How to Cite:
Chaudhari, W. A., Kakani, A., Deshmukh, M., Aade, S., Gelda, A., & Agrawal, M. (2022). Shaping ability of waveone primary reciprocating files and oneshape rotary files in severely curved root canals: A comparative study with micro-computed tomography. *International Journal of Health Sciences*, *6*(S1), 12561–12571. https://doi.org/10.53730/ijhs.v6nS1.8338

Shaping ability of waveone primary reciprocating files and oneshape rotary files in severely curved root canals: A comparative study with micro-computed tomography

Dr Wasifoddin A. Chaudhari
Reader, Department of Conservative Dentistry and Endodontics, Nanded Rural Dental College and Research Centre, Nanded.
Email: wasifoddin.chaudhari@yahoo.in

Dr Abhijeet Kakani
Reader, Department of Conservative Dentistry and Endodontics, Nanded Rural Dental College and Research Centre, Nanded.
Email: abhijeetkakani@yahoo.com

Dr. Mrunal Deshmukh
Senior Lecturer, Department of Conservative Dentistry and Endodontics, Nanded Rural Dental College and Research Centre, Nanded.

Dr Sharda Aade
Senior Lecturer, Department of Conservative Dentistry and Endodontics, Nanded Rural Dental College and Research Centre, Nanded.
Email: dr.shardaade@gmail.com

Dr Akshay Gelda
Private Dental Practitioner.
Email: akshaygelda@gmail.com

Dr. Madhuri Agrawal
Reader, Department of Conservative Dentistry and Endodontics, Maharashtra Institute of Dental Science & Research, Latur.
Email: drmadhuriagrawal03@gmail.com

***Abstract*---**Introduction: This study compared the amount of canal transportation, canal centering ability after instrumentation and time required for shaping of canal with WaveOne Primary Reciprocating file and OneShape Rotary file. Method: Thirty intact mesial roots of mandibular first molars were divided into Group I and Group II. Specimens in Group I were shaped with WaveOne Primary

reciprocating files to the working length (WL) and specimens in Group II were shaped with OneShape Rotary file to the WL. Time required to prepare each canal was recorded. All the specimens were submitted to micro-computed tomography (μCT) unit for Pre- and post-instrumentation scan. Images were reconstructed and cross-sections corresponding to distances 3, 6 and 9 mm from the anatomic apex were selected for analysis. Statistical analysis was performed with Kruskal Wallis and paired t test. Results: Overall, both rotary files maintained root canal curvatures well. During canal preparation, OneShape file performed significantly better in the apical third when compared to the WaveOne Reciprocating file. WaveOne file required reasonably less time to prepare canal when rather than OneShape file. Conclusions: The OneShape rotary system, probably owing to its cross-sectional design and comparative less taper (than WaveOne Primary file) seems under the conditions of this study to be a better choice in preparing severe curved root canals.

***Keywords*---**canal centering, micro-computed tomography, OneShape, transportation, WaveOne.

Introduction

Cleaning and shaping the root canal is recognized as an important phase in endodontic therapy (1). The ability to enlarge a canal without deviation during instrumentation is a primary objective in endodontics. The introduction of instruments manufactured from nickel titanium (NiTi) alloys (2), a significant improvement of the quality of root canal shaping, with predictable results and less iatrogenic damage has been observed, even in severely curved root canals (3).

Unlike multiple NiTi file system, it has been proposed that the single-file shaping technique may simplify instrumentation protocols and avoid the risk of cross contamination (4). Moreover, the use of single file system is more cost effective, and the learning curve is considerably reduced (5). The WaveOne NiTi single-file system has been recently introduced by Dentsply Maillefer (Ballaigues, Switzerland). The system is designed to use with a dedicated reciprocating motion motor. It consists of 3 single-use files: 1. Small file is used in fine canals. The tip size is ISO 21 with a continuous taper of 6%. 2. Primary file is used in the majority of canals. The tip size is ISO 25 with an apical taper of 8% that reduces towards the coronal end. 3. Large file is used in large canals. The tip size is ISO 40 with an apical taper of 8% that reduces towards the coronal end (5).

Another concept of single-file instrumentation with totally clockwise rotation is OneShape (Micro Méga, Besançon, France). The OneShape system consists of only one instrument, which has a tip size of 25 and a constant taper of 6% and is characterised by different cross-sectional designs over the entire length of the working part. There are no studies available on the canal shaping ability of the WaveOne (single reciprocating file) and OneShape (single rotary file) instruments till date. Hence, the purpose of this study is to compare canal shaping parameters such as canal transportation, canal centering ability & preparation time with two

newly designed single file systems i.e. Wave One Primary Reciprocating file and OneShape Rotary file using micro-computed tomography (μCT).

Materials and Methods

Thirty mandibular first molars with intact pulp chambers, fully formed roots, 2 mesial canals with independent foramina, severe (25-35°) curvature (6), and a curvature radius less than 10 mm were selected (7). Teeth having calcified canals and defects such as caries, cracks, perforation and resorptive defects were excluded. Tooth length was standardized at 18 mm by grinding the occlusal surfaces with a diamond disk (Buehler, IL, USA). In all specimens, distal root with the respective part of crown was sectioned at furcation level and discarded. The radiographs were taken in mesiodistal dimension to confirm the presence of two distinct and separate root canals before instrumentation. After standard access preparation, the mesio-buccal canals were negotiated using K file sizes 10 and 15 (Maillefer, Ballaigues, Switzerland) until the tip of the file became visible at the apical foramen with the help of an operating microscope (Seiler Precision Microscopes, USA), at 10 X magnification. Working length was measured and recorded by reducing 0.5 mm from the total length of file in the respected canal.

To ease in the holding of specimen during instrumentation, each sectioned mesial root was embedded into transparent acrylic resin block (DPI RR Cold Cure, India) up to cemento-enamel junction with the customized mould (15 mm length x 15 mm width and 20 mm height). The prepared specimens were randomly divided into 2 experimental groups and embedded in custom made mount made up of vinyl polysiloxane impression material (Aquasil, Dentsply DeTrey GmbH, Germany) for μCT scanning.

Pre and Post-instrumentation scanning:
Pre and post instrumentation scan of the entire specimens were taken with a μCT unit (SkyScan 1172, Aartselaar, Belgium) at 35 μm resolution. Raw scanned data was reconstructed into images by using the software (NRecon V1.6.1.0 SkyScan).

Root canal Instrumentation:
The entire specimens were instrumented in strict accordance with the manufacturer's recommendation for each system.
Group I: WaveOne Primary Reciprocating File.
Each specimen was shaped with a new WaveOne primary reciprocating to respective working length using pecking motion. The dedicated reciprocating motor of WaveOne file was used with the manufacturing configuration setup.
Intermittently canals were irrigated with 3 mL of 3% NaOCl (ChlorCid Ultradent, Utah, USA) using 30 gauge needle (NaviTip, Ultradent, Utah, USA). Flutes of the files were cleaned with moist gauze piece soaked with NaOCl. EDTA paste (Glyde, Dentsply Maillefer, Ballaigues, Switzerland) was used as the lubricating agent. Final irrigation was conducted with 10 mL of 3% NaOCl.
Group II: OneShape Rotary File.
Canals were shaped with OneShape rotary files attached to endomotor system (X-smart, Dentsply Maillefer, Ballaigues, Switzerland). OneShape file was used in continuous rotary motion in gentle in-and-out motion. According to the manufacturer's instructions, endo motor was set at the speed of 400 rpm with 4

Ncm torque. Every specimen was shaped with a new file. Same irrigation protocol was followed as in Group I.

Shaping Assessment:
Cross sections of mesiobuccal canals at 3, 6 and 9 mm from the root apex were viewed in explorer mode.
Canal transportation:
Degree of canal transportation was calculated at each level according to following formula: (A1 - A2) - (B1 - B2) as described by Gambill (8), where A1 is the shortest distance between the mesial edge of the root and the mesial edge of the uninstrumented canal; B1 is the shortest distance between the distal edge of the root to the distal edge of the uninstrumented canal; A2 is the shortest distance between the mesial edge of the root and the mesial edge of the instrumented canal; B2 is the shortest distance between the distal edge of the root and the distal edge of the instrumented canal . According to this formula the result of "0" indicates no canal transportation. The result other than "0" means that transportation has occurred in the canal. Pre- and postoperative measurements were compared to reveal the presence or absence of deviations in canal anatomy.

Canal centering ability:
According to Gambill *et al.* the mean centering ratio indicates the ability of the instrument to remain centered in the canal (8). This ratio was calculated by the formula (A1 - A2) ÷ (B1 - B2). Whenever these numbers were not equal, the lower figure was considered to be the numerator of the ratio. According to this formula, the result of 1 indicates perfect centering ability (11).

Preparation time:
A stop watch was used to measure the total instrumentation time for each canal and was recorded in seconds. It also included the actual instrumentation time in the canal, application of lubricant, intermittent cleaning the flutes of instrument and irrigation.

All root canal preparations were completed by one operator whilst the measurements on the μCT data prior to and after instrumentation and statistical analysis were carried out by a second examiner who was blind in respect of all experimental groups. Data pertaining to canal transportation, canal centering ability and preparation time was analyzed by using Kruskal Wallis test. The paired t test was used for pair wise comparison at three different levels.

Results

During the preparation of the curved canals neither deformation of an instrument nor instrument fracture was noted.

Canal transportation:
The degree of canal transportation in both the groups at three different levels is shown in Table 1. According to the results obtained in the present study both rotary systems had shown canal transportation at all levels of assessment. To compare at 6 mm and 9 mm from apex, the difference in the transportation was statistically not significant. But it was statistically significant at the level of 3 mm

from the apex. WaveOne files transported more than OneShape files with mean values of 0.55 ± 0.42 and 0.17 ± 0.10, respectively.

Canal centering ability:
Both the file systems have shown the loss of canal centering ability at all three levels of examination. No significant difference was observed at the level of 6 mm and 9 mm between both the groups. At 3 mm from the apex, WaveOne file lost canal centering ability more than OneShape file, which is statistically significant as shown in Table: 1.

Preparation time:
The mean time for instrumentation with WaveOne reciprocating file was 204.40 Seconds (S.D- 18.25) whereas for OneShape rotary file system was 289.44 seconds (S.D- 30.42), which is statistically. (Table: 2).

Discussion

New NiTi rotary systems are continuously being marketed with the claim of improved flexibility, cutting efficiency, resistance to fracture and reduced preparation time. In order to prove these claims, recently few single file systems have been designed such as WaveOne, Reciproc (VDW, Munich, Germany), F-360 (Komet Brasseler, Lemgo, Germany) and OneShape (Micro Méga, Besançon, France).

Till date, there have been no studies published on the quality of canal preparation with WaveOne and OneShape to maintain canal curvature. So the purpose of the present study was to compare root canal transportation, canal centering ability and preparation time with WaveOne and OneShape in severely curved root canals, using micro-computed tomography (μCT). Literature reveals different experimental designs and methods used for this purpose. Such as:

1. Use of resin blocks of different geometry to simulated root canals and then superimposing pre and post-operative instrumentation photographic images (9).
2. Comparative analysis by superimposing radiographic images of root canal before and after instrumentation (10).
3. Use of silicone impressions of instrumented root canals (11).
4. Use of an analytical reassembly technique, which examined cross-sections of root canals before and after instrumentation, popularized as Bramante technique. (12). Then modified Bramante technique has been used (13).
5. Stereomicroscopic evaluation of cross or longitudinal sections of prepared root canals (14).
6. Scanning electron microscopic study of the walls of instrumented root canals (15).
7. Computed tomography (CT) (16).
8. Micro-computed tomography (μCT) (17).

Among all these, μCT helps to visualize and study the morphology of the root canals before and after instrumentation in 3 dimensions without destruction of the specimens (9,18). In this in-vitro study, mesial roots of mandibular first molars were chosen as study objects because mesial canals are often curved in 2

planes (19). Considering the morphologic variations in mandibular first molars, in the present study attempts were made to ensure comparability of the experimental groups. Therefore, the teeth in both groups were balanced with respect to the apical diameter (negotiated with #15 K-file), length of the root canal (approx.18 mm from apex to occlusal reference point), severe degree of root curvature (25-35°) (6), and a curvature radius less than 10 mm were selected (7).

Although simulated root canals in the resin block can also be used as substitutes, but they have not been considered ideal to be used for the study of rotary instruments because the difference in micro hardness between resin and dentine may affect the cutting behaviour of the instruments. They do not cut in the same manner as dentin owing to the difference in micro hardness between dentin (35 to 40 Kg/mm) and resin (20 to 22 Kg/mm) (20). Moreover the heat generated during instrumentation can soften the resin. Additionally, it has been criticized that the size of resin chips and natural dentine chips may be not identical, resulting in frequent blockages of the apical root canal space and difficulties to remove the debris in resin canals. So, data on quality of canal preparation, working safety and working time from any studies using resin blocks may not be transferable to the clinical situation (20).

In the present study, distal root of the each tooth was separated at the furcation and discarded. This was done in order to place the specimens as close as possible to the x-ray source of the μCT unit. This also facilitated taking radiograph of each mesial root in mesio-distal direction to confirm 2 separate root canals in it. The crowns were maintained to simulate, as closely as possible, the clinical endodontic practice, in which the interference of cervical dentin projections creates tensions on the files during root canal instrumentation (21).

Many authors suggested the size of master file should be at least ISO No. 25 to predictably clean and seal the foramen (22). Among the WaveOne family, the Primary file with a tip size of 25 was selected. Moreover, OneShape is only available with a tip size of 25.

According to the results obtained in the present study both rotary systems had shown canal transportation at all levels of assessment. No significant difference in the transportation was observed at the level of 6 mm and 9 mm. At 3 mm from the apex, WaveOne file significantly transported canal more than OneShape file.

This significant difference at apical 3 mm is probably due to canal curvature and resulting higher stresses on the instrument owing to the critical changes on the relationship of diameter and flexibility. These results are in agreement with the finding of López et al. (23) who found an increased tendency toward canal transportation as the diameter of file increased. Another important factor responsible for apical transportation is taper of the file. Taper of the file is directly proportional to the amount of apical transportation (24). The transportation is caused by tendency of the instrument to return to its original straight shape when inserted into a curved root canal (25). The results of our study are in accordance with previously mentioned factors responsible for canal transportation. The WaveOne Primary file transported more in the apical region of the canal may be due to its 8% taper and resulting larger core diameter from D1

to D3 as compared to OneShape file having constant taper of 6% throughout its working length.
According to the results obtained in the present study for canal centering ability, both rotary systems have a similar behaviour and allowed the preparation of mesiobuccal canals of mandibular first molars with little deviation from the center. Neither of the systems used in the study have perfect centering ability. No significant difference in the canal centering ability was observed at the level of 6 mm and 9 mm in both groups. At 3 mm from the apex, WaveOne file lost canal centering ability more than OneShape file, which is statistically significant.

The relevance of canal centering during instrumentation pertains primarily to canal transportation (26). For centering ability, the results obtained in this study are in agreement with the findings of previous reports (15). They found that constant tapered instruments produced good centering ability in the apical section of curved roots compared to instruments with variable taper along the cutting surface. WaveOne primary file is thicker & stiffer than OneShape file owing to its 8% taper as compared to OneShape file with 6% taper. This may attribute to our results.

At the point of discussion on cross section, both systems show variable cross section designs along the length of working part to make them more flexible.
WaveOne file has 2 different cross section designs. (5)
1. Modified convex triangular cross section: From D0 to D8
2. convex triangular cross section: From D9 to D16

In the 17 mm length of working part, OneShape file has 3 different cross-section zones (27):
1. Zone with 3 cutting edges : From D0 to D2
2. Transition zone : From D2 to D9.5
3. Zone with 2 identical cutting edges : From D9.5 to D17

This feature makes OneShape file more flexible and helps it to remain centered in the canal. In contrast to results of this study, it is worth noting that OneShape instruments are made of a conventional austenite 55-NiTi alloy, while WaveOne instruments are made of M-wire alloy (M-Wire, Dentsply Tulsa Dental Specialties, Tulsa, OK, USA). According to some studies instruments made of M-wire alloy have an increased flexibility and torsional resistance compared with conventional NiTi (28). Preparation time depends on the technique and the numbers of instruments used, the operator experience and on further details of the study design (29).

In the present study the preparation time includes active instrumentation as well as the time requires to clean the flutes of the instruments and irrigation in order to allow comparison of the results with those of previous studies conducted with an identical experimental setup (30). The current study reveals statistical significant difference between 2 groups regarding the preparation time. WaveOne primary reciprocating file requires approximately 30% less time to prepare canal to full working length rather than OneShape single rotary file. The obtained results may be due to the following facts. The WaveOne file is dedicated to be used with rechargeable battery operated pre-programmed motor. In the program,

the counter clockwise (CCW) movement is greater than the clockwise (CW) movement. CCW movement advances the instrument, engaging and cutting the dentine. CW movement disengages the instrument from the dentine before it can (taper) lock into the canal. It is claimed that the instrument advances continuously towards the apex of the root canal. On the contrary, OneShape file during its continuous rotary movement, binds into dentine due to taper-lock. There is no mechanism to unlock this taper lock which is seen in reciprocating movement.

The reduction in preparation time while using both the single-file systems is a clinically relevant finding. Simultaneously, the time available for irrigation and chemical debridement of the root canal system is also markedly reduced. To compensate the decreased irrigation time when using single-file systems, larger volumes of irrigant and/ or additionally activation of the irrigant seem to be advisable in order to improve chemical dissolution of residual debris and disinfection of the root canal system (31). The use of EDTA as one of the irrigating solutions in the present study should be taken into account because the study (32) reported that dentin demineralization caused by EDTA irrigation increased root canal transportation in canals. Further studies are required to compare these for amount of residual radicular dentin and canalk volume after preparation, with dynamic μCT.

Conclusion

Within the limitation of this study, it is possible to conclude that the quality of canal preparation with WaveOne single file system and OneShape single file system is acceptable.

Innovated method of manufacturing the OneShape system resulted in superior canal centering and least transportation at the most critical area of root canal i.e. apical third. On the other hand, WaveOne single file with reciprocating movement requires less time to prepare root canal. Whether, once obturated, these differences affect the final clinical success cannot be determined and will need to be investigated in long term clinical studies.

Tables

Table: I
Showing Canal transportation & Centering ability

Level of examination (from apex)	Number of samples (n)	Canal Transportation		Centering Ability		Level of Significance
		Group I: WaveOne	Group II: OneShape	Group I: WaveOne	Group II: OneShape	
		(Mean ± S.D.)	(Mean ± S.D.)	(Mean ± S.D)	(Mean ± S.D)	
3 mm	30	0.55 ±	0.17 ±	0.39 ±	0.59±	Significant

6 mm	30	0.42 0.35 0.29	±	0.10 0.33 0.31	±	0.20 0.38 ±0.20	0.25 0.49 ±0.13	Not significant
9 mm	30	0.17 0.19	±	0.15 0.18	±	0.43± 0.30	0.40 0.31	± Not significant

Table: II
Average preparation time (in seconds) required for both file systems

Instruments	Mean (seconds)	S.D.
Group I: WaveOne	204.40	18.25
Group II: OneShape	289.44	30.42

References

1. Schilder H. Cleaning and shaping the root canal. Dent Cli N Am 1974;18:269-96.
2. Walia HM, Brantley WA, Gerstein H. An initial investigation of the bending and torsional properties of nitinol root canal files. *J Endod* 1988;14:346-51.
3. Kuhn WG, Carnes DL Jr, Clement DJ, Walker WA 3rd. Effect of tip design of nickel-titanium and stainless steel files on root canal preparation. *J Endod* 1997;23:735–8.
4. Smith A, Letters A, Lange A, Perrett D, McHugh S, Bagg J. Residual protein levels on reprocessed dental Instruments. *J Hosp Inf* 2005;61:237–241.
5. Webber J, Machtou P, Pertot W, Kuttler S, Ruddle C, West J. The WaveOne single-file reciprocating system. *Roots* 2011;1:28-33.
6. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1971;2:271-5.
7. Schäfer E, Diez C, Hoppe W, Tepel J. Roentgenographic investigation of frequency and degree of canal curvatures in human permanent teeth. *J Endod* 2002;28:211-6.
8. Gambill JM, Alder M, Del Rio CE. Comparison of nickel titanium and stainless steel hand-file instrumentation using computed tomography. *J Endod 1996;22*:369-75.
9. Weine FS, Kelly RF, Lio PJ. The effect of preparation procedures on original canal shape and on apical foramen shape. *J Endod 1975;*1:255-62.
10. Iqbal MK, Maggiore F, Suh B, Edwards KR, Kang J, Kim S. Comparison of apical transportation in four NI-Ti rotary instrumentation techniques. *J Endod 2003;*29:587-91.
11. Abou-Rass M, Jastrab RJ.The use of rotary instruments as auxiliary aids to root canal preparation of molars. *J Endod 1982;*8:78-82.
12. Bramante CM, Berbert A, Borges RP. A methodology for evaluation of root canal instrumentation. *J Endod 1987;*13:243-5.
13. Kuttler S, Garala M, Perez R, Dorn SO. The endodontic cube: A system designed for evaluation of root canal anatomy and canal preparation. *J Endod 2001;*27: 533-6.

14. Wu MK, Wesselink PR. Efficacy of three techniques in cleaning the apical portion of curved root canals. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;*79:492-6.
15. Schafer E, Vlassis M. Comparative investigation of two rotary nickel-titanium instruments: ProTaper versus RaCe. Part 2.Cleaning effectiveness and shaping ability in severely curved root canals of extracted teeth. *Int Endod J 2004;*37: 239-48.
16. Gluskin AH, Brown DC, Buchanan LS. A reconstructed computerized tomographic comparison of Ni-Ti rotary GT files versus traditional instruments in canals shaped by novice operators. *Int Endod J 2001;*34:476-84.
17. Nielsen R, Alyassin A, Peters D, Carnes D, Lancaster J. Microcomputed tomography: an advanced system for detailed endodontic research. *J Endod 1995;* 21: 561-8.
18. Rhodes JS, Pitt Ford TR, Lynch JA, Liepins PJ, Curtis RV. Microcomputed tomography: a new tool for experimental endodontology. *Int Endod J* 1999;32:165–70.
19. Cunningham C, Senia S. A three-dimensional study of canal curvatures in mesial roots of mandibular molars. *J Endod* 1992;18:294–300.
20. Lim KC, Webber J. The validity of simulated canal preparation on the shape of the curved root canal. *Int Endod J 1985;*18:240-6.
21. Vanni JR, Santos R, Limongi O, Guerisoli DMZ, Capelli A, Pécora JD. Influence of cervical preflaring on determination of apical file size in maxillary molars: SEM analysis. *Braz Dent J* 2005;16:181-6.
22. Weine Franklin (2004) Endodontic therapy, 6th Edn. pp 175 Mosby Inc. publication.
23. López FU, Fachin EV, Camargo-Fontanella VR, Barletta FB, Só MV, Grecca FS. Apical transportation: a comparative evaluation of three root canal instrumentation techniques with three different apical diameters. *J Endod* 2008;34:1545-8.
24. Schafer E, Dzepina A, Dent CM, Danesh G. Bending properties of rotary nickel titanium instruments. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;*96:757-63.
25. WildelyW L, Senia E S, Montgomery S. Another look at root canal instrumentation. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1992;74:499-507.
26. Knowles KI, Ibarrola JL, Christiansen RK.Assessing apical deformation and transportation following the use of LightSpeed root-canal instruments. *Int Endod J* 1996;29:113-117.
27. Http:/OneShape-mm.com/English/
28. Alapati SB, Brantley WA, Iijma M, *et al.* Metallurgical characterization of a new Nickel-titanium wire for rotary endodontic instruments. *J Endod* 2009;35:1589-93.
29. Hülsmann M, Peters OA, Dummer PMH. Mechanical preparation of root canals: shaping goals, techniques and means. *Endo Topics2005;*10:30-76.
30. Bürklein S, Schäfer E. The influence of various automated devices on the shaping ability of Mtwo rotary nickel-titanium instruments. *Int Endod J 2006;*39:945-51.
31. Bürklein S, Hinschitza K, Dammaschke T, Schäfer E. Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals

of extracted teeth: Recproc and WaveOne versus Mtwo and ProTaper. *Int Endod J 2012;*45:449-61.

32. Bramante CM, Betti LV. Comparative analysis of curved root canal preparation using nickel-titanium instruments with or without EDTA. *J Endod* 2000;26:278-80.