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EQUIPMENT ANALYSIS : CANAL SHAPING ABILITY OF RECENT TRUE SHAPE FILE SYSTEM WITH WAVE ONE GOLD

Shree Ranjan Pandey
Dept of Conservative Dentistry & Endodontics, Saveetha Dental College and Hospitals Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai 77
Email: 151906002.sdc@saveetha.com

Manish Ranjan
Associate Professor, Dept of Conservative Dentistry & Endodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai 77, Email: manish@saveetha.com

1.ABSTRACT

1.1 Aim: The aim of the present study was to compare the canal transportation and centering ability of Rotary Wave One gold, True Shape using cone beam computed tomography (CBCT) in root canals to find better instrumentation technique for maintaining root canal geometry.

1.2 Materials and Methods: Total 10 freshly extracted premolars having Straight root canals were divided into two groups of 5 teeth each. All teeth were scanned by CBCT to determine the root canal shape before instrumentation. In Group 1, the canals were prepared with the True Shape file system,in Group 2 the canals were prepared with Rotary Wave One Gold files . After preparation and post-instrumentation scan was performed. Pre-instrumentation and post-instrumentation images were obtained at three levels, 3 mm apical, 3 mm coronal and 8 mm apical above the apical foramen were compared using CBCT software. Amount of transportation and centering ability were assessed. The two groups were statistically compared with analysis of variance and Tukey honestly significant.

1.3 Results: All instruments maintained the original canal curvature with significant differences between the different files. Data suggested that True Shape files presented the best outcomes for the variables evaluated. True Shape files caused lesser transportation and remained better centered in the canal than Rotary Wave One Gold files.

1.4 Results:

1.5 Conclusion: The canal preparation with True Shape files showed lesser transportation and better centering ability than Wave One Gold filing system

Keywords: Canal transportation; canal centering ability; CBCT

2.INTRODUCTION

In endodontics one of the instruments of greatest significance to the clinicians are the rotary files systems.These file systems not only provide an efficient outcome to the clinician but also help in cutting the dentine of the infected with root canal . The widely accepted filing system in the dental fraternity is that of the Wave One File System(Dentsply sirona). The successor to these systems is the Wave One Gold (Dentsply Sirona) which offers the increased

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flexibility in the apical region (Vorster, van der Vyver, and Paleker 2018). Recently developed True Shape file system offers the canal centering ability and with its particular S Shaped Curvature offers great ability to avoid canals of the premolar teeth in particular (Zuolo et al. 2016).

In endodontics the root canal shaping is a key stage of the treatment. A successful shaping of the root canal eliminates the chance of poor prognosis of tooth. An ideal root canal preparation should be in a continuous tapered preparation in which the path of canal should be maintained without deviation .The preparation of the root canal should be such that the apical foramen should be as small as possible (Hulsmann, Peters, and Dummer 2005). These objectives are very challenging to achieve when the root canal is prepared with a conventional stainless steel based filing system.With the invention of the rotary file system which are basically Nickel and Titanium (Ni-Ti) based alloy filing systems the paradigm shift happened in the field of endodontics. These Ni-Ti based rotary systems had great advantages over the conventional systems.The advantages included the that less time was consumed during the cleaning and shaping process, a procedure which was more safer would be carried out more efficiently as compared to conventional stainless steel filing system.The Ni-Ti files were more accuracy oriented compared to the other filing systems and offered lower risk of procedural errors compared to hand filing system(Pettiette, Olutayodelano, and Trope 2001).

One of the prerequisites for safer instrumentation of the root canal is to perform effective cleaning and shaping without causing the apical transportation of the canal. After the Ni-Ti alloy based system was introduced , there was a significant improvement in the quality of the root canal shaping with the predictable results and less iatrogenic damage in all forms of canal shapes and sizes .In recent years the Ni-Ti file systems have been upgraded with the help of scientific technology like CAD-CAM. These manufacturing advancements have been proposed with the aim of increasing the reliability, the effectiveness and the safety of these filing systems.Wave One Gold Rotary file system is a new generation of Ni-Ti filing system , with the pre existing advantages of the conventional Wave One system with added increased flexibility in it. This improved flexibility helps in better negotiation of the canal in the apical third of the root canal (Srivastava 2018).The design of the Wave One file system cross-section resembles that of the K file system when compared to other rotary instrument.With this kind of design structure the dentine is cut in a more elective fashion.This further reduces the torsional load on the filing system and prevents one of the second most common procedural error being instrument separation (Goldberg, Dahan, and Machtou 2012). Among the clinicians around the globe , the greater concern is the instrument separation . One of the concerns with these instruments is that they offer aggressive dentinal cutting and hence the chances of the canal transportation increases many folds.The modern filing systems have a stringent safety feature known as reciprocating motion (Ahn et al. 2020). The basic mechanism behind this feature is that there are two angles operating in the filing systems which have this reciprocating motion.The first angle is a large rotating angle which works in a counterclockwise direction when the instrument advances and cuts the dentine. The other angle is the smaller angle which disengages the file system .This angle works in clockwise direction.This is the critical safety

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feature behind the modern Ni-Ti filing systems.This contributes to reduction in the screwing effect and the file separation with ease Canal centring ability is the ability of the file system to not deviate from the normal canal curvature and to cut the only selected part of the infected dentine. The canal centring ability is influenced by the following factors . The foremost being the design cross section of the instrument , followed by the taper of the instrument (Agarwal 2015). The flexibility of the filing system is governed by the material properties of the alloy with an uncontrollable factor by the operator which is the root canal anatomy depending on the various root canal morphologies.It has been found that the instrument receives lesser constraint in the straighter canals. In conventional techniques to assess the pre operative and the post operative outcome the reassembly techniques were used where the pre op image of the canal was taken and the postoperative image of the canal cross section was compared. The modern advanced technology of precision is the Ultra conservative treatment(UCT) which helps in assessing the outcome faster, and with higher accuracy.This technology of CBCT offers the three dimensional analysis (Patel et al. 2019)

The study aims to assess the canal centring ability of Wave One Gold instruments with the recently developed filing system the True Shape file system.Our team has done previous studies in this field and also wants to do study in future as this is a challenging field.(Rao and Kumar 2018; Felicita 2017; A. R. Jain 2017; Patturaja 2016; Mp 2017; Sivamurthy and Sundari 2016; Kumar et al. 2006; Azeem and Sureshbabu 2018; Krishnan and Lakshmi 2013; Sekar et al. 2019; Felicita, Chandrasekar, and Shanthasundari 2012)(Neelakantan et al. 2011; R. K. Jain, Kumar, and Manjula 2014; Johnson et al. 2019; Keerthana and Thenmozhi 2016; Lakshmi et al. 2015)

3. MATERIALS AND METHODS

3.1 Specimen Selection -

The present study consisted of 10 freshly extracted mandibular premolars with fully formed apices.These teeth were collected from the cases which had to undergo prosthodontic rehabilitation or had to undergo orthodontic treatment.The treatment plan in these cases indicated the extraction of such teeth.These teeth were selected for the study.These teeth were stored in saline at 4ºC.The access cavities were prepared with the help of size no.2 Endo Access bur (Dentsply Sirona). After this a size 10 K file was used to establish the working length. The file was made to negotiate till apex in all the cases until it was visible at the apical foramen. The working length was established 1 mm short of the apex in all cases.

These ten teeth were embedded in the modelling wax, which was stimulated in the mandibular arch form. These teeth were randomly divided in two groups of five teeth each. Before the instrumentation the pre operative scan of these ten teeth was taken with the help of CBCT. The cross section at three levels was assessed, the first being at 3mm from the apex(apical level), the second cross section being at 8mm from the apex (mid root level) and the third being at 15 mm from the apex (Coronal level). After this all the root canals were instrumented to the working length by a single operator with the help of standardized technique. All the specimens were instrumented to the working length with the help of size K10,K15 and

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K20 files.

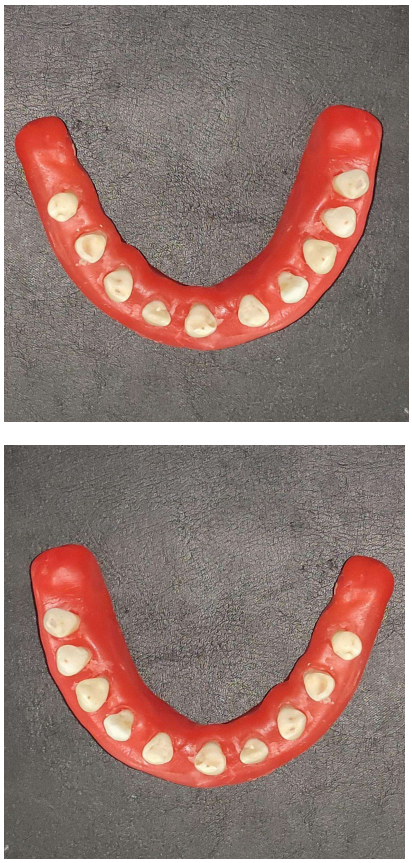

Figure 1- Image of Wax model

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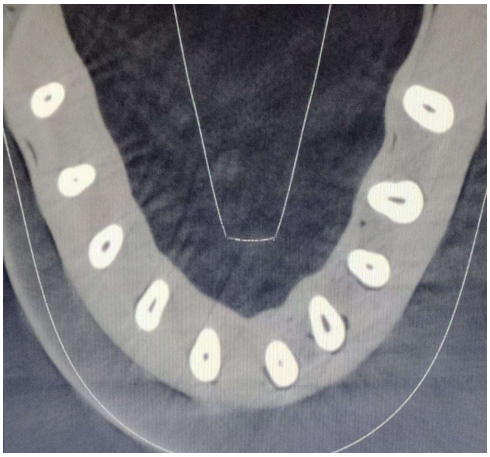
Figure 2- Decoronated Section teeth with wax model



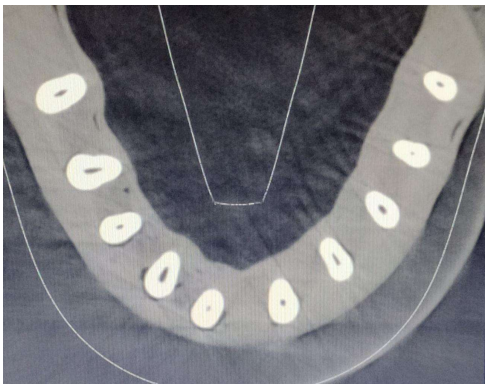


Figure 3 - CBCT scan of decoronated section

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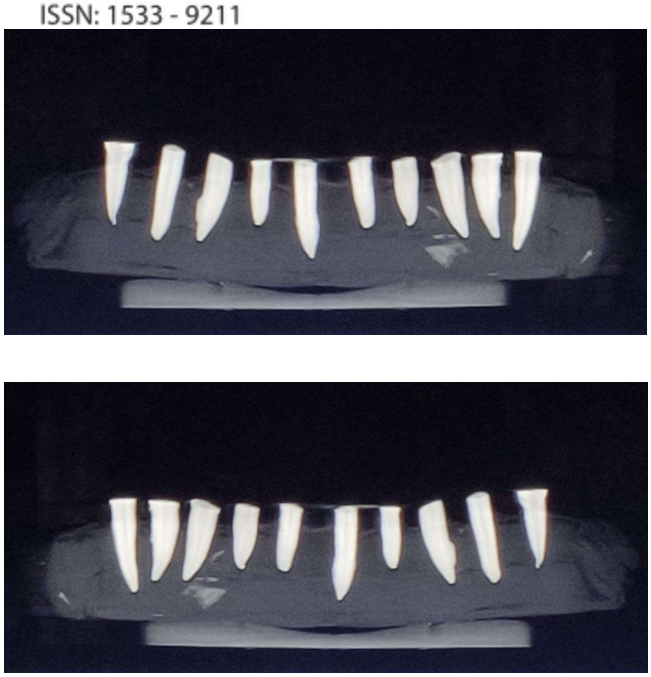

Figure 4 - CBCT scan of decoronated view represented from the frontal aspect

Specimens in Group 1 (n = 5) were prepared with the Rotary wave one gold file (Dentsply sirona) using a reduction gear handpiece powered by electric motor as guided by the manufacturers recommendations.

Specimens in Group 2 (n = 5) were prepared with the Trushape file (Dentsply sirona) using a reduction gear handpiece powered by an electric motor as guided by the manufacturer's recommendations.

The motion used in the preparation for both the specimens were in a slow and in a out pecking motion.The flutes of the files were cleaned with the help of wiping the file with 70% isopropyl alcohol rub after three in and out motions.Each instrument was discarded after the use in two canals , as per recommendations by manufacturers.

3.2 Evaluation of Canal Transportation:

The canal transportation can be assessed first by analysing the pre instrumented canal. The pre instrumented canal was analysed by taking measurement from the shortest distance at the edge of the canal to the periphery of the root canal either mesially or distally.This unistrumented canal was later compared with the instrumented canal.All the values were cross verified by two evaluators and a mean value was taken.

The formula to measure the difference was (a1-a2) - (b1 - b2). The value “a1” was the shortest distance from the mesial edge of the root to the mesial edge of the uninstrumented canal. The value “b1” was the shortest distance from the distal edge of the root to the distal edge of the uninstrumented canal. The value “a2” was the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal .The value “b2” was the shortest

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distance from the distal edge of the root to the distal edge of the instrumented canal .

The statistical analysis was performed with the One - way analysis of variance followed by post hoc Tukey(Honestly Significantly Different) statistical tests.The level of significance was set at a value of 0.05.

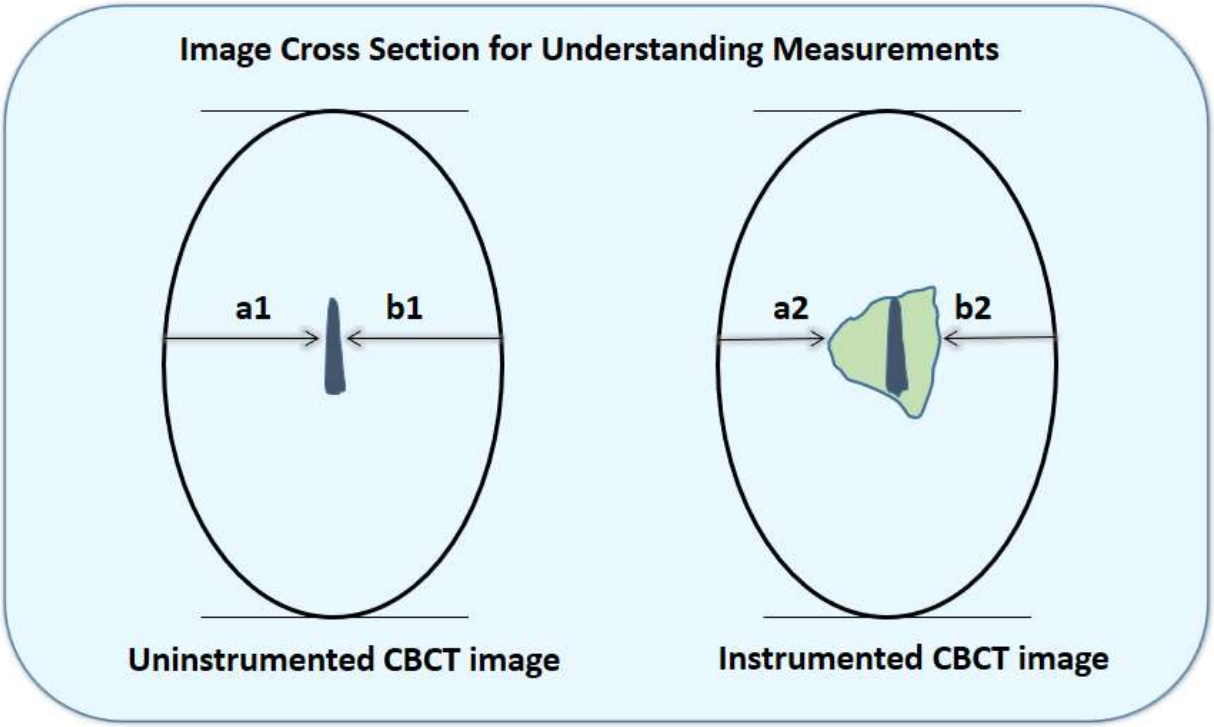

Figure 1. Depicting the cross sectional view of the uninstrumented and the instrumented canal. The initial measurement of the uninstrumented canal is shown by a1,b1 values .The instrumented canal measurements are taken by the a2,b2 values.The value a1 represents distance from the mesial edge of the root to the mesial edge of the uninstrumented canal.The value "a2" was the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal. The value "b2" was the shortest distance from the distal edge of the root to the distal edge of the instrumented canal .

3.3 Evaluation of Centering Ability:

The mean centering ratio indicates the ability of the instrument to not deviate from the glidepath and to stay centered in the canal . It was calculated by the following ratio:(a1-a2)/(b1-b2). A value of 1 indicates the perfect centering ability.One way analysis of variance followed by Tukey HSD multiple comparisons was conducted to look at a significant difference in mean centering ratio.The level of significance was at 0.05.

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4. RESULTS

The following results were obtained.

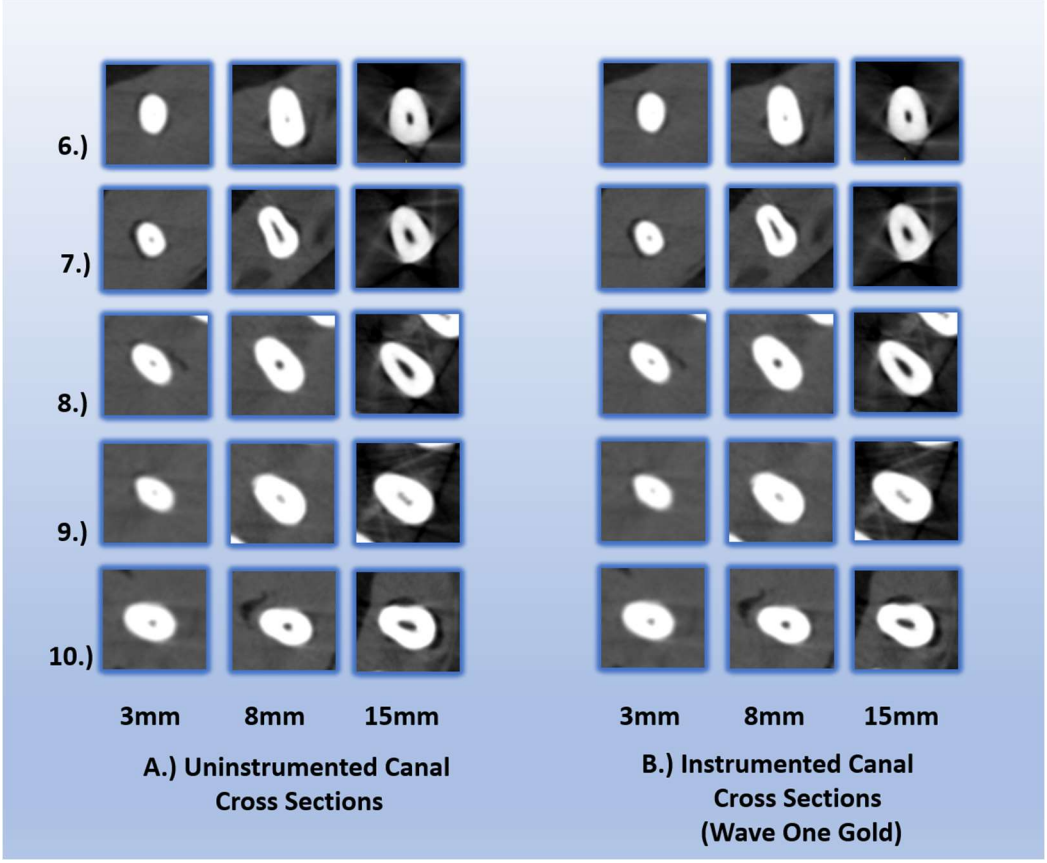

Figure 2 : Uninstrumented VS Wave One Gold (depicted as a1 in the statistical table)

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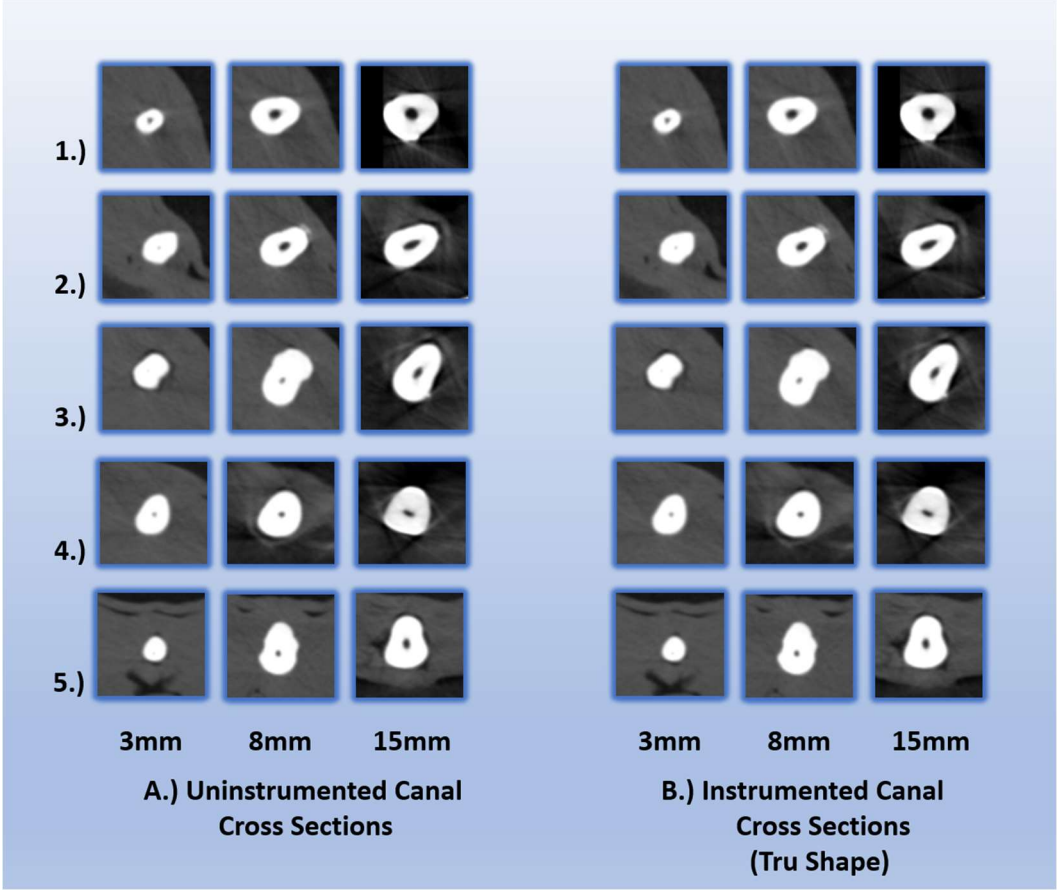

Figure 3 : Uninstrumented VS True Shape (depicted as b1 in the statistical table)

Group Statistics						
	Group	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**p-value**
3mm(a1)	1.00	10	1.8810	.50571	.15992	.566
	2.00	10	2.0240	.58396	.18466	
3mm(b1)	1.00	10	1.6350	.53163	.16812	.069
	2.00	10	2.1480	.64853	.20508	
8mm(a1)	1.00	10	2.6460	.58123	.18380	.983
	2.00	10	2.6410	.45103	.14263	
8mm(b1)	1.00	10	2.3430	.23894	.07556	.058
	2.00	10	2.6910	.48873	.15455	
15mm(a1)	1.00	10	2.7220	.29713	.09396	.760
	2.00	10	2.6840	.24959	.07893	
15mm(b1)	1.00	10	2.6170	.39260	.12415	.104
	2.00	10	2.9040	.35722	.11296	

Table 1 .Statistical Output .The is no significant difference between groups. A1 stands for the samples of the waveone gold file system and B1 stands for the trushape file system.

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5. DISCUSSION

Canal centering ability plays a significant role in the preservation of the dentine and offers the selective removal of carious dentine . The instruments which offer a better canal centering ability enhance the life of the tooth after the root canal treatment (Venkateshbabu et al. 2009) Canal centring ability predominantly depends on the design and the cross section of the instrument. Canal centring ability with a value of 1 depicts perfect ability of the file system to only remove the carious dentine and to not waver from the path of removal of the canal curvature (A. Jain et al. 2016). Niti instruments play an effective role in offering better centring ability than traditional instruments made out of stainless steel. Niti instruments offer better flexibility that adapt to the canal as they are heat treated files which are formed by the martensitic transformation. The ideal objective of the root canal preparation is to have a continuous tapered preparation with the apical foramen as small as possible(Gavini et al. 2018) One of the other studies showed that transportation patterns found the advantage of using these types of mechanized preparation systems in clinical practice, primarily due to their safety. Other aspects , such as resistance to cyclic and torsional fatigue, clinical factors associated with the apical transportation and centring ability emphasize the quality of these NiTi systems . These instruments produce few changes in the canal anatomy during root canal preparation. The measurement of post-instrumentation root canal transportation and centring may reveal the efficacy of root canal instruments in maintaining the original root canal anatomy, reducing aberrations and ultimately facilitating the three-dimensional cleaning of the root canal walls .However, because of the large number of systems available, each presenting different sequences composed of instruments with various different designs, taper, and function it is important for clinicians to have information about their safety and effectiveness during root canal preparation (Pinheiro et al. 2018)

The modern Niti instruments like the wave one gold and the Trushape files are created with the help of CAD - CAM technology , this gives them better cutting ability closer to the apical third region. One of the significant but crucial uncontrollable factors is the clinician skill that plays a valuable role in preparation of the canal (Radcliffe et al. 2017) Our team has done previous studies in this field and also wants to do study in future as this is a challenging field.(Rao and Kumar 2018; Felicita 2017; A. R. Jain 2017; Patturaja 2016; Mp 2017; Sivamurthy and Sundari 2016; Kumar et al. 2006; Azeem and Sureshbabu 2018; Krishnan and Lakshmi 2013; Sekar et al. 2019; Felicita, Chandrasekar, and Shanthasundari 2012)(Neelakantan et al. 2011; R. K. Jain, Kumar, and Manjula 2014; Johnson et al. 2019; Keerthana and Thenmozhi 2016; Lakshmi et al. 2015)

6. CONCLUSION

The canal centring ability of the Trushape file systems was much effective as compared to the samples created by wave one gold

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8.CONFLICT OF INTEREST -NIL

9. REFERENCES

- Agarwal, Rolly S. 2015. "Comparative Analysis of Canal Centering Ability of Different Single File Systems Using Cone Beam Computed Tomography- An In-Vitro Study." *JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH*. https://doi.org/10.7860/jcdr/2015/12097.5863.
- Ahn, Sangmi, Jung-Hong Ha, Sang Won Kwak, and Hyeon-Cheol Kim. 2020. "Advancement of Mechanical Properties of Nickel-Titanium Rotary Endodontic Instruments by Spring Machining on the File Shaft." *Materials*. https://doi.org/10.3390/ma13225246.
- Azeem, Rubeena Abdul, and Nivedhitha Malli Sureshbabu. 2018. "Clinical Performance of Direct versus Indirect Composite Restorations in Posterior Teeth: A Systematic Review." *Journal of Conservative Dentistry: JCD* 21 (1): 2.
- Felicita, A. Sumathi. 2017. "Quantification of Intrusive/retraction Force and Moment Generated during En-Masse Retraction of Maxillary Anterior Teeth Using Mini-Implants: A Conceptual Approach." *Dental Press Journal of Orthodontics* 22 (5): 47–55.
- Felicita, A. Sumathi, Shyamala Chandrasekar, and K. K. Shanthasundari. 2012. "Determination of Craniofacial Relation among the Subethnic Indian Population: A Modified Approach - (Sagittal Relation)." *Indian Journal of Dental Research: Official Publication of Indian Society for Dental Research* 23 (3): 305–12.
- Gavini, Giulio, Marcelo dos Santos, Celso Luis Caldeira, Manoel Eduardo de Lima Machado, Laila Gonzales Freire, Elaine Faga Iglecias, Ove Andrea Peters, and George Táccio de Miranda Candeiro. 2018. "Nickel–titanium Instruments in Endodontics: A Concise Review of the State of the Art." *Brazilian Oral Research*. https://doi.org/10.1590/1807-3107bor-2018.vol32.0067.
- Goldberg, Mathieu, Sandrine Dahan, and Pierre Machtou. 2012. "Centering Ability and Influence of Experience When Using WaveOne Single-File Technique in Simulated Canals." *International Journal of Dentistry*. https://doi.org/10.1155/2012/206321.
- Hulsmann, Michael, Ove A. Peters, and Paul M. H. Dummer. 2005. "Mechanical Preparation of Root Canals: Shaping Goals, Techniques and Means." *Endodontic Topics*. https://doi.org/10.1111/j.1601-1546.2005.00152.x.
- Jain, Aditi, Hemant Asrani, Abhinavchand Singhal, Taranjeetkaur Bhatia, Vaibhav Sharma, and Pragya Jaiswal. 2016. "Comparative Evaluation of Canal Transportation, Centering Ability, and Remaining Dentin Thickness between WaveOne and ProTaper Rotary by Using Cone Beam Computed Tomography: An in Vitro Study." *Journal of Conservative Dentistry*. https://doi.org/10.4103/0972-0707.190024.
- Jain, Ashish R. 2017. "Prevalence of Partial Edentulousness and Treatment Needs in Rural Population of South India." *World Journal of Dentistry* 8 (3): 213–17.

DOI: 10.5281/zenodo.7095048

- Jain, Ravindra Kumar, Sridhar Prem Kumar, and W. S. Manjula. 2014. "Comparison of Intrusion Effects on Maxillary Incisors among Mini Implant Anchorage, J-Hook Headgear and Utility Arch." *Journal of Clinical and Diagnostic Research: JCDR* 8 (7): ZC21–24.
- Johnson, Jayapriya, Ganesh Lakshmanan, M. Biruntha, R. M. Vidhyavathi, Kohila Kalimuthu, and Durairaj Sekar. 2019. "Computational Identification of MiRNA-7110 from Pulmonary Arterial Hypertension (PAH) ESTs: A New microRNA That Links Diabetes and PAH." *Hypertension Research: Official Journal of the Japanese Society of Hypertension* 43 (4): 360–62.
- Keerthana, B., and M. S. Thenmozhi. 2016. "Occurrence of Foramen of Huschke and Its Clinical Significance." *Journal of Advanced Pharmaceutical Technology & Research* 9 (11): 1835.
- Krishnan, Vidya, and T. Lakshmi. 2013. "Bioglass: A Novel Biocompatible Innovation." *Journal of Advanced Pharmaceutical Technology & Research* 4 (2): 78–83.
- Kumar, Muthusamy Senthil, Gelli Vamsi, Ramasamy Sripriya, and Praveen Kumar Sehgal. 2006. "Expression of Matrix Metalloproteinases (MMP-8 and -9) in Chronic Periodontitis Patients with and without Diabetes Mellitus." *Journal of Periodontology* 77 (11): 1803–8.
- Lakshmi, T., Vidya Krishnan, R. Rajendran, and N. Madhusudhanan. 2015. "Azadirachta Indica: A Herbal Panacea in Dentistry - An Update." *Pharmacognosy Reviews* 9 (17): 41–44.
- Mp, Santhosh Kumar. 2017. "THE EMERGING ROLE OF BOTULINUM TOXIN IN THE TREATMENT OF OROFACIAL DISORDERS: LITERATURE UPDATE." *Asian Journal of Pharmaceutical and Clinical Research*, September, 21–29.
- Neelakantan, P., C. Subbarao, C. V. Subbarao, G. De-Deus, and M. Zehnder. 2011. "The Impact of Root Dentine Conditioning on Sealing Ability and Push-out Bond Strength of an Epoxy Resin Root Canal Sealer." *International Endodontic Journal* 44 (6): 491–98.
- Patel, Shanon, Simon Harvey, Hagay Shemesh, and Conor Durack. 2019. *Cone Beam Computed Tomography in Endodontics*. Quintessenz Verlag.
- Patturaja, Kiruthika; Pradeep. 2016. "Awareness of Basic Dental Procedure among General Population." *Research Journal of Pharmacy and Technology; Raipur* 9 (9): 1349–51.
- Pettiette, M., E. Olutayodelano, and M. Trope. 2001. "Evaluation of Success Rate of Endodontic Treatment Performed by Students with Stainless-Steel K–Files and Nickel–Titanium Hand Files." *Journal of Endodontics*. https://doi.org/10.1097/00004770-200102000-00017.
- Pinheiro, S. R., M. P. Alcalde, N. Vivacqua-Gomes, C. M. Bramante, R. R. Vivan, M. A. H. Duarte, and B. C. Vasconcelos. 2018. "Evaluation of Apical Transportation and Centring Ability of Five Thermally Treated NiTi Rotary Systems." *International*

DOI: 10.5281/zenodo.7095048

Endodontic Journal. https://doi.org/10.1111/iej.12881.

- Radcliffe, Eloise, Swapnil G. Ghotane, Victoria Harrison, and Jennifer E. Gallagher. 2017. "Interprofessional Enhanced Skills Training in Periodontology: A Qualitative Study of One London Pilot." *BDJ Open*. https://doi.org/10.1038/bdjopen.2017.1.
- Rao, Tinesh Dayaa, and M. P. Santhosh Kumar. 2018. "Analgesic Efficacy of Paracetamol vs Ketorolac after Dental Extractions." *Journal of Advanced Pharmaceutical Technology & Research* 11 (8): 3375.
- Sekar, Durairaj, Ganesh Lakshmanan, Panagal Mani, and M. Biruntha. 2019. "Methylation-Dependent Circulating microRNA 510 in Preeclampsia Patients." *Hypertension Research: Official Journal of the Japanese Society of Hypertension* 42 (10): 1647–48.
- Sivamurthy, Gautham, and Shantha Sundari. 2016. "Stress Distribution Patterns at Mini-Implant Site during Retraction and Intrusion—a Three-Dimensional Finite Element Study." *Progress in Orthodontics* 17 (1): 1–11.
- Srivastava, Swati. 2018. "Current Strategies in Metallurgical Advances of Rotary NiTi Instruments: A Review." *Journal of Dental Health, Oral Disorders & Therapy*. https://doi.org/10.15406/jdhodt.2018.09.00333.
- Venkateshbabu, Nagendrababu, Ilango Porkodi, Gali Pradeep, and Deivanayagam Kandaswamy. 2009. "Canal-Centering Ability: An Endodontic Challenge." *Journal of Conservative Dentistry*. https://doi.org/10.4103/0972-0707.53334.
- Vorster, Martin, Peet J. van der Vyver, and Farzana Paleker. 2018. "Influence of Glide Path Preparation on the Canal Shaping Times of WaveOne Gold in Curved Mandibular Molar Canals." *Journal of Endodontics*. https://doi.org/10.1016/j.joen.2018.01.017.
- Zuolo, Arthur de Siqueira, Arthur de Siqueira Zuolo, Mario Luis Zuolo, Carlos Eduardo da Silveira Bueno, Rene Chu, and Rodrigo Sanches Cunha. 2016. "Evaluation of the Efficacy of TRUShape and Reciproc File Systems in the Removal of Root Filling Material: An Ex Vivo Micro–Computed Tomographic Study." *Journal of Endodontics*. https://doi.org/10.1016/j.joen.2015.11.005.