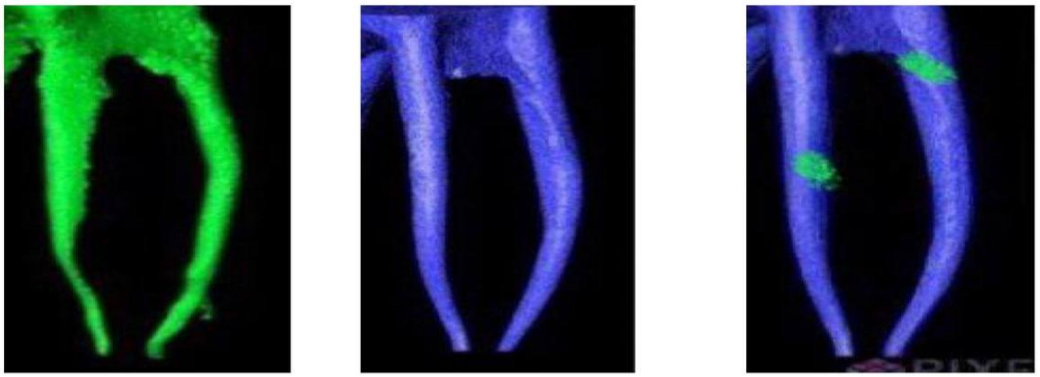

Figure (3):Representative 3D reconstructed image of mesial two canals(Mesio buccal and Mesiolingual) prepared by 2S Shape illustration the canal shaping and the canal area that was untouched during canal preparation the green picture was A-before instrumentation and B-purple was for after canal preparation .c- is the superimposed of the A combined image to directly compare the pre- and post-preparation canal shapes

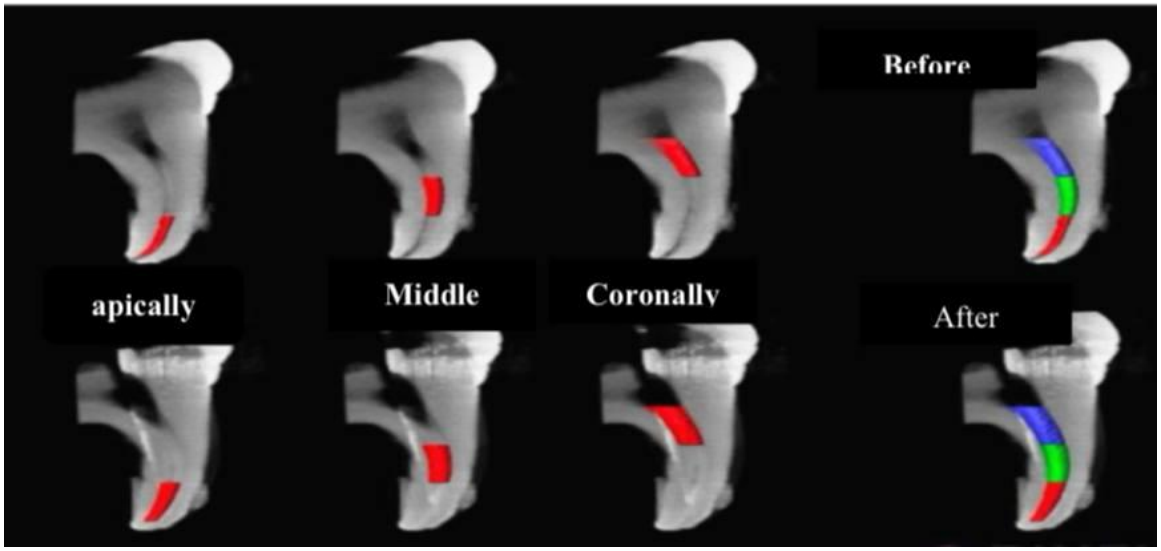

Figure (4): longitudinal section shows 3D Images of mesiobuccal canal , From left to right : apical, middle, coronal, and total volumes, the isosurfaces (red) represent the canal prepared by WO

Table (1):Normality Test

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Parameters	Statistic	df	Sig.	Statistic	df	Sig.
G-1 2S Shape	initial	.208	15	.080	.907	15	.122
	After	.186	15	.174	.883	15	.052
	Δ	.217	15	.055	.898	15	.088
	initial	.209	15	.077	.916	15	.165
	After	.106	15	.200*	.954	15	.595
	Δ	.191	15	.146	.911	15	.142
G-2 Wave.One	initial	.139	15	.200*	.964	15	.761
	After	.157	15	.200*	.936	15	.330
	Δ	.163	15	.200*	.941	15	.399
	initial	.153	15	.200*	.956	15	.622
	After	.081	15	.200*	.992	15	1.000
	Δ	.139	15	.200*	.948	15	.493

Table (2): Paired samples- T test

Group	Parameters		Mean	Std. Deviation	t-value	sig
G-1 2S Shape	Canal area (mm2)	Initial	119652	44.93950	5.556	0.000
		After instrumentation	151932	41.43414		
	Canal volume (mm3)	Initial	29.5133	6.04724	2.158	0.000
		After instrumentation	33.4273	4.39749		
G-2 WaveOne	Canal area (mm2)	Initial	86.46	38.57778	14.411	0.000
		After instrumentation	113.77	38.70991		
	Canal volume (mm3)	Initial	17.2347	7.83180	7.119	0.049
		After instrumentation	24.4793	10.04553		

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