

## ORIGINAL RESEARCH

### Evaluation of Canal Transportation and Centering Ability of Three Single File Systems

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#### ABSTRACT

**Introduction:** The canal transportation is defined as as removing the structure of canal wall on the outer curve in the apical half of the canal due to the fact that the rotary files being used failed to restore themselves to their original linear shape during canal shaping. The success of an endodontic treatment is determined majorly by the effective biomechanical preparation and following the original anatomy of the root canal.

**Materials and Methodology:** For the study purpose, eighty mesio-buccal root canals from human permanent mandibular first molars teeth which were extracted for various periodontal reasons, caries free and non-carious lesion free accompanied by normal anatomical form and structure were carefully selected. At once, the root canals were prepared, CBCT series of images were taken for all the teeth. Both mesiodistal and buccolingual diameters were recorded at 2mm, 3mm and 4 mm from the apex in both the diagnostic and postoperative CBCT imaging.

**Results:** The Reciproc (Group I) system revealed the greatest canal transportation with least centering ability when compared to other file systems that have been studied. The observable difference in the canal transportation in the 3 groups was reported to be statistically significant ( $p < 0.001$ ), except while comparing the 4 mm distance from the root apex, the buccolingual transportation was not statistically significant between the Reciproc and WaveOne groups ( $p = 0.591$ ). In, OneShape rotary file system has recorded the highest centering ability, while the Reciproc displayed the lowest under certain experimental conditions.

**Conclusion:** To conclude that the OneShape rotary file system reported with the lowest transportation in both the mesiodistal and buccolingual directions with the highest centering ability However, the Reciproc system revealed the highest transportation and the lowest centering ability. When considering the limitations of the present experimental study it can be ascertained that the Single file Oneshape system is suitable instrument of choice for the biomechanical preparation of root canal in curved scenario.

**Keywords:** Canal Transportation, Biomechanical Preparation, Single File Systems, Waveone, Reciproc.

## INTRODUCTION

An effective cleaning and shaping of the root canal system without changing the original true anatomy determines the success of root canal treatment.<sup>1</sup>The procedures such as the cleaning and shaping might lead to the removal of the remaining dentin from the canal walls irrespective of the instrumentation technique that has been adopted for that particular case.<sup>2</sup>The term 'canal transportation' could be defined as removing the structure of canal wall on the outer curve in the apical half of the canal due to the fact that the rotary files being used failed to restore themselves to their original linear shape during canal shaping.<sup>3</sup>The shaping ability of a particular rotary file system is assessed by analysing the postoperative root canal conicity, taper, flow of the prepared root canal, and maintaining the original canal shape. The ability of an instrument that is the rotary files or a technique to permit the prepared canal to stay centred is inferred as a positive aspect whereas the canal transportation and preparation errors were seen as a negative aspect. Various undesirable apical preparation outcomes such as damage to the apical foramen, elbow formation, zip formation and perforation have been described as the observable results of canal transportation.<sup>4</sup>

From the time of the introduction of the nickel-titanium (NiTi) instruments, the application of rotary instruments intended for biomechanical canal preparation, has revolutionized the endodontic therapy thus making it faster, reducing operator fatigue and treatment time and allowing only negligible procedural errors which are commonly associated with the use of stainless steel instruments,<sup>3</sup>thereby, decreasing the chair side time of the treatment procedure.<sup>4</sup>

Reciproc (VDW, Munich, Germany) is a novel, single-file system which is made from M-Wire NiTi alloy with S-shaped cross-section and a regressive taper that permits greater flexibility and cyclic fatigue resistance. This rotary system is used in reciprocation motion to finish the canal preparation by enabling the instrument to move through the root canal without a necessary for a glide path.<sup>5</sup>

WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) is another single-file shaping system, made up of M-Wire NiTi alloy comprises of reverse helix and 2 distinct cross-sections on the length with modified convex triangular cross section that encourages unequal clock-wise (CW) / counter clock-wise (CCW) angles. Increased flexibility is observed in such instrument due to the presence of deeper flutes thus making the instrument good to use in the preparation of curved canals.<sup>5</sup>

OneShape (Micro Méga, Besançon, France) is another single-file rotary instrument made up of NiTi alloy which has the constant taper with different cross-sectional design over its entire working length and variable pitch length thus making it desirable to be used in continuous rotary motion.<sup>6</sup>

Cone-beam computed tomographic (CBCT) is the three-dimensional imaging technique that gives sectional images for a meticulous and precise endodontic diagnosis. It can be useful for eliminating the various differential diagnosis of periapical lesions thus revealing the complexity of the root canal system which cannot be determined in a two-dimensional radiographic image. CBCT is also useful in the identification of lateral and accessory canals, internal and external resorption and detection of vertical root fracture which could be seen barely in a radiographic image. CBCT can be effectively used as a diagnostic aid for measurements before and after instrumentation of the root canals, in evaluating the amount of dentin removed during preparation of the root canals. It allows the exact analyses of certain variables such as volume, surface area, cross-sectional shape and taper.<sup>6</sup> The present study has been adopted to compare the canal transportation and its centering ability of the following three single-file systems: Reciproc, WaveOne and OneShape in curved root canals using CBCT imaging.

## MATERIALS AND METHODOLOGY

For the study purpose, eighty mesio-buccal root canals from human permanent mandibular first molars teeth which were extracted for various periodontal reasons, caries free and non-carious lesion free accompanied by normal anatomical form and structure were carefully selected. The selection criteria included a fully formed root apex, teeth with  $15^{\circ}$ – $30^{\circ}$  canal curvature (based on Schneider method),<sup>7</sup> curvature radius of less than  $10^{\circ}$ , a minimum length of 18 mm, uncalcified canals and Type IV Vertucci canals (two separate canals)<sup>8</sup>

The access cavity was made using a round carbide bur followed by the use of Endo-Z bur (Dentsply Maillefer, Ballaigues, Switzerland) for the de-roofing of pulp chamber. The method to determine a working length is by placing a hand #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) into the root canal. 1 mm from the file length was reduced while the file is being emerged from the apical foramen in order to establish the working length. The teeth were then allowed to be mounted on an acrylic base followed by its stabilization using putty silicone impression material (Speedex, Coltene Whaledent, Altstätten, Switzerland). All teeth were then scanned with the CBCT device (Sirona Dental System Inc, Bensheim, Germany). The presence of file at various distances such as 2mm, 3mm and 4mm from the root apex were recorded in the CBCT images for evaluating the canal transportation and centering ability of the rotary file systems that has been selected for the study purpose.

The biomechanical root canal preparation has done in all the groups and it was performed by a single operator. Glide path was established with K-file #10 and K-file #20.

Group I was made using Reciproc files with 8% taper and a 0.25mm tip size

Group II was adopted using WaveOne having 8% taper and 0.25mm tip size

Group III was made using OneShape having 6% taper and 0.25mm tip size.

Each file was utilised to prepare 5 canals and then discarded promptly. CanalPro2 (Coltene Whaledent, Switzerland) endomotor was enabled to prepare the canals during biomechanical preparation. And during the biomechanical preparation, the canals were subsequently irrigated with 5ml of 2.5% normal saline and 2 ml of 3.0% sodium hypochlorite. Each instrument was then inserted into the canal in slow pecking motion till the established working length.

At once, the root canals were prepared, CBCT series of images were taken for all the teeth. Both mesiodistal and buccolingual diameters were recorded at 2mm, 3mm and 4 mm from the apex in both the diagnostic and postoperative CBCT imaging.

## RESULTS

The present in-vitro study, the levels from the apex which are precisely 2mm, 3mm and 4 mm distance, the Reciproc (Group I) system revealed the greatest canal transportation with least centering ability when compared to other file systems that have been studied. The observable difference in the canal transportation in the 3 groups was reported to be statistically significant ( $p < 0.001$ ), except while comparing the 4 mm distance from the root apex, the buccolingual transportation was not statistically significant between the Reciproc and WaveOne groups ( $p = 0.591$ ). In, OneShape rotary file system has recorded the highest centering ability, while the Reciproc displayed the lowest under certain experimental conditions as tabulated in Table-1. The results obtained were obtained by comparing the centering ability in the three file systems studied showed statistically significant values. ( $p < 0.001$ )

**Table 1: Canal Transportation (Mean  $\pm$  SD) and Centering Ration of the experimental rotary single file systems**

Rotary single file system	Distance from apex (mm)	M-D transportation (mm)	B-L transportation(mm)	Centering ratio (Mean $\pm$ SD)
<b>Reciproc (Group I)</b>	2	0.08 $\pm$ 0.023	0.08 $\pm$ 0.021	0.53 $\pm$ 0.059
	3	0.09 $\pm$ 0.027	0.06 $\pm$ 0.017	0.55 $\pm$ 0.082
	4	0.07 $\pm$ 0.019	0.05 $\pm$ 0.019	0.60 $\pm$ 0.072
<b>WaveOne (Group II)</b>	2	0.04 $\pm$ 0.019	0.05 $\pm$ 0.023	0.61 $\pm$ 0.053
	3	0.04 $\pm$ 0.017	0.04 $\pm$ 0.021	0.65 $\pm$ 0.079
	4	0.04 $\pm$ 0.015	0.04 $\pm$ 0.022	0.71 $\pm$ 0.072
<b>Oneshape (Group III)</b>	2	0.03 $\pm$ 0.013	0.02 $\pm$ 0.014	0.91 $\pm$ 0.052
	3	0.03 $\pm$ 0.012	0.02 $\pm$ 0.012	0.92 $\pm$ 0.057
	4	0.02 $\pm$ 0.010	0.01 $\pm$ 0.010	0.93 $\pm$ 0.063

## DISCUSSION

The major objective in the root canal preparation is to attain a thorough cleaning and shaping of the canal walls and still maintaining the original form of the canal lumen. Proper and adequate instrumentation (shaping) was done combined with effective irrigation is necessary to achieve a sufficient disinfection that is required for the endodontic therapy. This helps in attaining the biological and mechanical objectives of the root canal therapy and finally useful in achieving a 3- dimensional obturation.<sup>5</sup>The curved canals pose a great challenge during endodontic therapy since all the instruments and preparation techniques bound to change the natural root canal pathway during the biomechanical preparation of the root canal.<sup>6</sup> This basically occurs due to the rigid nature and the lack of flexibility & shape memory of the endodontic instruments being used in the procedure which may pose an unequal force distribution at the point of contact with the root canal wall during the biomechanical preparation. Hence, as the instrument has the tendency to regain back to its original shape, greater force is concentrated on the external surface at the point where there is maximum root curvature which could lead to undesirable canal transportation.<sup>7,8</sup> Transportation could be either type I (mild form), type II (moderate) or type III (severe form). Literatures show that only type I transportation can be treated by non-surgical endodontics while others might need a surgical intervention for the prompt prognosis.<sup>9</sup> Transportation of the root canal might be directed to various iatrogenic errors like inadequate debridement of the root canal at the apical region followed by overt removal of dentin in the coronal root region which could lead to zipping or perforation which result in poor or questionable prognosis of those teeth treated endodontically.<sup>10</sup>

The usage of simulated root canals in resin blocks has the potent disadvantage of being unable to assess the root canal and its cross-section in a three-dimensional view. But, the extracted natural teeth most precisely simulate the internal environment of root canal while biomechanical preparation in the clinical condition, by giving compatibility of the apex to a specified instrument size and the curvature angle.<sup>11</sup> Additionally, the mechanical properties of the resin are usually varied from those of human teeth. Therefore, in the current invitro study, extracted tooth roots were studied instead of resin blocks.

The CBCT three-dimensional imaging is one the most viable radiographic tools employed for the meticulous diagnosis in in-vitro experimental studies, since it infers more reliable values in the evaluation of root canal transportation for clinical simulation.<sup>12</sup> Various studies have been conducted with the fact that they are aimed to compare apical transportation occurs due to the rotary instruments with rotational and reciprocal motions and the reported superiority of reciprocal motion has been made clear from time to time that various authors quoted that the single file reciprocation generated a cutting action that is much higher than

disengagement, thereby permitting better apical progression and higher cutting efficiency.<sup>3,13-19</sup> But, *You SY* and *Kim HC* et al<sup>15</sup> reported no difference between the two motions with regards to apical transportation. Most studies that are available nowadays suggest that the reciprocal motion is more efficient in preventing apical transportation which could be attributed to the reduced torsional and flexural stresses generated in the reciprocating movement which in turn increasing the canal centering ability of rotary files and reducing the taper lock within the root canal.<sup>20</sup>

In modern endodontic practice, single-file Ni-Ti rotary systems are the choice of instruments among endodontists as they create fewer canal transportation by almost closely following the root canal anatomy and hence the balance is achieved during the removal of dentin on the inner and outer wall of the root canal thus maintaining the same proportion causing fewer displacement of the apical foramen.<sup>21</sup> This canal centering property of the instrument is majorly dependent on its cross section design of the file, its flexibility and the type of alloy being used in manufacturing. Therefore, in the present experimental study, three single-file systems were used to understand their effectiveness in the performance as the right instruments of choice for a successful endodontic therapy during biomechanical preparation.<sup>22</sup> In the present study, OneShape (Group III) had the lowest transportation and the highest centering ability. Based on the literature available,<sup>6</sup> unique design of the OneShape file system which incorporates varied cross sections along the entire length of the working area and offers an optimal and enhanced cutting action in all the three zones of the root canal. This asymmetrical design is proposed to eliminate threading and binding of the instrument in continuous rotation and minimal cyclic fatigue along the length of the entire file and thereby eliminating the risk of instrument separation.

The Reciproc (Group I) and WaveOne (Group II) systems are manufactured from M-Wire in its austenitic phase. These files have a continuous taper in the first 3mm of their working part followed by a decreasing taper.<sup>19</sup> In the present study, WaveOne single file rotary systems showed higher centering ability and lesser canal transportation as compared to Reciproc file system. *Ferreira MM* and *Rebello D* et al<sup>24</sup> revealed in their study that the WaveOne rotary system is an effective instrumentation system which has the ability that prevents transportation of the root canal and also helps in maintaining the anatomical position. This finding is consistent with the present study. These findings are also corroborated by *Gergi R* and *Arbab-Chirani R* et al<sup>25</sup> revealed that the centering ability in the WaveOne system is observed to be higher than the Reciproc system. Another study by, *Capar ID* and *Ertas H* et al<sup>26</sup> compared six different rotary systems intended in canal transportation, canal curvature, centering ratio, surface area and volumetric changes of severely curved root canals using CBCT images. They found that there was no observed significant difference in the performance of these rotary systems. Moreover, in the present study, none of the instrumentation systems used caused more than 0.3mm of transportation. As, according to *Wu MK* and *Fan B* et al<sup>27</sup> that the apical transportation observed more than 0.3 mm may have the possibility that can affect the success of endodontic treatment by compromising the seal of the obturating material.

## CONCLUSION

To conclude that the OneShape rotary file system reported with the lowest transportation in both the mesiodistal and buccolingual directions with the highest centering ability. However, the Reciproc system revealed the highest transportation and the lowest centering ability. When considering the limitations of the present experimental study it can be ascertained that the Single file Oneshape system is suitable instrument of choice for the biomechanical preparation of root canal in curved scenario.

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