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Shaping Ability of Three Different Rotary Nickel Titanium Systems An In Vitro Study

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Aim: The aim of the study was to compare the changes in transportation and changes in curvature after instrumentation in WaveOne Gold (WOG) system and One Curve (OC) system. Protaper Next (PTN) system was used as reference for comparison.
Material and Methods: A Forty-five human mandibular first molars were selected. Teeth were randomly allocated into three groups (n=15): Group 1: PTN; Group 2: WOG; Group 3: OC. Cone beam computed tomography (CBCT) were taken for all specimens before instrumentation. Pre instrumentation evaluation for angle of curvature was done using Schneider method. Also, transportation was evaluated using Gambill's method. After instrumentation, radiographs (CBCT) were taken and changes in transportation and curvature were measured using Planmecca Romexis software. One-way ANOVA was used to compare between different groups, followed by Tukey's Post Hoc test for multiple comparisons.
Results: After root canal instrumentation, regarding transportation, results showed significant difference between all groups at 6mm level as PTN group showed highest transportation (P=0.09). While there was insignificant difference between groups at 3mm and 9 mm level. As for changes in curvature, there was insignificant difference between groups (P=0.46).
Conclusion: Single file systems better respected the original canal anatomy compared with multi-sequence file system.

Keywords: WaveOne Gold, Protaper Next, One Curve, Transportation, Curvature

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Introduction

Successful treatment depends primarily on enlarging the canal as practical as possible without compromising the natural anatomy of the canal.[1] Common undesirable situations that can lead to inadequate disinfection of the canals therefore making it more challenging is transportation of the canal from its original path as well as from apical foreman, zip perforation, ledge formation and instrument separation.[2] Over the years, various changes to the metallurgy and the designs of the NiTi files were introduced to improve their performance. Different cross-sectional designs were produced to achieve a faster and more predictable preparations as well as minimize apical transportation. These improvements include changes in design, metallurgy, and even the motion which the file is driven with.[3]

The reciprocation motion and single file NiTi system allow preparation of the rot canals by using a single file, this requiring less time for complete preparation when compared with full sequence rotary systems.4 Also, reciprocation mode decreases the stress imposed on the file by counter-clockwise (cutting) and clockwise (non-cutting) movements, which result in expanding the life time and durability of the file and also increases their resistance to cyclic fatigue in comparison with system that use continuous rotation motion. [5]

ProTaper Next (PTN) file system (Dentsply) is a continuous rotation system. It is constructed using M-wire, a NiTi metal that has undergone thermo-mechanical treatment. One notable feature of this system is its off-centered rectangular cross section, which gives the file a unique swaggering motion as it progress through the canal. This movement help create sufficient room for clearing debris. [6,7] The manufacturer claims that the PTN system offers excellent flexibility and can effectively prepare the canal of a larger size that would typically require bigger files.

The WaveOne Gold (WOG) file system, developed by Dentsply Maillefer, made its debut in 2015. It is a single-file system designed for shaping the entire canal.[8] Similar to the PTN system, WOG files feature an off-centered parallelogram-shaped cross section. As per the manufacturer's claims, WOG files possess excellent resistance to torsional stress, fracture resistance and offer enhanced flexibility.[9] Additionally, the reciprocal mode employed by these files reduces the likelihood of instrument binding and extends the lifespan of the file when compared to fully rotating files in a clockwise direction.

One Curve (Micromega, France) file system is also a single file system that works in full rotation motion. it's made from CM wire heat treatment technology that offers controlled memory to it. The manufacturer claims that the heat treatment lessens the threading of the file and its binding to the canal.[10] Also, it has increased flexibility.
The present study was designed to evaluate degree of curvature and transportation changes achieved by One Curve which is a single file rotary system and WaveOne Gold which is a single file reciprocating system and comparing it to PTN which is full sequence rotary file system. The null hypothesis tested was that there are no differences among the tested systems.

Materials and Methods

Specimen preparation

Sixty-five mandibular first molar teeth (mesio-buccal canals) were selected for this study. Teeth with mature apices having curvature ranging from 20° to 45° without evidence of root caries and resorption is included in this study. Radiographs were taken to determine the degree of curvature according to Schneider method. The Schneider methods employs first drawing a

line parallel to the long axis of the tooth in coronal third, then a second line drawn to apex to intersect the point where the first line left the long axis of the canal, the schneider angle is the intersection between these lines.[11]

Standard access was done using round bur and Endo-Z burs (Dentsply Maillefer) with removal of the distal root and flattening of occlusal surface. Working length of the canal (16mm) was determined by inserting file size 10 K-file into canal till its visible from the apex then retracting one millimeter. 12 Apical constriction was enlarged to size 20 k-file then the apex was sealed with double layer of nail polish to shield against bacterial leakage. Teeth were mounted vertically in a silicone impression material (Zetaplus, Zhermack). Figure 1 showing photograph of decoronated and dissected teeth after removal of distal root. Figure 2 showing photograph of sample arrangement in silicone mold.

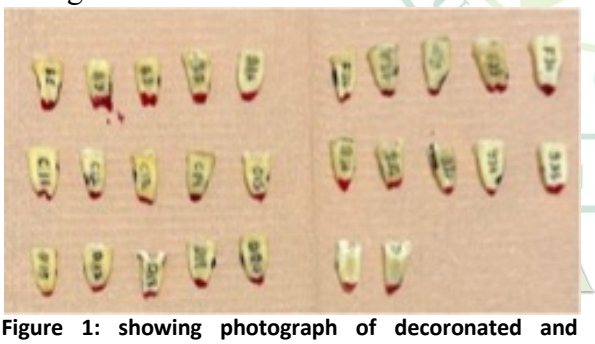

Figure 1: showing photograph of decoronated and dissected teeth after removal of the distal root.

Figure 2: showing photograph of sample arrangement in Silicone mold. All samples are directed toward buccal side with attaching orthodontic wire as a reference.

Pre-instrumentation CBCT evaluation

The specimens were randomly assigned to three groups (n=15) according to type of rotary instrument used.

Group 1: Protaper Next X2. Group 2: WaveOne Gold. Group 3: One Curve.

Scanning was done using Planmeca Promax 3D unit. The machine was operating with parameters (90Kvp, 12mA, exposure time 15 seconds and voxel size 75 um).

Reconstruction of images in axial direction as done using Planmeca Romexis 3D software. Schneider method (Figure 3) was employed to determine canal curvature of teeth.[11]

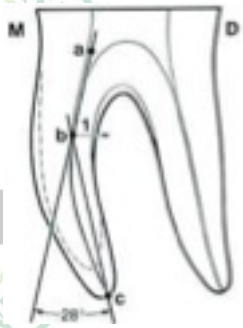

Figure 3: Showing Schneider method determining angle of schneider.

Three cross sectional planes at levels 3, 6 and 9 mm from the apex were taken on images reconstructed on the software using Gambill method. [5–8]

The canal transportation (figure 4) at each level was measured using this formula: (X1-X2) - (Y1-Y2). 5–8 Where Y is the shortest distance between the canal distal periphery and the roots distal periphery (thickness of distal wall), and X is the shortest distance between the canal walls and the root mesial peripheries (mesial wall thickness). The first and second values represent the pre instrumentation and post instrumentation measurement respectively. [5–8]

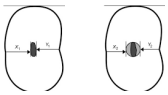

Figure 4: showing cross-sectional measurement (X1, Y1) in pre instrumentation scans and (X2, Y2) in post instrumentation scans.

Root canal instrumentation

Instrumentation was done with torque and speed according to each group's manufacturer's recommendation. E-connect Pro electric motor (Eighteeth, China) with torque control was used. After initial file preparation and glide path using #10 and #15 K-file was done, irrigation was done with sodium hypochlorite using 30-gauge side vented needle. Total irrigation volume used for each system is 7ml. After each stroke, file flutes were cleaned with a gauze wetted in alcohol.

The final apical preparation was adjusted to size 25 in all groups.

Group 1 (PTN X2): instrument was used with a brushing motion at speed 300 rpm and torque 2N.Cm. Preparation was done in a rotational movement using orifice opener XA (#19/035), then X1 file (#17/04) then X2file (#25/06).

Group 2 (WOG): Preparation was done using pecking motion with short amplitude strokes to passively advance the file and a brushing motion on the outstroke at speed 350 rom in a reciprocation motion with file (#25/07) in 150 CCW and 30 CW direction and completes 360 in 3 cycles. 17

Group 3 (OC): the canals was prepped with speed 300rpm wand maximum torque 2.5 N.Cm. preparation was done in rotational movement using One Flare then One Curve file (#25/06).

Post instrumentation CBCT evaluation

The post operative angle of curvature was measured after instrumentation according to schneider's method. Also, transportation changes were measured in a mesio-distal direction (figure 5,6) using the following equation: (X1-X2) -(Y1-Y2). A zero outcome would mean lack of transportation, while positive and negative outcome would mean distal and mesial transportation respectively. [5–8]

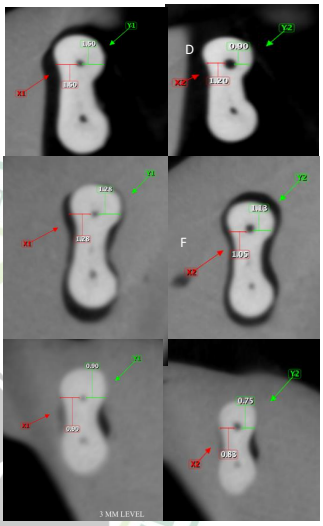

Figure 5 CBCT Images showing canal measurements at 9mm, 6mm and 3mm level of the canals before (A-C-E), and after instrumentation (B-D-F) by One Curve file system

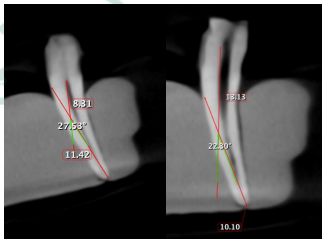

Figure 6 showing CBCT images of changes in angle of curvature after instrumentation with WaveOne Gold file system.

Statistical analysis

The data collected was statistically analyzed by using the SPSS for Windows. All data were explored for normality by using Shapiro Wilk and Kolmogorov Normality test and presented as means and standard deviation (SD) values. One way ANOVA test was used to compare between different groups, followed by Tukey's Post Hoc test for multiple comparisons. The levels of significance were set at ($P \leq 0.05$).

Results

Regarding the changes in degree of transportation, at 6mm level there was a significant difference between groups with PTN group is significantly the highest, while there was insignificant difference between WOG and OC. At 3mm level and 9mm level, there was insignificance difference between groups. Table.1 shows mean and standard deviation of 3mm, 6mm and 9mm level of degree of transportation. Figure. 7: Bar chart showing mean of 3mm, 6mm, 9mm of degree of transportation in all groups.

Regarding changes in angle of curvature, there was insignificance between all groups. Table.2 displays mean and standard deviation of pre, post and difference in angle of curvature and comparison between them using ANOVA test. Figure.8: Bar chart shoeing mean of pre, post and difference in angle of curvature in all groups.

Table.1: Data showing degree of transportation changes in all groups

Table.1	Group I (PTN)	Group II (WOG)	Group III (OC)	P value
	M ± SD	M ± SD	M ± SD	
3mm	0.0426 ª± 0.11	0.0006 ª± 0.11	0.0224 ª± 0.09	0.53
6mm	0.1107 ª± 0.21	-0.0741 ᵇ± 0.16	-0.1173 ᵇ± 0.24	0.009*
9mm	-0.1193 ª± 0.14	-0.208 ª± 0.26	-0.0706 ª± 0.41	0.43

Table.2: data showing degree of changes in angle of curvature in all group

Table.2	Group I (PTN)	Group II (WOG)	Group III (OC)	P value
	M ± SD	M ± SD	M ± SD	
Pre	35.84 ª± 7.06	35.06 ª± 6.72	30.56 ª± 5.45	0.06
Post	31.36 ª± 7.8	31.65 ª± 7.83	25.69 ᵇ± 4.77	0.03*
Difference	4.47 ª± 3.45	3.42 ª± 2.77	4.87 ª± 3.61	0.46

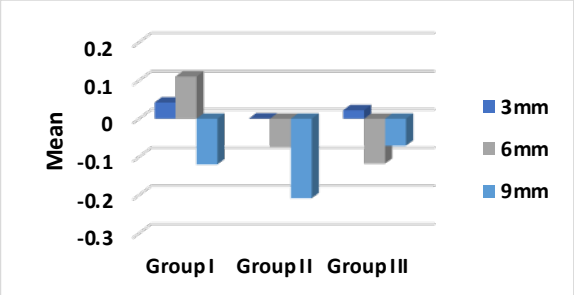

Figure. 7: Bar chart showing mean of 3mm, 6mm, 9mm of degree of transportation in all groups.

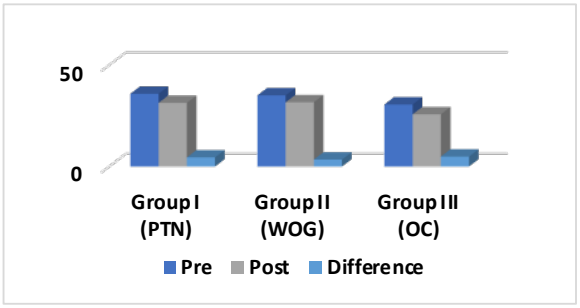

Figure.6: Bar chart shoeing mean of pre, post and difference in angle of curvature in all groups

Discussion

Since the introduction of rotary nickel-titanium instruments (NiTi), there have been continuous advancement in different aspects like design of the files, metallurgical properties of different alloys and working motions.18 Reciprocation motion was introduced in a way to decreases the stress imposed by the instrument during rotation through traveling to a shorter angular distance than rotation motion does.[19, 20] The kinematics of a root canal file system can significantly influence the efficacy of shaping and cleaning the canals. Different file systems with varying kinematics may operate differently, leading to differences in their performance within the root canal system. Another parameter is the use of single-file systems in root canal treatment, which has been a subject of extensive research, particularly in comparison to multi-sequence file systems. Single file systems are gaining clinical acceptance as they reduce the time required for biomechanical preparation, as well as reduce the number of failures and mishaps related to instrumentation.[4]

This study was designed to determine whether the movement kinematics, number of files and metallurgy may influence the degree of root transportation, changes in curvature of the canal after instrumentation. WaveOne Gold and One Curve were tested and Protaper Next was used as benchmark.

It's important to eliminate variable parameters in the study when evaluating

shaping ability of different file systems as different factors can greatly impact the overall performance of these files. [21, 22] For this reason, standardization of the tip size to 25 was made in all groups along with taper of file (0.06) except for WOG (0.07). also, the total volume of irrigation used for each file system is 7 ml of sodium hypochlorite regardless of the number of files used within each system to exclude this as a variable factor. [23]

Three levels (3mm, 6mm, 9mm) were calculated from the apex representing apical, middle and coronal thirds respectively where curvature at these levels is highly susceptible to iatrogenic mishaps.[24] The method used for measuring changes in transportation before and after instrumentation at three different levels is Gambill method using CBCT. And the method used for measuring the angle of curvature before and after instrumentation is Schneider method. This method is proven to be accurate, reliable and has been used by many authors.[25] Sodium hypochlorite was used as irrigation solution to remove debris after instrumentation as it is still the gold standard irrigant. [26]

In the present study, teeth were flattened coronally fixing the working length to 16mm. de-coronation allow standardization and elimination of some variable such as crown anatomy and root canal access therefore more reliable comparison. [27] Distal roots were resected to facilitate insertion of mesial root into the silicone mold.

Non-invasive imaging techniques such as small field of view cone beam computed tomography (CBCT) scanning were employed to accurately and reproducibly evaluate changes in root canal structure before and after preparation. [28] This method allows for a three-dimensional assessment without damaging the samples. In contrast, conventional radiography, which offers a two-dimensional image of a three-dimensional object, has also been used to compare canal shape before and after preparation. However, it has limitations in providing detailed data on root canal morphology. Another imaging technique, microcomputed tomography, offers superior image features of the root canal system and provides detailed information. However, it is not suitable for clinical use and is relatively expensive compared to cone beam computed tomography. [29]

According to the results of the study, regarding changes in transportation, there was significant difference between all groups at 6mm level as PTN group showed highest values of transportation. This result agrees with Gajoum et al (2021) [3] who found that PTN was statistically significantly greater than WOG system in terms of canal transportation. Also, Eliasz et al (2020) [30] who found that PTN produced more transported canal preparation when compared with WOG and twisted file. This increase in transportation could be due to the metallurgical features of the file; M-wire does have more file memory compared to WOG thus straightening the canal more. Another factor that can lead to more dentin removal is the envelope of motion by offsetting a rectangular cross section. 30 in addition transportation coincides with the greatest taper of the file.

As for the changes in curvature after preparation, there was no statistically difference between all groups. However, WOG showed better values in maintain the canal centrality. This result agrees with Filho et al (2016) [31] who concluded that the use of rotary instrument achieved an effect like that of reciprocating instruments in relation to change in angle.[31] This also agrees with Yammine et al (2018)[32] whose results showed non-significance between PTN, WOG and BT Race in relation to straightening of the canal.[32] This outcome

could be because all instruments terminate with the same tip size.

The null hypothesis was rejected as the results of the study showed that, there was significant difference between the different NiTi rotary file system on transportation changes at mid-root area.

Conclusion

Within the limitation of this study, we can conclude that WOG, PTN and OC systems were all suitable for preparation of molar root canals with moderate curvature. Also, Single file systems better respected the original canal anatomy compared with multi-file system.

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