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The Effect of Different Single System Designs and Movements on Canal Transportation in The Curvature Apical Third (Review With Cone Beam Computed Tomography)

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ABSTRACT:- Background: Root canal curvature in the apical third affects the ability of the instrument for preparation and can cause canal transportation. Aim: to look at the effect of different single file system designs and movements on root canal transportation in the curvature apical third. Method: Thirty-two mandibular premolar teeth were CBCT radiographed to obtain data for sample inclusion criteria and mesial and distal wall thickness 3 mm from apical. Samples were divided into 2 groups (n=16) according to file design, each grup was further divided into 2 subgroups (n=8) according to file motion. Samples were prepared according to file design and movements. CBCT radiographs were taken to obtain data afterroot canal preparation. Data were analyzed by two-way ANOVA. Result: There were no effect of different single file system designs and movements on canal transportation in the curvature apical third (p> 0.05). Conclusion: there was no effect of the design and movement of different single file systems on canal transportation in the curvature apical third (CBCT study).

Keywords - single file system, canal transportation, cone beam computed tomography

I. INTRODUCTION

Root canal treatment aims to maintain the health of the periradicular tissue by eliminating infection in the root canal. The treatment consists of three important principles of triad endodontics: cavity access, root canal preparation (cleaning and shaping) and obturation[1].

Successful root canal preparation minimizes microorganisms in the root canal system by maintaining the original shape and path of the root canal[2]. Curvature of the root canal affects the ability of the instrument in the preparation and cleaning of all canal walls without regard to the instrumentation system used[3]. Curved canals can cause increased pressure on the rotary file and consequently cause instrument fracture or root canal preparation errors such as perforation, ledge, and canal transportation[1].

File technology was developed to make preparation techniques more effective and efficient. Technological developments regarding files ranging from instruments made from stainless steel (SS) to nickel-titanium (NiTi), and from manual to rotary machine. Instruments with stainless steel have a high risk of perforation because of its inelasticity, high risk of canal transportation[4]. Niti files are still vulnerable to fractures due to fatigue files, torsional failure, or a combination of the two factors[5].

File design factors (helical angle, pitch, cutting angle, rake angle, radial land), especially the tip design, cross-section and taper influence canal transportation[4]. The use of a single file preparation technique has been introduced to simplify the instrumentation protocol because only one instrument is needed for root canal preparation[6]. The results showed that single file with reciprocal motion had the advantage of flexural resistance to high cyclic fatigue, less extrusion of debris, reduced possibility of cross contamination and the ability to complete canal preparation according to the length of work with only one instrument[7].

The difference in canal transportation between the reciprocal motion technique and continuous rotation in curve canal is not significant, reciprocal motion is an alternative method to prevent procedural errors during root canal preparation[8]. The results from Moazzami et al. states that bucolingual and mesiodistal root canal transport occurs more in reciprocal motion than continuous rotation but reciprocal motion files remain safe to use clinically[2].

Cone Beam Computed Tomography (CBCT) is more accurate radiographic techniques that recommended for the assessment of the success of root canal preparation[9]. CBCT is being used to evaluate canal transportation because of its accuracy and tooth structure can be maintained[1]. This study aims to determine the effect and causes of the design and movement of different single file systems on canal transportation in the curvature apical third.

II. MATERIAL AND METHOD

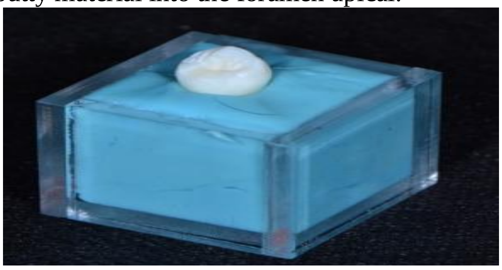
This study was an experimental research and approved by the institutional Ethics Committee with no.00233/KKEP/FKG-UGM/EC/2019. The subjects were 32 mandibular premolar teeth with curve apical third and single root canal.

Teeth fixation was made with a red wax imitating a jaw with a height of 1 cm and a width of 1cm. The jaw's form should be less than 5x5 cm (the maximum field of view). The fixation was used for CBCT radiographic imaging of subjects before and after root canal preparation.

The mold of the tooth fixation site during root canal preparation was made an acrylic material with a size of 2x2x2 cm and thickness 3 mm. Samples (11-12 subjects) were implanted into the jaw from red wax so several samples could be taken CBCT radiographs simultaneously (**Picture 1**). Subjects were numbered for matching sample data before and after CBCT radiographs. CBCT scan (Volux Genoray, Korea) with voxel resolution of 0.11 millimeter (mm) and maximal Field of view (5x5cm) to analyze tooth length from apical to curve root canal, no root fracture, degree of curvature apical third 10°-30°, single root canal, apical closure and complete root formation. At this stage also measured mesio and distal dentin thickness at an altitude of 3 mm from apical as initial data samples before root canal preparation.

Picture 1. Jaw was made from wax for placing sample fixation for CBCT radiographs.

Cavity access was prepared and the working length was done by measuring K-file#10 until file appeared and reduced by 1 millimeter. The prepared tooth was implanted in the center of an acrylic mold block filled with a putty as a root canal preparation site (**Picture 2**). The apical foramen was sealed with a red wax to prevent intrusion of the silicone putty material into the foramen apical.



Picture 2. Tooth with access preparation was implanted in a putty mold.

The division of sample groups were based on previous randomization of samples, namely:

Group IA. A rotary single file cross-sectional parallelogram taper 7%/WaveOne Gold Primary (WOGP) was used for root canal preparation in the continuous rotation group.

Group IB. A rotary single file cross-sectional parallelogram taper 7%/ WaveOne Gold Primary (WOGP)was used for root canal preparation in the reciprocal motion group.

Group IIA. A rotary single file cross-sectional S-shape taper 8% /Reciproc Blue R25 (RBR) was used for root canal preparation in the continuous rotation group.

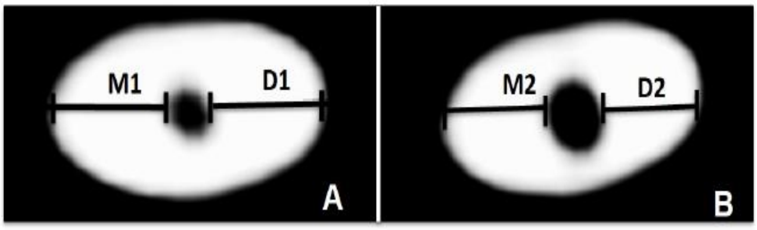
Group IIB. A rotary single file cross-sectional S-shape taper 8%/Reciproc Blue R25 (RBR) was used for root canal preparation in the reciprocal motion group.

All samples were treated as follows: K-file #10 was used as a glide path to the working length. Irrigation with 2.5% NaOCl with a 30G irrigation needle; 17% EDTA and 2.5% NaOCl were used for final irrigation and smear layer elimination. Root canals were prepared according to each group using endomotor (IM2C, Denjoy, Chinnese). Speed was set at 300 RPM and 2 Nm(torque). Preparation of root canals (according to each group) with a predetermined working length. EDTA 24% was used as a lubricating file. Saline 0.9% for rinsing irrigation.

After preparation, all subjects were implanted in a jaw form (red wax) so that CBCT radiographs could be taken simultaneously. The thickness of the mesial and distal root canal walls after preparation was measured at a height of 3 mm from apical with CBCT radiographs.

Canal transportation is calculated using the following formula:

$$CT = (M1 - M2) - (D1 - D2)$$



Picture 3. (A) cross-section of the root canal before preparation (B) cross-section of the root canal after preparation

CT = Canal Transportation

M1 = the shortest distance between the mesial aspect of the external root surface and the mesial portion of the internal root canal that has not been prepared.

M2 = the shortest distance between the mesial aspect of the external root surface and the mesial part of the internal root canal that has been prepared.

D1 = the shortest distance between the distal aspect of the external root surface and the distal portion of the internal root canal that has not been prepared.

D2 = the shortest distance between the distal aspect of the external root surface and the distal part of the internal root canal that has been prepared[1].

In this formula, Canal Transportation (CT) = 0 indicates no transportation while a negative value indicates the transportation toward the distal direction and a positive value indicates the transportation toward the mesial direction. The data were analyzed with two-way ANOVA.

III. RESULTS

This research was done at the Integrated Research Laboratory of Faculty of Dentistry Universitas Gadjah Mada and the Dentomaxillofacial Radiology Installation of Soedomo Dental Hospital, Yogyakarta. The subjects were 32 mandibular premolars previously CBCT radiographed according to inclusion criteria. The samples were divided into 2 groups (n = 16) based on the file design (group A: Rotary single file cross-sectional parallelogram taper 7%/WaveOne Gold Primary(WOGP) and group B: Rotary single file cross-sectional S-shape taper 8%/Reciproc Blue R25(RBR)). Each group was further divided into 2 sub-groups (n = 8) based on file movements (continuous rotation and reciprocal motion), resulted 4 groups in total. Prepared subjects were photographed radiographically with CBCT to measure mesial and distal dentin thickness at a height of 3 mm from the apical.

The mean and standard deviations of canal transportation can be seen in **Table 1,** the mean value of canal transportation is greatest in the rotary single file cross-sectional group S-shape taper 8% continuous rotation (0.256) and the lowest mean value is indicated by the rotary single group file cross-sectional S-shape taper 8% reciprocal motion (0.234). The two way Anova test results can be seen in **Table 2**, there was no significant difference in canal transportation between treatment groups based on the rotary file design and based on the preparation of the movement (p> 0.05). The two-way ANOVA test results showed no interaction between the rotary file design and the movement of the root canal preparation (p> 0.05).

Table 1. The mean canal transportation value in the curvature apical third between each group (in millimeters)

Group	N	x ± SD
WaveOne Gold Primary continous rotation	8	0,246 ± 0,04596
WaveOne Gold Primary reciprocal motion	8	0,234 ± 0,03420
Reciproc Blue R25 continous rotation	8	0,256 ± 0,04868
Reciproc Blue R25 reciprocal motion	8	0,254 ± 0,05502

Table 2. Two way ANOVA results canal transportation in the design of WaveOne Gold Primary and Reciproc Blue R25 with continuous rotation and reciprocal motion preparation

Source of Variance	Number square	Degree	Average square	F count	p
File design	0,002	1	0,002	0,830	0,370
Preparation movement	0,000	1	0,000	0,207	0,652
File design and Preparation movement	0,000	1	0,000	0,092	0,764
Information: p = probability					

IV. DISCUSSION

Two way Anova test showed no significant effect between the design of rotary single file cross-sectional parallelogram taper 7%/ WaveOne Gold Primary(WOGP) and rotary single file cross-sectional S-shape taper 8%/ Reciproc Blue R25(RBR), as well as continuous rotation and reciprocal motion preparation preparations on canal transportation in the curve canal. Thus the hypothesis that there is an effect of the design and movement of different single file system preparations on canal transportation in the curvature apical third (CBCT study) was not proven. The mean range of results of canal transportation is 0.234-0.256 and the results of calculations with the canal transportation calculation were nonzero in each study subject. These results indicated that each group of samples contained canal transportation, in accordance with the opinion of Hong Ha (2015) that transportation in curve canals is unavoidable[10]. The mandibular premolar subject has a buccal and lingual root canal shape which allows the preparation axis of the file will increase the degree of file bending in the apical third and cause more transportation. Factors causing canal transportation include improper preparation of root canal access, factors related to operator fatigue, degree and diameter of canal curvature: If the diameter is small and the degree of root curvature is greater, it is likely that transportation is greater, irrigation is inadequate, improper biomechanical preparation techniques[11].

The heat treatment in both file types is able to adjust the canal curvature in the range of degrees of apical one-third curvature between 10°-30° even though all subjects had canal transportation. The flexibility of WOGP is the result of the thermal cycle procedure, by heating and cooling the file repeatedly[12]. RBR have a thermal treatment that can resistance to cyclic fatigue and greater flexibility[13] so as to produce files with highly elastic NiTi properties that can reduce canal transportation[14].

WOGP and RBR are both made of special NiTi alloy called M-wire. M-wire alloys are characterized by increased flexibility and cyclic fatigue resistance compared to NiTi martensites[15]. WOGP was produced using a thermal process with a new phase transition point between martensite and austenite. The file is slightly curved when pulled from a curve canal because NiTi thermal processes show better shape memory compared to conventional nickel titanium. The file can be straightened or if placed back into the root canal will follow the natural shape of the root canal[16] and prevent excessive cutting of the root canal dentin. Excessive cutting of root canal dentin is another consequence of root canal transport. In root canal transport, the outer dentin wall of the curve canal is to be more cut off[11].

The core diameter and cross-sectional area of WOGP and RBR have a large impact on the ability of root canal preparation. The two instruments have similar apical diameters (size 25) which indicate the degree of taper which is fixed in the first 3 mm, with a slight difference in the taper level (taper 7% and 8%) and the same number of cutting edges. WOGP has two 85 ° cutting edges that intersect the root canal wall and one cutting edge that intersects the root canal wall alternately. The design reduces contact between the edge of the file blade and dentin to only 1 or 2 contact points on each side of the cross-section. This edge significantly reduces file pressure during preparation, minimizes screw-in effects on cutting efficiency, and allows better coronal discharge of debris[17][12]. The design of S-shape (RBR) has the end of an S cross-section file, with two cutting edges that intersect the root canal wall[18].

The results of both reciprocal motion and continuous rotation show that there is no difference in canal transportation. It can be explained between the reciprocal motion and continuous rotation groups are moved in a counter clockwise (CCW) direction. The reciprocal motion on WOGP and RBR use same rotation angle in counterclockwise / clockwise direction (150°/30°)[17]. 30° clockwise movement in reciprocal motion aim to reduce cyclic fatigue and torsinal failure to prevent instrument fractures[14]. WOGP has a cutting edge having an angle of 85 °, the angle of the inverted helix is in contact with the root canal wall when the file rotates counter-clockwise[19]. The larger counter-clockwise rotation angle allows the file to have high dentin cutting efficiency, faster work efficiency without the need for excessive pressure into the root canal[17]. Both movements produce root canal transportation. This is caused by a curve canal. Curve canals can cause increased pressure on the rotary file and result in root canal transportation, zip formation, ledge, and perforation[1].

V. CONCLUSION

Based on the results of the study it can be concluded that there was no effect of different single file system designs on canal transportation in the curvature apical third and there was no effect of the movement of different single file system preparations on canal transportation in the curvature apical third.

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