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Original Article

Influence of the glide path on various parameters of root canal prepared with WaveOne reciprocating file using cone beam computed tomography

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ABSTRACT

Background: Nickel–titanium (NiTi) rotary instrumentation carries a risk of fracture, mainly as a result of flexural (fatigue fracture) and torsional (shear failure) stresses. This risk might be reduced by creating a glide path before NiTi rotary instrumentation. The aim of this study was to compare various root canal parameters with the new WaveOne single-file reciprocating system in mesial canals of mandibular molars with and without glide path using cone beam computed tomography (CBCT).
Materials and Methods: One hundred mandibular molar teeth with canal curvature between 20° and 30° were divided into two groups of 50 teeth each. In Group 1, no glide path was created, whereas in Group 2, a glide path was created with PathFiles at working length (WL). In both groups, canals were shaped with WaveOne primary reciprocating files to the WL. Canals were scanned in a CBCT unit before and after instrumentation. Postinstrumentation changes in canal curvature, cross-sectional area, centric ability, residual dentin thickness, and the extent of canal transportation were calculated using image analysis software and subjected to statistical analysis. Data were analyzed using Student's *t*-test and Mann–Whitney U-test ($P < 0.05$).
Results: The mean difference of root canal curvature, cross-sectional area, centric ability, and residual dentin thickness increased, whereas it reduced significantly for canal transportation in Group 2.
Conclusion: WaveOne NiTi files appeared to maintain the original canal anatomy and the presence of a glide path further improves their performance and was found to be beneficial for all the parameters tested in this study.

Key Words: Cone beam computed tomography, glide path, reciprocating motion, WaveOne files

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INTRODUCTION

The goals of endodontic treatment are thorough cleaning and shaping of the root canal system by removing all the infected pulp tissue, bacteria, and their by-products.[1,2] Nickel–titanium (NiTi) rotary instruments are commonly used for shaping with an increased possibility to produce a more rounded and tapered funnel-shaped canal and a reduced incidence of procedural accidents such as transportation and ledge formation.[3,4] Despite these advantages, NiTi instruments appear to have a high risk of

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separation.[5,6] Canal curvature is considered as one of the major risk factors for instrument failure caused by bending cyclic fatigue;[7] stresses due to bending cannot be significantly influenced by the clinician. In 2008, a new preparation technique with only one ProTaper F2 instrument in a reciprocating motion was proposed by Yared.[8]

A reciprocating motion was introduced to decrease the impact of cyclic fatigue on NiTi rotary instruments, compared with a rotational motion.[9,10] This reciprocating movement is believed to ultimately increase the lifespan of the instrument.[10,11] The WaveOne NiTi single file system (DentsplyMaillefer, Ballaigues, Switzerland) is designed to be used with a reciprocating motion motor. The manufacturer claims that the reciprocal motion would reduce the torsional stress by periodically reversing the rotation (170° counter-clockwise, then 50° clockwise rotations) of the file. It consists of three single-use files: Small (International Organization for Standardization [ISO] 21 tip and 6% taper) for fine canals; primary (ISO 25 tip and 8% taper) for the majority of canals; and large (ISO 40 and 8% taper) for large canals. The files are manufactured with M-Wire NiTi alloy.[12] The clinical protocol does not advocate the preliminary creation of a glide path before use. WaveOne small is suggested when a #10 K-file is very resistant to the movement when reaching full working length (WL); WaveOne primary is indicated when a #10 K-file moves to WL easily, and WaveOne large when a #20 K-file or larger easily goes to WL.[13]

Cone beam computed tomography (CBCT) provides a higher resolution image in a three-dimensional pixel (voxel). As these voxels are isotropic, the object is accurately measured in different directions. This enables the rendering of geometrically undistorted images of the maxillofacial skeletal structure and allows viewing at different angles.[14] High resolution CBCT instruments might help in the reliable visualization of the root canal, improving the outcome of the endodontic treatment.

Therefore, the aim of this *ex vivo* study was to compare the various root canal parameters (root canal curvature, cross-sectional area, centric ability, residual dentin thickness, and extent of canal transportation) with the new WaveOne single-file reciprocating system in mesial canals of mandibular first molars with and without glide path using CBCT.

MATERIALS AND METHODS

One hundred mandibular first molars extracted due to periodontal disease were used under a protocol approved by the local ethical committee. All the samples were cleaned by scaling and soaking in 2.5% sodium hypochlorite for 24 h. Inclusion criteria were stipulated that the tooth had a curved mesial root with two separate canals and apices, with the curvature angles ranging within 20-30°. The curvature of each canal was measured using the method described by Schneider.[15] Teeth with curvature less or more than this were excluded from the study. The samples were stored in saline at 4°C until use. The teeth were embedded into autopolymerizing acrylic resin, endodontic access was gained, the mesial canals were located and explored with a size 10 K-type file (DentsplyMaillefer, Ballaigues, Switzerland), which was passively advanced into the canals until the tip of the instrument penetrated and adjusted to the apical foramen. The root canal length was recorded, and the WL was calculated by subtracting 1 mm from this measurement using an Endodontic Ruler (DentsplyMaillefer, Ballaigues, Switzerland). Preinstrumentation CBCT images using software CS9300 (Carestream Healthcare, Uttar Pradesh, India) were obtained. Teeth were assigned into two separate groups ($n = 50$).

In Group 1, glide path was not created. Each canal was shaped with WaveOne primary reciprocating files (DentsplyMaillefer, Ballaigues, Switzerland), with a pecking motion until it reached the full WL using Glyde (DentsplyMaillefer, Ballaigues, Switzerland) as lubricating agent. After instrumentation, all specimens in each group were repositioned in the slot.

In Group 2, the mechanical glide path was made using Glyde (DentsplyMaillefer, Ballaigues, Switzerland) as a lubricating agent, with NiTi rotary instruments PathFile (PF) (DentsplyMaillefer, Ballaigues, Switzerland). The system consists of three instruments with 21-, 25-, and 31-mm length and 0.02 taper; with a square cross-section. PF #1 (purple) has an ISO 13 tip size; PF #2 (white) an ISO 16 tip size; and PF #3 (yellow) has an ISO 19 tip size. PF #1 was used immediately after a size #10 hand K-file (DentsplyMaillefer, Ballaigues, Switzerland) had been used to prepare the root canal to full WL. An endodontic engine (X-Smart; DentsplyMaillefer, Ballaigues, Switzerland) at 300 rpm and 5 N/cm torque, was used with all reciprocating files. After the first PF #1 was used to WL, PF #2 and PF #3 were used sequentially.

Irrigation in both the groups was performed with a 30-G needle syringe 10 ml 2.5% NaOCl after each instrument. The files were discarded after preparation of each canal.

Superimposition and image evaluation

Following instrumentation, the pre- [Figure 1a and d] and post-operative images [Figure 1b and e] were measured using the CBCT scan software CS9300 equipment (Carestream Healthcare, Uttar Pradesh, India) in the high resolution dental mode (i.e., 90 µ resolution). Axial and coronal sections corresponding to distances 0, 1, 2, 3, 5, and 7 mm from the anatomic apex were selected and distances between the edges of uninstrumented canals and the root edges were measured in mesial and distal directions. After instrumentation, the same reference points were adopted for the acquisition of postoperative measurements. Then the pre- and post-instrumentation CBCT images were superimposed using OnDemand3D software version 1.0 (Cyber Med. Seoul, Korea). The postinstrumented image was outlined in red, and it was superimposed over the initial image (grey outline) [Figure 1c and f].

Changes in root canal curvature

To calculate the root canal curvature the angle of maximum curvature of the root canal from the anatomic apex in coronal and transverse section was measured. After superimposition of the pre- and post-instrumentation CBCT images the difference between the angles of curvature were measured.

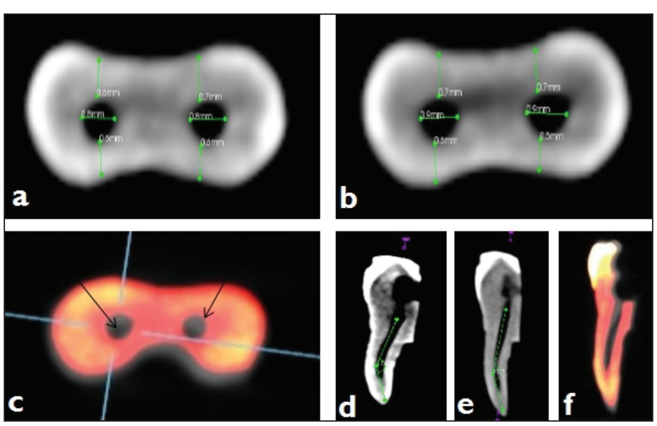

Figure 1: (a and b) Pre- and post-instrumented images at 7 mm in axial section. (c) Superimposed image. (d and e) Pre- and post-instrumented images at 7 mm in coronal section. (f) Superimposed image.

Cross-sectional area

To calculate the postoperative changes in cross-sectional area and to detect the root canal wall differences, the pre- and post-instrumentation CBCT images were superimposed using the OnDemand3D software (Cyber Med Inc.Korea version 1.0)

Evaluation of centric ability

The centring ratio, which measures the ability of the instrument to remain in a central position within the canal, was calculated for each cross-section using the values obtained in the assessment of root canal transportation. The ratio of (X1 − X2) to (Y1 − Y2) as described by Gambill *et al*.,[16] where X1 is the distance between the mesial portions of the root and the uninstrumented canal, X2 is the distance between the mesial portions of the root and the instrumented canal, Y1 is the distance between the distal portions of the root and the uninstrumented canal, and Y2 is the distance between the distal portions of the root and the instrumented canal, were measured.

Whenever the 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 the optimal centring ability.

Residual dentin thickness

For both the groups, the shortest distance from the canal outline to the closest adjacent root surface was measured at each level.

Evaluation of canal transportation

Canal transportation was calculated in millimeters with the formula [(X1 − X2) − (Y1 − Y2)].[11] Pre- and post-operative measurements were compared to reveal the presence or absence of deviations in canal anatomy and to identify the most affected region.

Statistical analysis

All statistical analyses were performed using the software package SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). The level of significance was set at $P < 0.05$.

Within each group, pre- and post-instrumentation changes in root canal curvature, cross-sectional area, and residual dentin thickness were analyzed statistically using Student's *t*-test at ($P < 0.05$). Mann–Whitney U-test was applied to test-centric ability and extent of canal transportation.

RESULTS

Changes in root canal curvature

In Group 1 (1.3540 ± 0.84520) and Group 2 (3.1700 ± 1.61400), a significant mean difference was found indicating that the root canal curvature increases more significantly in Group 2 [Figure 2a] ($P < 0.05$) [Table 1].

Changes in cross-sectional root canal area

The mean difference was significant between groups at all levels except at 2 mm ($P > 0.05$) [Figure 2b].

Centric ability and canal transportation

The centric ability increased [Figure 2c] and the extent of canal transportation decreased significantly in Group 2 [Figures 2d, 3a and b, Table 2].

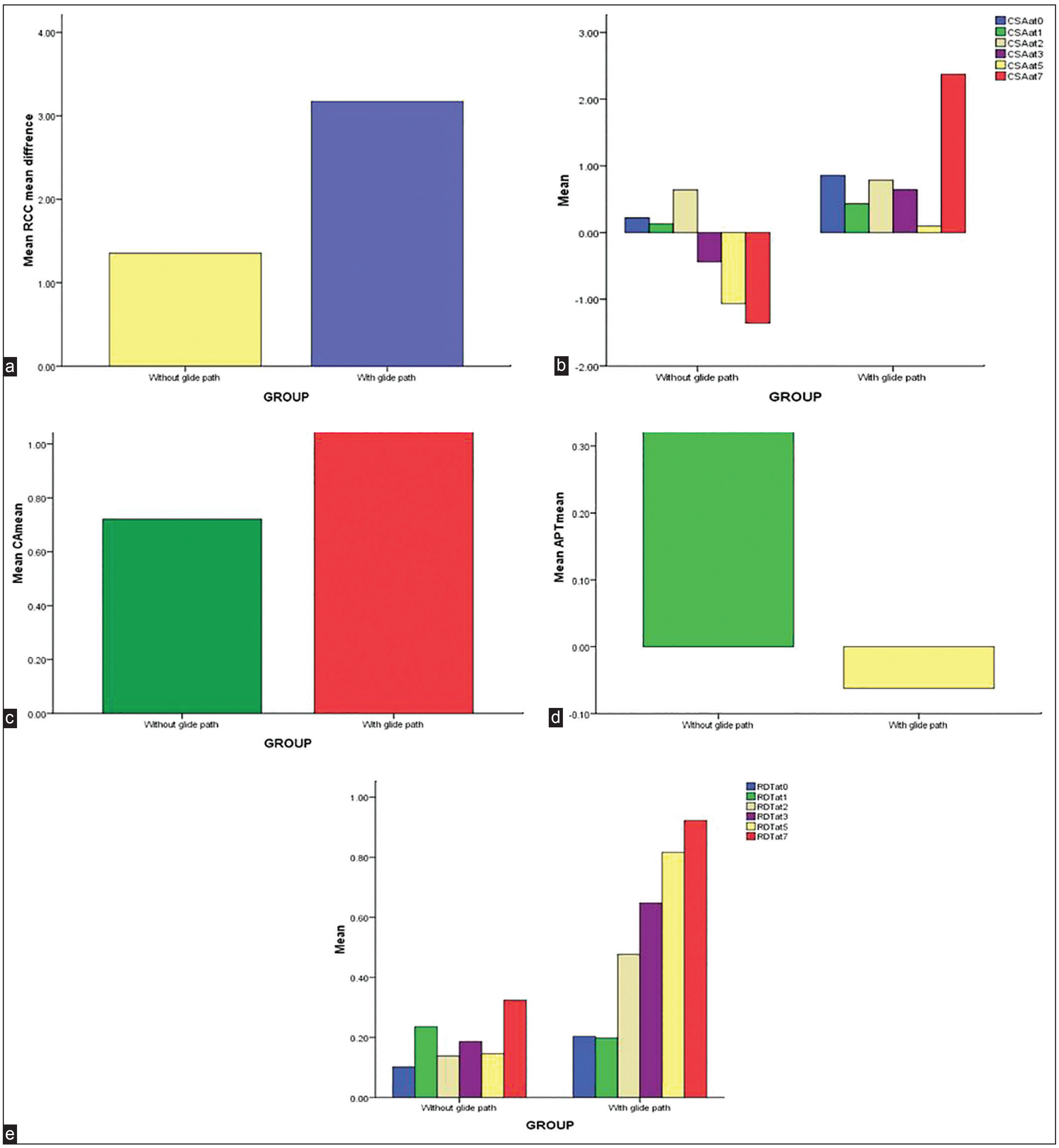

Figure 2: (a) Graphical representation of mean difference in root canal curvature between the two groups. (b) Cross-sectional area at different levels. (c) Mean difference in centric ability, (d) Mean difference in canal transportation. (e) Residual dentin thickness at different levels.

Residual dentin thickness

The residual dentin thickness was significantly more in Group 2 [Figure 2e] ($P < 0.05$).

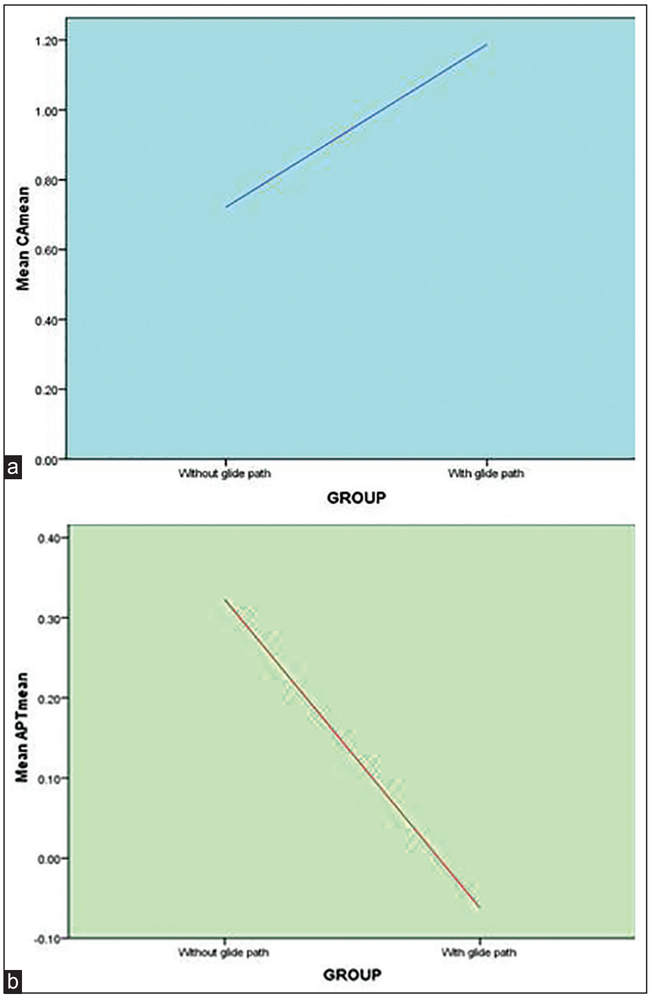

Figure 3: (a) Line diagram represents mean difference in centric ability. (b) Line diagram represents mean difference in canal transportation.

Table 1: Mean and SD of root canal curvature between two study groups

Group	*n*	Mean	SD	*P*	SEM
Without glide path	50	1.3540	0.84520	0.000	0.11953
With glide path	50	3.1700	1.61400		0.22825

SD: Standard deviation; SEM: Standard error of the mean.

DISCUSSION

The WaveOne NiTi reciprocating system has been introduced to simplify canal shaping.[13] Only a single file is suggested to reach adequate root canal size and taper. Single use, reciprocating motion, and M-Wire alloy manufacturing are the main characteristics of these instruments M-Wire NiTi technology raises performance to unprecedented heights by offering significantly more of the benefits endodontists care about most, including flexibility and the resistance to cyclic fatigue – the leading cause of file separation.[17]

Reciprocating motion was proposed to increase the canal centring ability as well as to reduce the risk of root canal deformity.[18-20] This statement supports the results founded in the present study, where both the experimental groups (Group 1 and Group 2) produced centric preparation, but increase in centric ability was seen in Group 2 (with previous glide path preparation).

Coronal enlargement[21] and preliminary creation of a glide path are fundamental for safer use of NiTi rotary instrumentation.[22,23] The use of a small-size hand K-file followed by a more flexible and less tapered NiTi rotary PF might be a less invasive and safer method to provide a glide path that better maintains the original canal anatomy, compared with manual preflaring performed with stainless steel K-file.[24] Similarly, in this study, a glide path was prepared using PF that significantly improved the shaping ability of the WaveOne file in curved root canals.

The literature suggests that the modification in canal curvature after instrumentation is a reliable method to evaluate the tendency of a shaping technique to maintain the original canal anatomy or to straighten the curves.[25] The methods commonly used for evaluating canal shaping are radiographs,[20] tooth sections,[26] and plastic blocks.[27] The newest techniques for evaluation of shaping ability of rotary instrumentation are microtomography,[28,29] high-resolution CT,[30,31] and CBCT,[32] which are nondestructive and show more details.[33]

Table 2: Mean of centric ability (CA) and canal transportation (APT) at different levels between two groups

Test	CA at 0 mm	CA at 1 mm	CA at 2 mm	CA at 3 mm	CA at 5 mm	CA at 7 mm	APT at 0 mm	APT at 1 mm	APT at 2 mm	APT at 3 mm	APT at 5 mm	APT at 7 mm
Mann–Whitney U	587.000	1223.000	399.000	951.500	989.000	928.000	1144.000	736.000	46.000	204.000	8.000	177.000
Z	−4.653	−0.187	−5.979	−2.070	−1.806	−2.229	−0.737	−3.567	−8.341	−7.229	−8.577	−7.406
P	0.000	0.852	0.000	0.038	0.071	0.026	0.461	0.000	0.000	0.000	0.000	0.000

CA: Centric ability; APT: Apical canal transportation.

Furthermore, CBCT images permit metrically exact analyses of variables such as volume, surface areas, cross-sectional shape, and taper. The fraction of prepared surface can be analyzed with software which does not interfere in the original format of the images, allowing the analysis of the exact position and direction of canal transportation.[34] In this study, a quantitative analysis was performed through observation of changes between pre- and post-instrumentation images by using CBCT.

Several studies have surveyed shaping ability of WaveOne file.[35,36] These studies have yielded that canal modifications are reduced with WaveOne file as compared with other rotary systems.

Another recommendation for improving the performance of WaveOne file is by preparing a glide path. Similarly, in this study, a glide path was prepared based on the findings of Berutti *et al.*[37] who reported that canal modifications seem to be significantly reduced when previous glide path is performed using the new WaveOne NiTi single-file system.

In the present study, establishment of a glide-path increased the ability of WaveOne file to remain centered in prepared canals and produced less canal transportation, consistent with the results reported by Lim *et al*.[38] and Saber *et al*.[35]

It can, therefore, be summarized that the root canal curvature, cross-sectional area, centric ability, and residual dentin thickness increased significantly, whereas the canal transportation significantly decreased in the presence of a previous glide path.

CONCLUSION

WaveOne NiTi files appear to maintain the original canal anatomy and the presence of a glide path further improves their performance and was found to be beneficial for all the parameters tested in this study.

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Conflicts of interest
The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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