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An *In-Vitro* Comparative Analysis on Root Canal Transportation, Centering Ability, Angle of Curvature Using XP-Endo Shaper and WaveOne Gold Rotary Systems-A CBCT Study

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ABSTRACT

Background: In this study we highlight the difference between two recent single file endodontic systems XP-endo Shaper by FKG and WaveOne Gold by Dentsply by measuring their efficiency through assessing the centering ability, canal transportations, preparation time and changes in canal curvature on resin endodontic blocks using Cone Beam Computed Tomography.

Material and Methods: Fourteen resin endodontic blocks are used for each system. The assessment was done by comparing and measuring the data collected of pre-instrumentation and post-instrumentation CBCT axial and sagittal images to assess the centering ability, canal transportation, preparation time and changes in canal curvature. These measurements were taken in 3mm ,5mm and 7 mm from the apical exit of the endodontic block used.

Results: The mean Canal Transportation of XP System (Group A) in 3mm, 5mm and 7mm sections measured with values (-.5214, -.2714 and -.02140) respectively. The mean transportation of WaveOne Gold system (Group B) in 3mm, 5mm and 7mm in sections with values (-.3214, -.2571 and -.1143.) respectively, whereas the mean centering ability of XP System (Group A) in 3mm, 5mm and 7mm sections measured with values (.0714, -.6131 and -.9881) respectively. The mean transportation of WaveOne Gold system (Group B) in 3mm, 5mm and 7mm sections is given as (-.3255, -.6310 and -.6429) and there was no significant difference noted in centering ability and canal transportation between the two systems. The mean root canal preparation time showed no statistical difference between the two systems employed. There was statistical difference noted in the changes in pre- and post-curvatures of the canal between two systems studied.

Conclusion: With our limitation in sample size, it was concluded that reciprocation motion in WaveOne Gold system gave better results in canal transportation and centering ability in the simulated apical part in endo-blocks than continues motion rotary preparation in XP endo shaper system. WaveOne Gold produced lesser canal transportation in the apical 3rd while XP endo shaper produced less canal transportation and centering ability in the middle 3rd simulated endo-blocks.

Keywords: WaveOne Gold, XP Shaper, Single file system, Canal transportation, Centering ability

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INTRODUCTION

For a proper and successful root canal treatment, the number of microbes needs to be reduced through different chemical and mechanical procedures.[1,2] The preparation for the root canal procedure is known to be one of the most crucial factors that have a linear relation with the efficacious disinfecting process and the consequent treatment result. The process of preparation of root canal by means of instruments made of nickel and titanium has gained popularity over the last twenty years. The root canal treatment process is one of the most significant therapies that provide help to the teeth to function properly and stay in the esthetic condition. The process of endodontic treatment is entirely concerned with the elimination of pulp present in the teeth region and the preparation of the canal for the process of obturation.[3] One of the major important stage that contributes to the treatment of the root canal is the preparation of the canal, as an outcome of the estimation of the organized procedures sequenced, which in turn help in placing the fluid of the root canal with appropriate canal covering for protection. [4] An important motive of the endodontic treatment is the debriding of the overall tissue by tightening the fluid obturation with respect to the amount of space made.[5] This target can be gained quite easily when straight and huge canals are considered, however, it becomes a tedious task when curved and dented canals have to be operated. [6] The mistakes that occur during the endodontic treatment procedures such as transportation of the apical root canal, the formation of an elbow structure in the teeth, the perforation of the strips, and lastly the damage caused to the tools and equipment used.[7] These errors caused during the dental procedures grow in number when the dentist or the operating doctor is attending a case of patients with dented and narrow canals or if the dental tools used are hard or already damaged.

The NiTi system can be of high usefulness as it can lead to the creation of better canals in the damaged teeth[8]. The system made up of nickel and titanium help in the reduction of the mistakes that occur during the transportation of the canals, and the errors that occur in the apical region of the tooth that possesses a narrow-dented canal. On the other side, there are a few limitations of the nickel and titanium system that it is comparatively more expensive than the other available systems, and there are chances that a sudden accident might occur due to the separation of the tool parts.[9] These tools make sure that perforation is not occurring and the teeth and the canal region are free of ledges.[10] The introduction of the nickel and titanium system has brought about a revolution in the endodontic procedures and teeth and root canal treatments, by bringing a reduction in the fatigue caused by the operations and surgeries, time that is taken for preparing the canal, and the treatment mistakes that occur due to the dental tools and instruments. Given these benefits, the NiTi dental tools are prone to breakage and fractures due to their limit of elasticity, without prior case or instance of dent or deformity.[11] The conventional hand tools made from steel might put the dentist or the endodontist in a dilemma for the preparation of majorly dented narrow and curved canals which has the possibility of affecting the treatment results.[12]

Instruments in endodontic procedures

The endodontic accidents that happen are completely unexpected and are inevitable sometimes during the treatment procedure.[13] There are a number of dental complications that take place, out of which the apical damages are quite common; for instance, the damage caused to the foramen of the apical region, [2] the formation of an elbow structure in the apical part. [14] and the formation of zip and strips in the teeth along with perforation.[15] These defects can be observed quite commonly as a subsequent outcome during the transportation procedures.

The rotary systems carry out a 36-degree rotational motion or oscillatory motions that help in the preservation of the original shape and structure. The angular motion of the instrument helps in maintaining the curve angle of the root canal. Adding to this, the use of the metallic and non-metallic mixture of nickel and titanium may aid in achieving expected outputs for the curvature in comparison to the manual procedures and tools. The automatic systems using reciprocatory motions that are known by the oscillatory movement of the filing system in the clockwise direction at 30 degrees and in the anti-clockwise direction at 45 degrees, which can be performed by alloys as well as steel.[16] The rotary instruments made up of nickel and titanium are more beneficial when compared to the steel tools used for manual operation. This is because of various factors such as safe usage, preciseness, and the accurate procedure with negligible risk of error.[4] Studies have shown that narrow canals can result in uneven and improper elimination of material during the process of canal shaping, along with a high prevalence of treatment procedural mistakes during the transportation of canal.[15]

Canal transportation using cone beam computed tomography.

Mechanically preparing the canal system is known to be one of the major stages of significance in the treatment of root canals.[17] Since 1988, different nickel and titanium dental tools have been manufactured for use either with the help of an automated endodontic instrument or manually operated.[18] There are different NiTi systems available in the market, therefore in-depth analysis of the effectiveness of shaping gains more importance to assess how the features will influence the potential.[19,20]

The most important factor to consider during the process of instrument selection is the prevention of accidents such as the formation of the elbow, perforation of the strip, or any other deformity in the canal due to the dental tools while the dentin is being removed.[18,21] Highly developed instruments that include tips that are non-cutting, various cross-sectional tools, and tapering tools are in the development in order to make the efficacy and safety factor better.[22,23.]

In the study of endodontics, it is highly recommended to conduct a radiographic evaluation in the screening and treatment of teeth related disorders.[24] Traditional radiological techniques give a 2D representation of a 3D model.[25,26] To put an end to the limitation of conventional treatments, highly developed digital imaging technology was introduced, amongst which is the cone-beam computed tomography. This technology is used mainly in the field of endodontics to check the screening of fractures occurring in the root, to assess the anatomy of the pulp region, and to evaluate the condition of the walls of the canals.[27,28.]

Effects of canal transportation

Canal transportation is a procedure of removing the wall of a canal on the apical region of the teeth, with the purpose of restoring the original shape of the canal which was damaged during the preparation procedure or perforation activity. Canal transportation is associated with many risk factors such as insufficient access to the activity area, parameters related to dentist and surgeons, the angle of the curved and narrow canal, inadequate irrigation, use of rigid dental tools, varying methods for preparing the canal mechanically, use of various alloys for giving shape and structure, a cross-sectional area of the dental tool, dental equipment with a sharp edge, and the inaccurate analysis of the radiographs obtained after treatment.[29] Canal transportation can cause a number of consequences such as the loss of resistance at the apical region, development of a narrow canal, deviated axis of the teeth, loss of natural shape, to name a few. All these incidents will eventually result in a tightened liquid seal around the canal and accumulation of microbes in between the teeth. The presence of debris, overextended filling in the canal, and irrigation are subsequent results of improper canal procedures. [4] These effects will subsequently impact the dentinal surface with a force that is highly unevenly distributed. The dentinal wall's thickness is of prime importance owing to the direct association between the thickness of the root and the capability of the teeth to avoid force, which will, in turn, affect the teeth's potential to prevent fractures.[12] Summing up the above effects of the canal treatment, it can be said that the drastic effect of errors occurring during treatment procedures have a linear relation with the longevity of the teeth treatment.

Types and management of apical transportation

The process of apical transportation can be classified into three categories as Type 1, Type 2, and Type 3, on the basis of the relocating movements of the foramen in the apical region. Type 1 procedure represents a small movement in the positioning of the foramen which results in iatrogenic delocalization. It can be managed by maintaining the presence of dentin and the correction of the prepared foramen. If the case is in its initial stage, then the dentist

can clean, shape the canal, and fill the material in the cavity. Type 2 showcases mild movements in the positioning of the foramen which results in iatrogenic delocalization on the exterior surface of the canal. This can be handled by keeping an obstacle to gain control of the bleeding and pain during obturation processes. Type 3 Showcases severe movements in the positioning of the foramen which results in iatrogenic delocalization on the exterior surface of the canal. This type of transportation can be managed using tooth extraction via surgery.[4]

MATERIALS AND METHODS

Twenty-eight root canal endodontic blocks made up of polyester resin with the length 16 mm and apical diameter of 0.15 mm, tapering of 0.02 and shape 'L' with 40 degrees' curvature was chosen for the said study as per Schneider methodology.[30] Cone beam computed technology was used to evaluate the working dimension of the block. The polyline tool for radiographic measurement in CBCT was used to measure the length of the canal. The blocks were segregated into two groups; Group A and Group B and fourteen blocks were allocated to both the groups. Fourteen XP-shaper blocks with 800 rpm speed and 1 N cm torque were used in Group A. The other fourteen blocks were prepared using Wave One Gold (Group B). The canals were prepared in a seating position with a balanced leg, and the reciprocatory movements used were CCW of 170 degrees and 50 degrees at a speed approximately near 350 rotations per minute. The canals were dyed with calcium hydroxide which was non-setting and barium sulfate in order to achieve clear results in the radiographic images. Instrumentation of the canals were done with distilled water to irrigate and lubrication was done using glycerin. The transportation of the canal, centering capability, and the time for preparation of the canal were assessed.[31]

Canal Transportation and centering capability*:* The transportation of the canal and the centering capability were first evaluated in 1996. The formula used for the calculation was (B1 - A1) -(B2 - A2); where B1 was the smallest distance from the external curved canal to the periphery with instrumentation of the canal which was without instrumentation, A1 was the smallest distance from the internal curved canal to the periphery with instrumentation of the canal which was without instrumentation, B2 was the smallest distance from the external curved canal to the periphery with instrumentation of the canal which was with instrumentation, A2 was the smallest distance from the internal curved canal to the periphery with instrumentation of the canal which was with instrumentation.

B1 and A1 belonged to the phase of pre instrumentation whereas B2 and A2 belonged to the phase of post instrumentation, and zero indicated that the transportation did not occur at all. These are the formulae used Canal Transportation = (B1 - A1) - (B2 - A2), Centering ability formula = (B1 - B2) / (A1 - A2). The ratio of proper instrument positioning in the canal was calculated by (B1 - B2) divided by (A1 - A2) (Figure 1).

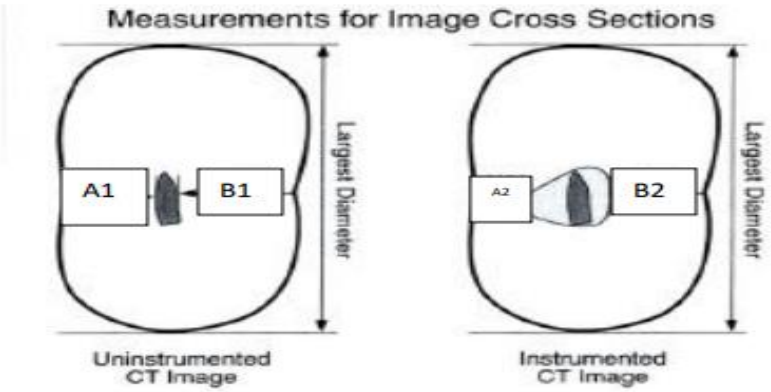


Figure 1. Diagrammatic representation of the Parameters

Preparation time for the canal: The preparation time was evaluated using a stopwatch, where the count was started at the introduction of the rotating system and was stopped at the stage of finalized irrigation. The time was measured using the second's hand. The difference in the angle between the results of the pre- and post-instrumentation stages was used to determine the changes in the curvature of the canal.[30]

Group A - XP-shaper (FKG DENTAIRE, Switzerland). The sequence of instrumentation proposed by the manufacturer is given below: Water bath has been used to warm up the blocks for 90 seconds and the irrigation solutions at 37 °C. Glide path has been ensured by inserting (K-File SS #15 and 0.02 taper Dentsply) till the full given working length and endoblocks are irrigated with Distilled water. The canals were socked in the water bath at 37°C for 90 Seconds. After warming up the blocks and ensuring the glide path XP-Shaper used up to the working length, in 5 strokes light up-and-down movements. After reaching the working length and irrigated with warm solution 5 more times of up-and-down movements strokes over the entire length of the canal. Final irrigation and dryness.

Group B - WaveOne Gold system (Dentsply Maillefer, Ballaigues, Switzerland). The sequence of instrumentation proposed by the manufacturer is given below: Glide path has been ensured by inserting (K-File SS #15 and 0.02 taper Dentsply) for the final working length. After securing the canal and ensuring the glide path, Primary (025/07 red) WaveOne gold file is using inside the canal. Allow the file to passively progress inward in brushing motion until it meets light resistance and bogs

down when it reaches 2-3mm of the canal then the file is removed and clean and inspects it flutes. The canal is irrigated and recapitulate with K-File NiTi #10 .02 taper Dentsply to break up the debris and re-confirm the glide path. Continue with the primary file, in 2-3 passes, to pre-enlarge the coronal two-thirds of the canal.

RESULTS

Canal Transportation: The average value of the transportation of the canal of XP Shaper System was found to be at 3mm as (-0.5214), 5mm as (-0.2714), and 7mm (-0.0214) sections respectively. The average value of the transportation of the canal of WaveOne Gold System with the sizes was found to be at 3mm as -0.3214, 5mm as -0.2571, and 7mm as -0.1143.
(Figure 2, Figure 3, Table 1 and 2)

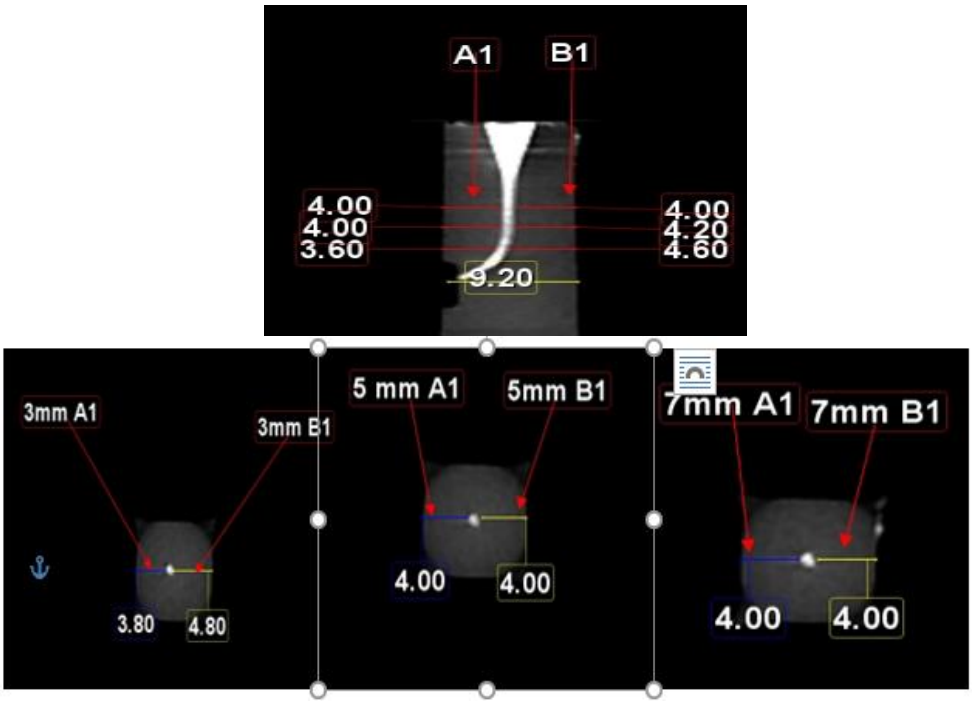


Figure 2. Pre- instrumentation analysis at 3 mm, 5 mm & 7 mm

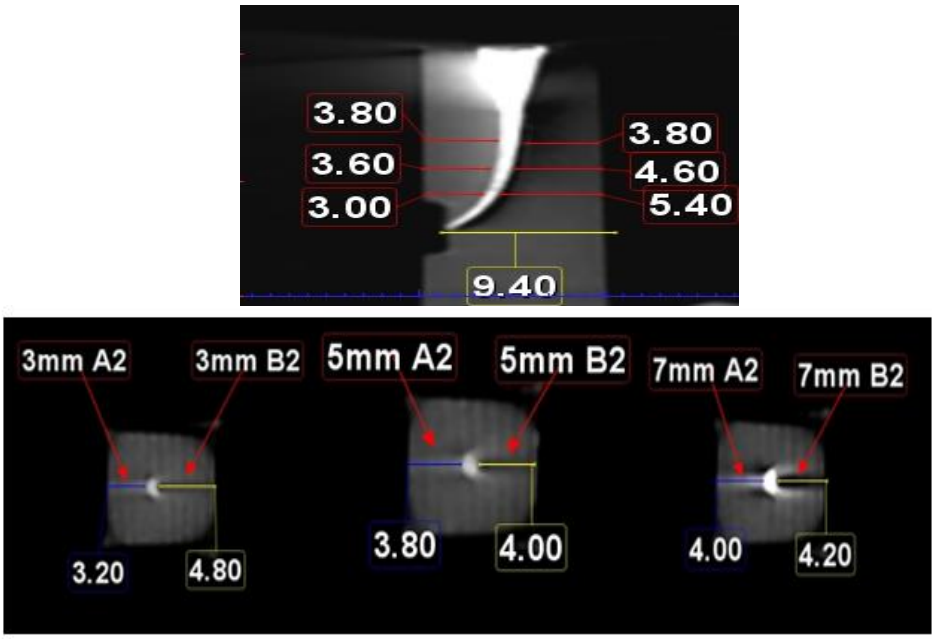


Figure 3. Post instrumentation analysis at 3mm, 5 mm & 7 mm

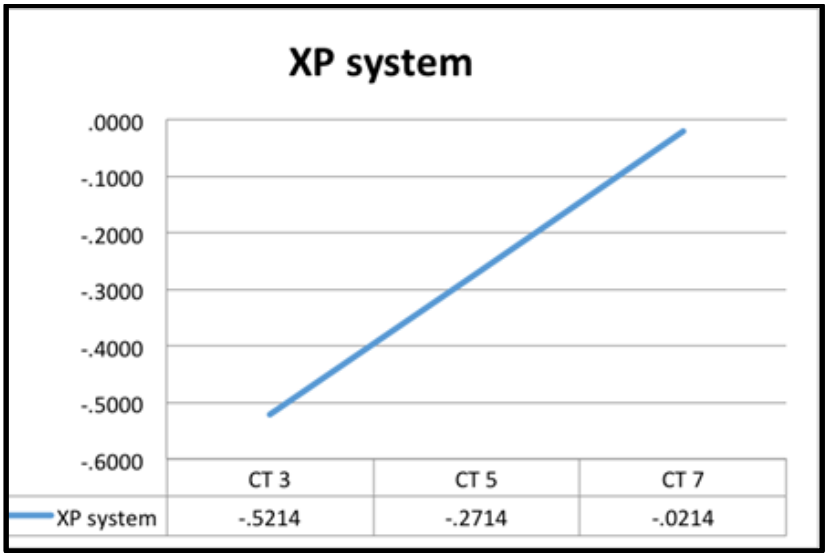


Table 1. Average value of the transportation of the canal of XP Shaper System

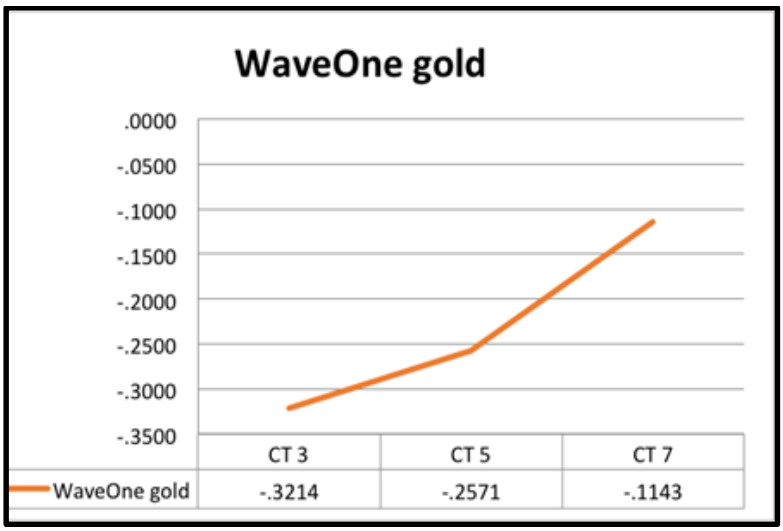


Table 2. Average value of the canal transportation of the canal of WaveOne Gold System

Centering ability*:* The average value of the centering capability of the canal of XP Shaper System with the sizes was found to be at 3mm as -0.0714, at 5mm as -0.6131, and at 7mm as -0.9881. The average value of the centering capability of the canal of WaveOne Gold System with the sizes was found to be at 3 mm as -0.3255, at 5 mm as -0.6310, and at 7mm as -0.6429 (Table 3,4).

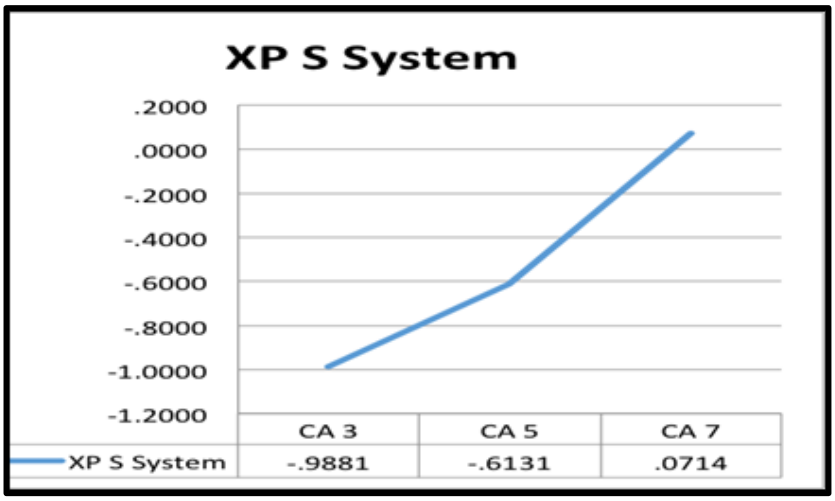


Table 3. Average value of the centering capability of XP Shaper System

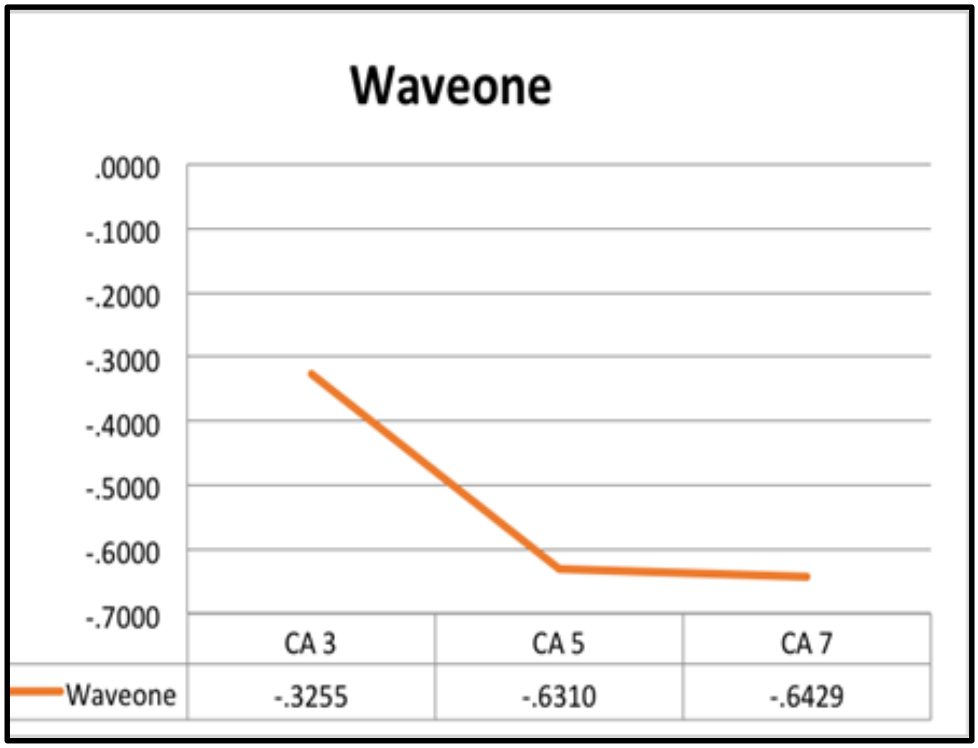
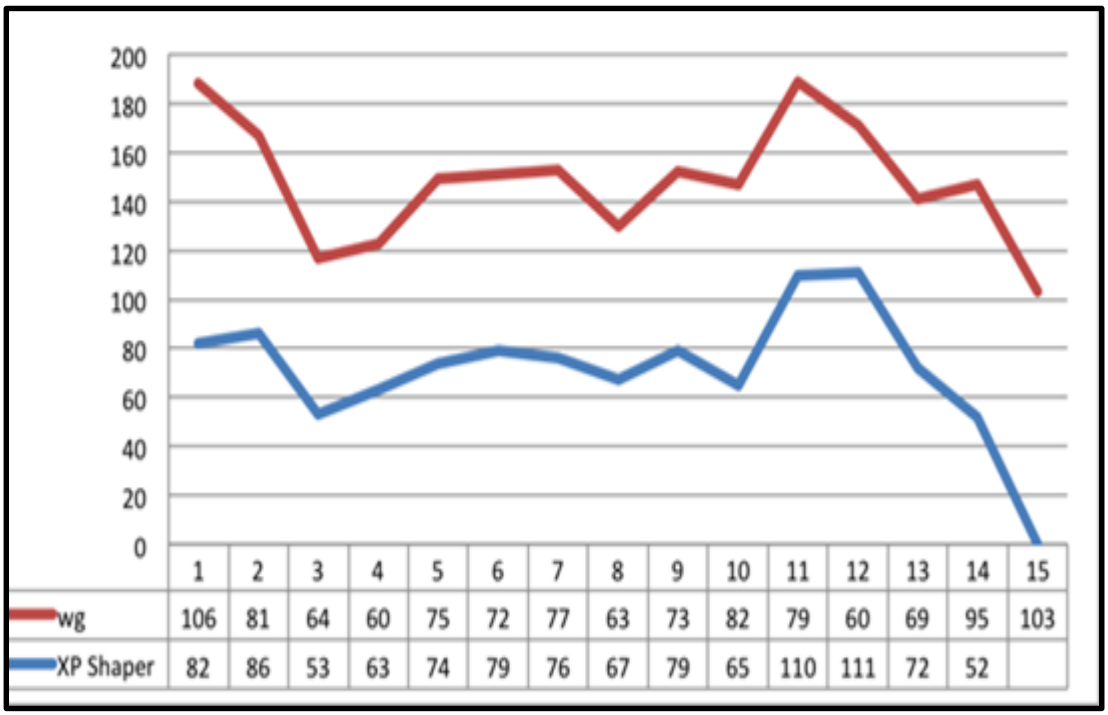


Table 4. Average value of the centering capability of WaveOne Gold System

Preparation time and changes in canal curvature

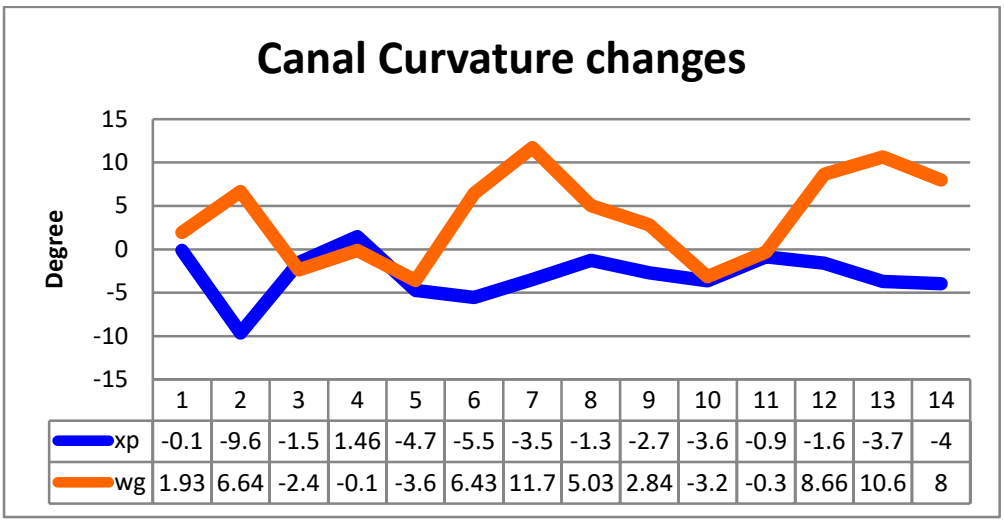
The mean time needed for the preparation of the canal for XP Shaper System was 76.3 seconds and for WaveOne Gold was 77.2 seconds and found to be comparable.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
wg	106	81	64	60	75	72	77	63	73	82	79	60	69	95	103
XP Shaper	82	86	53	63	74	79	76	67	79	65	110	111	72	52	

Table 5. Average time for canal preparation

Comparing the canal curvature changes post instrumentation in these systems, it has been found to be more with WaveOne Gold systems compared with XP endo shaper system. The tendency to mimic the original morphology was seen in XP endo shaper compared with wave one old system (Table 5).



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
xp	-0.1	-9.6	-1.5	1.46	-4.7	-5.5	-3.5	-1.3	-2.7	-3.6	-0.9	-1.6	-3.7	-4
wg	1.93	6.64	-2.4	-0.1	-3.6	6.43	11.7	5.03	2.84	-3.2	-0.3	8.66	10.6	8

pre–Canal Curvature	Between Groups	65.790	1	65.790	12.187	.002
	Within Groups	140.362	26	5.399		
	Total	206.152	27			
Canal curvature	Between Groups	91.912	1	91.912	6.037	.021
	Within Groups	395.835	26	15.224		
	Total	487.747	27			

Table 6. Diagrams view the difference in curvature angulation for each system.

	CT 3mm	CT 5mm	CT 7mm	CA 7mm	CA 5mm	CA 3mm
WaveOne Gold	-.3214	-.2571	-.1143	-.6429	-.6310	-.3255
XP Shaper	-.5214	-.2714	-.0214	.0714	-.6131	-.9881

Table 7. Difference between the two groups in canal transportation and centering ability of the files.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
3mm CT	Between Groups	.280	1	.280	1.425	.243
	Within Groups	5.107	26	.196		
	Total	5.387	27			
5mm CT	Between Groups	.001	1	.001	.017	.899
	Within Groups	2.243	26	.086		
	Total	2.244	27			
7mm CT	Between Groups	.060	1	.060	1.426	.243
	Within Groups	1.101	26	.042		
	Total	1.161	27			
3mm CA	Between Groups	45273235722437490000000000000.000	1	45273235722437490000000000000.000	1.000	.327
	Within Groups	11771041287833535000000000000000.000	26	45273235722436670000000000000.000		
	Total	12223773645057910000000000000000.000	27			
5 mm CA	Between Groups	.002	1	.002	.002	.964
	Within Groups	28.324	26	1.089		
	Total	28.326	27			
7mm CA	Between Groups	3.571	1	3.571	2.889	.101
	Within Groups	32.143	26	1.236		
	Total	35.714	27			

Table 8. Statistical analysis of the centering ability (CA) and canal transportation (CT)

Analyzing the parameters with ANOVA analysis, there is no statistical significance noted in any of the values at any given sections as given. This may be due to low number of samples involved in the study.

DISCUSSION

The process of endodontic treatment is entirely concerned with the elimination of pulp present in the teeth region and the preparation of the canal for the process of obturation. Canal transportation is associated with many risk factors such as insufficient access to the activity area, parameters related to dentist and surgeons, the angle of the curved and narrow canal, inadequate irrigation, use of rigid dental tools, varying methods for preparing the canal mechanically, use of various alloys for giving shape and structure, cross-sectional area of the dental tool, dental equipment with a sharp edge, and the inaccurate analysis of the radiographs obtained after treatment. Canal transportation can cause a number of consequences such as the loss of resistance at the apical region, development of a narrow canal, deviated axis of the teeth, loss of natural shape. Here the study assessed the difference in the XP endo Shaper and WaveOne Gold to shape the curved canals using cone beam computed tomography. The study inferred that the canal transportation is less with XP shaper and centering capability is more with XP shaper file and this difference was clearer in 7 mm slice that is in the middle 3rd of the endo block. However, when we analyze the values in the 3 mm, the values are more favorable with WaveOne Gold presenting lesser problems than XP shaper in the apical part of the endo block near the apical exit. Nevertheless, the values in both centering ability and canal transportation at the middle part (5 mm) for both systems are comparable. WaveOne Gold remains more centralized than XP endo Shaper (Table 7) as supported the study result given by Dhingra,[12] (2015) where they also stated that reciprocation motion produces less canal transportation than continuous motion. When you compare the preparation time there was insignificant difference between the two systems according to the mean of preparation time (Table 5). In addition, when you compare changes in canal curvature XP endo Shaper had produced less canal curvature changes comparing with WaveOne Gold due to the elasticity of the file and the changes in the curvature between the groups was found to be statistically significant (Table 6). The difference in canal transportation and centering ability at 3mm from the apical exit between the systems due to the XP-endo Shaper Booster tip may not distribute the force evenly in the canal which will produce increased taper in XP endo Shaper during the continues motion of the system. On the other hand, WaveOne Gold having two cutting tips with less taper having the reciprocation motion, produce less canal transportation and will be centralized in the apical part. Clinically this finding is very important as the canal transportation in the apical exit area in the endo block will pose more challenges with regard to insufficient access, inadequate debridement, deviation from the original morphological anatomy, and inability to get perfect apical seal. The difference in canal transportation and centering

ability in 7mm section between the systems may be due to elasticity of the XP-endo Shaper and memory ability of the wire (Max wire) aid in being the XP Shaper more centralized and less canal transportation comparing with WaveOne Gold. There was no statistical difference noted in the centering ability and canal transportation when we compared both systems mentioned in our study (Table 8).

CONCLUSION

Root canal is an endodontic procedure which is used to clean the root canal intricate morphological ecosystem and repair the damaged tooth. Shaping of the canals needs highly skilled operator as canal deviation might occur during the shaping process. The study has assessed the ability of two single-file systems XP endo Shaper and Wav One Gold to shape the curved canals using cone beam computed tomography. The study concludes that WaveOne Gold will be producing lesser issues in the transportation of canals and possesses a better centering capability, in comparison to XP endo Shaper for treatments in the apical third region, whereas XP endo Shaper possesses a better centering capability as compared to WaveOne Gold for treatments in the middle third region of the endo block. The clinical implications are more attributed with canal transportation and centering ability in the apical 3rd rather than the simulated middle 3rd in the endo block.

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