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Research Article

Centering Ability and Canal Transportation of Three Reciprocal Files in Moderately Curved Canals

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Abstract

Assessing the complexity of the root canal's curvature is one of the crucial factors for the root canal procedure to succeed. Iatrogenic complications can happen during the shaping procedure of the curved canal as it can deviate from the original anatomy, such as transportation and ledge. Therefore, maintaining the initial anatomy of the root canal's curvature and its centering during instrumentation is essential during the shaping procedure. This ex vivo study aims to analyze the centering ability and canal transportation of three reciprocal file systems, with and without a glide path in moderately curved canals. Thirty-six root canals with moderate curvature from freshly extracted maxillary premolar with separated buccal and palatal root canals, first maxillary molar with separated mesiobuccal and distobuccal canals, and first mandibular molar with separated mesial canals were selected then distributed into six random groups (n=6) according to with and without glide path procedure (#15 K-file) before instrumentation with different reciprocal system (GP+WOG, GP+R, GP+RB, NGP+WOG, NGP+R, NGP+RB). The centering ability and transportation were evaluated by CBCT both before and after instrumentation. One-way Analysis of Variances was employed to analyze the data. ($p<0.05$). There were significant differences in centering ability at the middle third ($p<0.05$) and transportation at the apical third and middle third ($p<0.05$). All techniques showed certain transportation, and none of them had perfect centering ability. Reciproc Blue had better canal centering and transportation compared to Reciproc when glide paths were used prior to instrumentation. All systems can shape the curved canal without iatrogenic complications.

Keywords: Canal centering; canal transportation; curved canals; reciproc.

INTRODUCTION

Endodontic treatment is a procedure to treat pulp and periapical disease through instrumentation and cleaning of the system of the root canals.[1,2] Understanding the root canal's anatomy is necessary for the root canal procedure to be successful, as most canals have curved shapes. The curvature of the canal serves as a key factor in assessing the difficulty of instrumentation during endodontic treatment.[2] Curved cans can hinder the shaping process as they can deviate from the original path, causing iatrogenic complications such as transportation, ledge, and broken instruments.[2,3] Preserving the root canal's anatomy, curvature, and centering is a crucial factor for successful instrumentation.[4]

Teeth with straight roots and root canals are rarely seen because most of them have curvature on the canal along its trajectory.[5] Complex root canal anatomy with a curved canal can make the shaping procedure much more challenging, which could lead to iatrogenic complications.[3] Transportation of the canal could happen due to excessive reduction of the dentinal wall because of the usage of the stiff

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endodontic instrument, which tends to return to its original form.[3]

The use of reciprocal NiTi files has higher flexibility, which increases the shaping ability to minimize iatrogenic complications that lead to weakened tooth structure.[4,6] The advantages of using reciprocal motion are reducing the time needed related to its single file system, reducing the chance of instrument fracture, and the ability to maintain the centering of the canal.[3,7,8]

WaveOne Gold® (WOG) is a reciprocating file system that combines the advantage of a gold-wire heat treatment file with reciprocating motion to enhance flexibility. WOG has a variable taper with a semi-active cutting tip. The cross-section design of this file is an offset parallelogram. This design was aimed at enhancing efficiency and fracture resistance.[9]

Reciproc® (R) system is a NiTi M-wire alloy. Reciproc has variable taper with a non-cutting tip and "S" cross-section design. Reciproc Blue® (RB) (VDW, Munich, Germany) has the same geometric design as Reciproc. However, the difference between Reciproc and Reciproc Blue is that the heat treatment of Reciproc Blue results from different heat treatments.[9,10]

Creating a glide path helps improve centering ability and maintains the canal's original shape, minimizes iatrogenic accidents, reduces torsional stress, and shortens the duration required to finish the shaping process. The preparation of glide paths is still advised, particularly on canals with curvature and small.[10,11] Preparation of the glide path enhances the resistance of the file up to six times.[12] Up until now, contradictory results regarding the need for glide path preparation before the preparation using a single file reciprocal system have been reported.[13] Previous studies showed that a single file reciprocal system is capable of instrumenting the canal up to its operating length without requiring a glide path to be created beforehand.[14]

No previous study compared three different materials of reciprocal files with and without a glide path; thus, in this study, six different groups consisting of three reciprocal files with different materials, each with and without a glide path, were compared to better visualize whether the glide path in reciprocal files is still needed to minimize the time of endodontic procedures. The purpose of this study using CBCT is to analyze the centering ability and canal transportation of three different reciprocal files with the creation of a glide path prior to instrumentation and without.

MATERIAL AND METHOD

Specimen sample preparation

The research design of this study is true experimental with a pre-test/post-test group. 36 curved root canals from freshly extracted maxillary premolar with separated buccal and palatal root canals, the first maxillary molar with separated mesiobuccal and distobuccal canals, and the first mandibular molar with separated mesial canals were selected. The research was approved by the Research Ethics Committee of Trisakti University (757/S2-Sp/KEPK/FKG/5/2024).

Only the canals with 5-20° curvature were included in this study. The degree of canal curvatures was analyzed using Schneider's method, with two radiograph angles (buccal-palatal and mesial-distal) taken for all specimens using periapical radiographs.[15]

Exclusion criteria were teeth with fracture line, post-endodontic treatment, calcification, internal resorption, C-shaped variation canal, and open apex. A saline solution was used to store all specimens. Teeth were decorated with diamond discs, leaving a 12 mm standardized root length. Apical patency was done by inserting #10 hand file K-file. One millimeter was deducted from the apical foramen to determine the working length for the instrumentation.

Pre-Instrumentation scanning

CBCT (3D accustom 170 Morita, Japan) was used to scan all specimens with the settings: Hi-Res mode, 90 kV, 5.0 mA, 0.080 voxel size, and 30.8 seconds scan time prior to instrumentation. The apical, middle, and coronal sections of the canals were represented by the three sections from each specimen that were analyzed at 3, 5, and 7 mm from the apex to assess the centering and transportation of the canals.

Preparation of the specimens

Specimens were assigned into 6 equal groups (n = 6) as detailed below: Group 1: WOG and glide path group. SS K-File #15.02 was used to create the glide path, and the WOG Primary file was used for preparation. Group 2: Reciproc and glide path group. SS K-File #15.02 was used to create the glide path, and the Reciproc R25 file was used for preparation. Group 3: RB and glide path group. SS K-File #15.02 was used to create the glide path, and the RB R25 file was used for preparation. Group 4: WOG group. Without a glide path, canals were instrumented using the WOG Primary file. Group 5: Reciproc group. Without a glide path, canals were instrumented using the Reciproc R25 file. Group 6: RB group. Without a glide path, canals were instrumented using the RB R25 file.

Root canals were instrumented using an endodontic motor (X-smart Plus, Dentsply Sirona, USA) following the manufacturer's instruction for each instrument by the same operator using a standardized technique. Light pressure and an in-and-out pecking motion with an amplitude of 3 mm were used to instrument the canals. Irrigation of the canal with sodium hypochlorite 5,25% was done using 30-gauge side-vented needle tips after 3 strokes. This procedure was repeated until the file reached working length. The canals were flushed using distilled water and then dried using paper points.

Post-Instrumentation scanning

After instrumentation, specimens were scanned with CBCT under the same condition. The acquired before and after instrumentation data were examined using the i-Dixel OneVolumeViewer software program (i-Dixel, OneVolumeViewer, version 2.0, Morita, Japan)

Analysis of centering ability and canal transportation

Gambill et al. examined the data.[16] Centering ability refers to the file's capacity to remain centered. The formula to calculate is as follows: (X1-X2)/(Y1-Y2). The lower number is used as the nominator of the ratio. Perfect centering is represented by a value of 1, while totally off-center is represented by a value of 0. For canal transportation, the formula to calculate is as follows: (X1-X2)-(Y1-Y2), whereas the closest width between the un-instrumented mesial edge of the canal and the root's mesial edge is denoted by X1. The closest width between the instrumented mesial edge of the canal and the root's mesial edge is denoted by X2. The closest width between the distal edge of the un-instrumented canal and the root's distal edge is denoted by Y1. The closest width between the instrumented canal's distal edge and the root's distal edge is denoted by Y2. A value equal to 0 represents no canal transportation. (Figure 1)

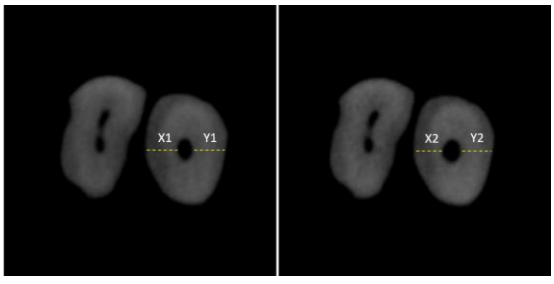

Figure 1. Evaluation of the root canal specimens. Pre-instrumented scanning (left) and post-instrumented scanning (right).

Statistical analysis

A software program for statistical analysis (SPSS for Windows, Version 26.0, Chicago, USA) was used to examine the

data. Shapiro-Wilk's test was used to test the normality, and Levene's test was used to test the homogeneity of variances. The test showed normal distribution and homogeneity of variances; therefore, one-way ANOVA was used to analyze the data, followed by a post-hoc Tukey test. The level of significance for all tests was set at $p<0.05$.

RESULT

Results of tests for canal centering were presented in Table 1, which showed that in the middle third, significant differences were observed between groups (p=0.040). The post hoc Tukey test showed that the RB+GP group had statistically significantly better centering ability than the R+GP group. (p=0.020). All groups showed no significant differences at the coronal and apical third (p>0.05).

Table 2 showed that there were significant differences between groups at the apical third (p=0.027) and middle third (p=0.047). The Post hoc Tukey test for the apical third showed that the RB+GP group had significantly less transportation than the WOG group (p=0.039), and the middle third showed that the R+GP group had significantly more transportation than the RB+GP group. However, for the coronal third, no significant differences were observed between all files (p>0.05).

Group 3 (RB+GP) has the highest mean value of canal centering and the lowest transportation, while group 2 (R+GP) has the lowest mean value of canal centering and the highest transportation. These results indicate that group 3 has the advantage of shaping the curved canals based on the criteria in this study.

Table 1. Canal centering mean value for apical, middle, and coronal third after instrumentation.

Distance from apex	Canal centering (Mean±SD) (mm)						
	WOG+GP	R+GP	RB+GP	WOG	R	RB	p
3 mm	0.64 ±0.07[a]	0.67 ±0.09[a]	0.76 ±0.05[a]	0.47 ±0.09[a]	0.49 ±0.09[a]	0.72 ±0.05[a]	0.053
5 mm	0.65 ±0.11[a]	0.37 ±0.06[a,b]	0.76 ±0.09[a,c]	0.51 ±0.09[a]	0.61 ±0.05[a]	0.62 ±0.06[a]	0.040*
7 mm	0.40 ±0.09[a]	0.75 ±0.11[a]	0.53 ±0.06[a]	0.51 ±0.08[a]	0.47 ±0.08[a]	0.44 ±0.07[a]	0.072

Values with different superscripts indicate a statistically significant group difference *significant (p<0.05).

Table 2. Canal transportation mean value for apical, middle, and coronal third after instrumentation.

Distance from apex	Canal transportation (Mean±SD) (mm)						
	WOG+GP	R+GP	RB+GP	WOG	R	RB	p
3 mm	0.04 ±0.01[a]	0.06 ±0.02[a]	0.03 ±0.01[a,b]	0.10 ±0.02[a,c]	0.09 ±0.02[a]	0.06 ±0.01[a]	0.027*
5 mm	0.07 ±0.03[a]	0.12 ±0.02[a,b]	0.04 ±0.01[a,c]	0.08 ±0.01[a]	0.07 ±0.01[a]	0.08 ±0.01[a]	0.047*
7 mm	0.11 ±0.03[a]	0.06 ±0.02[a]	0.09 ±0.02[a]	0.09 ±0.03[a]	0.10 ±0.02[a]	0.12 ±0.02[a]	0.551

Values with different superscripts indicate a statistically significant group difference *significant (p<0.05).

DISCUSSION

Three-dimensional root canal shaping, cleaning, and filling is the goal of endodontic treatment. Instrumentation of curved canals poses a challenging factor and is much more difficult as iatrogenic mishaps can easily happen. These factors include the microhardness of the dentin, flexibility, and diameter of the files used to instrument the canals, as well as the degree of curvature.[17] Reciprocal single-file system has the advantage of lesser duration of instrumentation with single file, lower fracture possibility, and better centering ability.[3]

This present study aimed to analyze the ability of the files to remain centered and the transportation of the canal of three different reciprocating files with and without the use of a glide path for shaping curved canals. In the present study, the findings showed there were significant differences in canal centering ability between the group on the middle third and canal transportation on the apical and middle third. However, on the coronal third, there were no significant

differences between the groups on shaping ability and canal transportation.

Some studies investigating the shaping ability of reciprocal files in artificial acrylic resin blocks have been done. [6,10,18,19] However, an artificial acrylic resin block cannot represent the root canal anatomy system, natural dentin hardness, and structure of the dentin itself.[20] Microhardness of resin block (20-22kg/mm^2) is lower when compared with natural dentin (35-40kg/mm^2).[21] Resin material may also become softer due to the heat generated during instrumentation.[22]

Three reciprocating files' centering ability and canal transportation were examined at three levels, each representing curvature level with the most common iatrogenic mishaps at apical, middle, and coronal third.[23] CBCT was used in this study because of its effectiveness in giving high-resolution images of the three-dimensional anatomy of the root canal. This present study's voxel size (0.080 mm) was higher compared to the previous study in analyzing canal centering ability.[13,20]

A glide path was created to improve the centering ability of the next file and to avoid iatrogenic complications during instrumentation. It has been recommended, especially on curved and narrow canals.[13,24,25] A rotary instrument and a K-file can be used to create the glide path, while better tactile sense and decreased fracture risk are the advantages of using a K-file when creating a glide path.[26]

In this study, instrumentation of three different reciprocal files with a glide path and without a glide path prior to instrumentation showed no significant differences among groups. This result is in agreement with earlier research findings.[11,23,27] No significant differences were observed between the three reciprocal files without glide path creation prior to instrumentation. The study's findings are in agreement with earlier research that showed the heat treatment on Reciproc Blue did not improve the centering and canal transportation in comparison to Reciproc, and both of them have the same geometry.[20,28] Moreover, all three files have the same reciprocation motion, have an apical diameter of #25 with a consistent taper at apical 3 mm.[29]

There were no statistical differences in the coronal third of all groups. It might be explained by the fact that all files have the same approximate size of #25 and taper size (7% and 8%).[23] At the apical third, there was a significant difference between RB+GP and WOG. This result might be because the glide path may enhance the ability of Reciproc Blue, while the WOG group was instrumented without the glide path prior to the shaping procedure.[23]

All groups lead to a certain level of canal transportation at the coronal, middle, and apical thirds. Fan et al. found that transportation only affects the instrumentation if it is more than 0.3 mm; thus, transportation of all groups does not affect the root canal procedure at all levels.[30] In this present study, all systems are able to shape curved root canals without iatrogenic mishaps such as ledges or broken instruments. A single-file reciprocating system is capable of shaping moderately curved root canals.

Based on the results of this study, group 3 (RB + GP) has the highest mean value of canal centering and the lowest value of transportation, which indicates the advantage compared to other groups in shaping such canals. It helps the clinician to minimize the iatrogenic accident, better shape the canals, and preserve their original anatomy.

A limitation of this study was that the criteria of the samples did not consider the radius of the curvature and the patient's age at which the extracted teeth were used. Therefore, further research is advised to evaluate those factors in canal centering and transportation.

CONCLUSION

Establishing a glide path using K-files prior to instrumentation with a single file reciprocal motion system showed no

significant differences in centering ability and canal transportation. Moderately curved root canals can be instrumented using a single-file system with reciprocating motion without the need for a glide path. All groups are able to instrument the canals without iatrogenic mishaps. Reciproc Blue with a glide path has higher canal centering and transportation ability in shaping curved canals compared to other groups, but this is not significant.

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