THE EFFECT OF GLIDE PATH PREPARATION ON THE SHAPING ABILITY OF XP-ENDO® SHAPER IN SIMULATED CANALS

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ABSTRACT

Aims: To compare the shaping efficiency of the XP-endo Shaper with or without glide path preparation with sequenced Scout Race files in J-shaped resin blocks

Material and Methods: Forty simulated J-shaped root canals were classified into two groups (n=20). While the root canals were shaped with XPS after a glide path was created with Scout Race files in Group 1, the same procedures were done without the glide path preparation in Group 2. The pre-and post-instrumentation images were taken and superimposed. Transportation value (TV), centering ability (CA) and the total amount of resin removed (TRR) was calculated by using the obtained images with Adobe Photoshop CS5 software. These parameters were calculated based on 18 reference points (9 inner/9 outer walls) with 1-mm intervals according to 3 sections (coronal, middle, and apical of the canals). The data were analyzed with Kruskal-Wallis and then Dunn's multiple comparison tests ($p \leq 0.05$).

Results: More resin was removed in Group 2 apical and coronal sections than in Group 1 ($p=0.036$). In Group 2, a higher transportation value was obtained in apical and middle sections compared to Group 1 ($p<0.001$). Group 1 showed a higher centering ratio in apical and middle sections than in Group 2 ($p<0.001$). The centering ability of the instruments was decreased in the curvature part (middle section) of the canals.

Conclusions: Within the limits of this study, glide path preparation using Scout Race instruments improved the shaping ability of XPS instrument by leading to less transportation and maintaining centering ability.

KEYWORDS: Glide path. Rotary instruments. Resin blocks. XP endo Shaper.
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INTRODUCTION

Due to the complex morphological structure of the root canal system and root canal irregularities, complications such as perforation, root canal transportation, ledge formation, noncentral preparation, excessive instrumentation, and instrument breakage may occur during root canal shaping [1,2]. Studies have reported that an ideal glide path should be created in order to prevent these complications that may occur during chemomechanical preparation, especially in canals with curvature [3,4]. Glide path prepared with hand files can be difficult and time-consuming for clinicians, especially in teeth with calcified canals or in teeth with canals with severe curvature [5]. For this reason, NiTi glide path files used with rotary instruments have been reported to preserve root canal morphology, reduce post-operative pain and cause less aberration in canals compared to manual files [1,6].

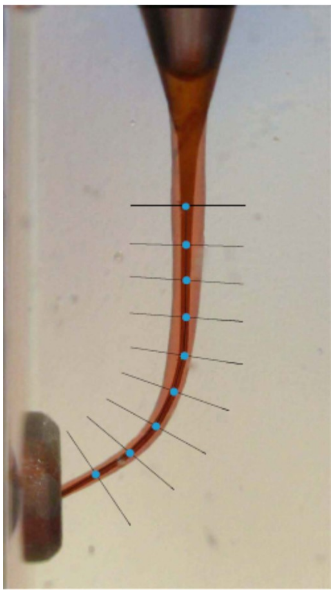

Figure 1. Schematic presentation of lines that were drawn at 1mm intervals perpendicular to the middle axis of the canal.

With the increasing popularity of the use of guide files in recent years, PathFile (Dentsply Maillefer, Ballaigues, Switzerland), G-File (Micro-Mega, Besanc¸on Cedex, France), ProGlider (Dentsply Maillefer), HyFlex GPF (Coltene Whaledent, Allstetten, Switzerland) and Scout Race (FKG Dentaire, La Chaux-de-Fonds, Switzerland) files have been introduced to the market. Scout RaCE files (SR; FKG Dentaire, La-Chaux de Fonds, Switzerland) are introduced for creating glide paths and reducing the number of manual files required for scouting in the root canal. The Scout RaCe file consists of 3 files with tip sizes ISO 10, 15, and 20, with a taper of 0.02. In addition, this file system has 4 cutting edges with a square cross-section that increases torque resistance [7].

XP-endo Shaper (XPS; FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) is the only file system used with a continuous rotation movement. Manufactured from MaxWire alloy, the file has an ISO # 30 apical diameter and 0.01 constant taper. MaxWire technology gives the file super flexibility, shape memory, and high cyclic fatigue resistance characteristics [8]. The recommended XPS file for root canal shaping after creating a glide path of at least ISO 15 size has a six-cutting edge triangular Booster tip design that allows the apical size to gradually increase to create ISO 30 [8,9]. At 35°C or higher, it expands and takes the shape of a semicircle and performs an asymmetrical rotational motion. They protrude towards the walls of the root canal during asymmetrical rotational movement and adapt to the morphology of the root canal system as they progress (expand or narrow) along the working length. According to the manufacturer, the final canal width after preparation with XPS corresponds to 30 apical diameters and 0.04 taper [9]. In addition, due to its adaptation to the root canal walls, the shaping efficiency in larger canals has been reported as successful. Compared to other file systems, XPS has been reported to have high cyclic fatigue performance, shorter preparation time, and more contact with root canal walls [8,10,11]. Besides, it has been reported that during the shaping of the root canals, since the original form of the canal is preserved, it can remove more infected tissue and reduce the amount of debris extruded from the apical [12,13].

In the literature, many studies are evaluating the effect of using glide path file systems together with rotary multiple file systems [4,14], reciprocal single file systems [15,16,17] and rotary single file systems on the shaping ability [18]. However, so far, no study has been encountered to evaluate the effectiveness of the use of the XPS file system with glide path files on root canal shaping. Therefore, in this study, the effect of using the Scout Race (glide path) file system with the XPS file system on transportation, centering ability, and the total amount of resin removal was evaluated. The null hypothesis is there would be no difference in these parameters while XPS files were used with or without glide path preparation.

MATERIALS AND METHODS

Sample Preparation

Forty endo-training resin blocks with J-shaped canals (19) (Dentsply Maillefer, Ballaigues, Switzerland) with an initial size of ISO #15 and a 0.02 taper were used in this study. Each block has a 10 mm radius of curvature, a 70º angle of curvature, and a 16 mm canal length.

The working length was determined to be where the canal instrument appeared at the tip of the artificial canal [20]. A stainless-steel K-file size 10 (Dentsply Maillefer) was used to negotiate the canal up to the WL. The blocks were stained with black ink (Winsor & Newton, Colart Tianjin Art Materials, Tianjin, China). The images of the samples before the instrumentation were taken with a camera (Canon EOS 700 D, Canon Incorporated, Tokyo, Japan) which was adapted to a standard setup that has a metal holder for the stabilization of the blocks. All canals were irrigated with 2 mL tap water to remove the excess dye and patency was verified with a 10 K-file (Dentsply/Maillefer, Ballaigues, Switzerland). Then all resin blocks were randomly divided into two experimental groups, with or without a glide path.

Experimental groups and shaping procedures

Group 1 (n = 20): Scout RaCe (FKG Dentaire, La Chaux-de-Fonds, Switzerland) sizes 10, 15, and 20 (0.02 taper) were used as glide path in continuous rotation with an endodontic motor (X Smart Plus; Dentsply Maillefer) at 800 rpm and 1.5 Ncm torque setting according to the manufacturer's instructions. The patency was again checked by a # 15 K-file. The canals were prepared with the XPS at 800 rpm and 1 Ncm torque.

Group 2 (n=20): XPS was performed without glide path preparation with similar procedures of Group 1.

During the shaping procedures of both groups, 20mL of distilled water was used. During root canal preparation, samples, files, and irrigation solution were kept in a 37°C water bath in a temperature-controlled immersion tank to simulate clinical conditions [8,21]. All the files were used only once and then discarded. The flutes of the instruments were cleaned with a gauze patch in every 3 pecks [22]. All the procedures were performed by the same experienced operator who strictly observed the manufacturer's instructions. The canals were irrigated with 5 ml distilled water as final irrigation and stained with red ink following the preparation. The post-instrumentation images were taken under identical conditions.

Image analysis and evaluation of shaping ability

The pre-and post-operative images were taken by the other operator who was blind to all experimental steps. The images were superimposed using Adobe Photoshop CS5 software (Adobe Systems, Inc., San Jose, CA). Measurement scale was also prepared on superimposed images, and 9 levels[16] on each side [from the outer wall of curvature (A side) and the inner wall of curvature (B side)] of the root canal were calculated by using the same program. The measurement was made in 1-mm intervals; level 1- 3 represented the apical section, levels 4-6 represented the middle section (the curvature portion of the canal), and levels 7-9 represented the coronal section (the straight portion of the canal) (**Figure 1**). Canal transportation and centering ratio were calculated using the following criteria [16,23,24].

1) The total amount of resin removal (TRR): Resin removal from the outer wall of curvature (A) + the inner wall of curvature (B)

2) Transportation value (TV): Resin removal from the outer wall of curvature (A) - the inner wall of curvature (B) (|A-B|)

3) Centering ratio (CR): Resin removal from the outer wall of curvature (A) / the inner wall of curvature (B) or the inner wall of curvature (B) / the outer wall of curvature (A)

Statistical analysis

Data were analyzed with IBM SPSS V23. The compatibility of data to normal distribution was examined by Shapiro-Wilk and Kolmogorov Smirnov tests. Generalized linear models method was used to compare the total amount of resin removal, transportation value, and centering ratio values according to group and region main effects and interactions. A Bonferroni test was used in multiple comparisons. Data were presented as mean and standard deviation. The significance level was set at $p < 0.05$.

Table 1. Mean and standard deviation values in apical, middle, and coronal sections for the amount of removed resin material, transportation value, and centering ratio.

		Group 1	Group 2	Total
Total amount of resin removal	Apical section	0.199 ± 0.047^{E}	0.250 ± 0.035^{C}	0.225 ± 0.049^{a}
	Middle section	0.324 ± 0.070^{B}	0.355 ± 0.064^{B}	0.339 ± 0.068^{b}
	Coronal section	0.427 ± 0.089^{D}	0.504 ± 0.097^{A}	0.465 ± 0.101^{c}
	Total	0.317 ± 0.117	0.370 ± 0.126	0.343 ± 0.124
Transportation value	Apical section	0.057 ± 0.051^{D}	0.137 ± 0.065^{C}	0.097 ± 0.071^{a}
	Middle section	0.097 ± 0.062^{A}	0.189 ± 0.081^{B}	0.143 ± 0.086^{b}
	Coronal section	0.068 ± 0.044^{AD}	0.079 ± 0.056^{AD}	0.074 ± 0.051^{c}
	Total	0.074 ± 0.055	0.135 ± 0.082	0.105 ± 0.076
Centering ratio	Apical section	0.605 ± 0.255^{C}	0.333 ± 0.222^{B}	0.469 ± 0.275^{b}
	Middle section	0.574 ± 0.197^{C}	0.330 ± 0.191^{B}	0.452 ± 0.229^{b}
	Coronal section	0.729 ± 0.150^{A}	0.746 ± 0.155^{A}	0.737 ± 0.152^{a}
	Total	0.636 ± 0.215	0.469 ± 0.273	0.553 ± 0.259

a-c: There is no difference between regions with the same letter, A-E: There is no difference between groups with the same letter.

RESULTS

There was no instrument separation and canal aberration in the study. No other procedural errors such as loss of working length or danger zone formation were observed during the canal instrumentations. The mean values and standard deviations of the total amount of resin removal, transportation, and centering ratio values are presented in **Table 1**.

The Total Amount of Resin Removal (TRR)

There was a statistically significant difference in the amount of material removed between the groups at the apical and coronal levels (p=0.036) (**Table 1**). In group 2 (no glide path), the amount of material removed from the coronal and apical levels of simulated root canals was higher than Group 1(with glide path).

There was no significant difference between groups in the middle section. In both groups, more resin was removed in the coronal, middle, and apical parts of the canals, respectively ($p < 0.001$).

Transportation Values (TV)

Both groups caused transportation at all 3 levels (Table 1). There was a statistically significant difference in transportation values between the groups at the apical and middle levels ($p<0.001$). Mean transportation values in group 2 were higher than group 1 at apical and middle levels. The transportation value was higher in the middle, apical and coronal parts of the canals in both groups, respectively ($p <0.001$) (**Table 1**).

Centering Ratio (CR)

There was a significant difference in mean centering ratio between two groups in apical and middle section of the canal ($p<0.0001$) (**Table 1**). Group 1 showed a higher centering ratio in the apical and middle section. There was no statistically significant difference between the two groups in the coronal section. The centering ability of the instruments was decreased in the curvature part (middle section) of the canals (**Figure 2**).

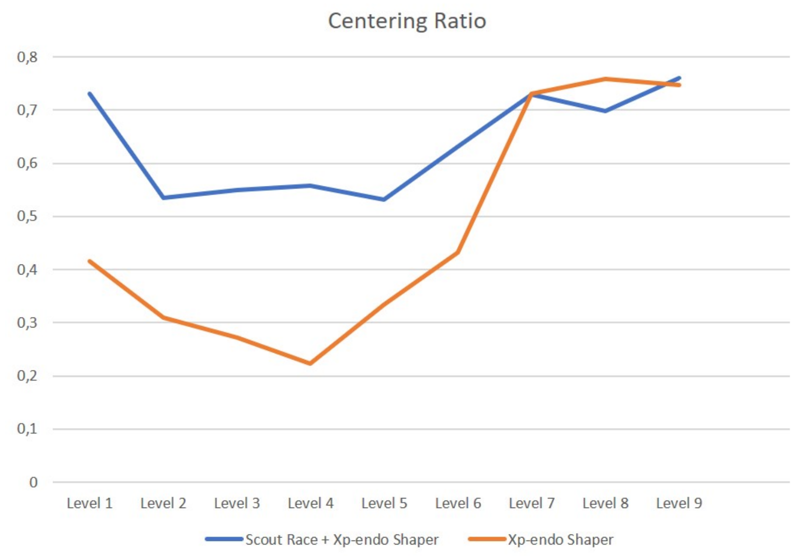

Figure 2. Centering ratio values for groups at 1 mm intervals.

DISCUSSION

In this study, the effects of using the Scout Race (glide path) file system with the XPS file system on transportation, centering ability, and the total amount of resin removal were evaluated. According to the results, it was determined that the use of Scout Race files improves the shaping ability of the XPS system. In the glide path group, statistically significant less resin was removed in the apical and coronal sections ($p = 0.036$). In addition, less transportation ($p <0.0001$) and higher centering ability ($p <0.0001$) were found in the apical and middle sections in the glide path group. Therefore, the null hypothesis was rejected.

Many studies investigating the effects of using glide path on the shaping ability of NiTi files have been identified [3,15-17,20,25,26]. Dhingra et al.[25] have reported that creating a glide path with PathFile files reduced the transportation of Wave One Gold files and increased the centering ability. Elnaghy & Elsaka[4] have reported that the use of PathFile and ProGlider glide path files together with ProTaper Next files resulted in less transportation than the group without glide paths. Hage et al.[15] have reported that creating a glide path with PathFile files increased the Reciproc Blue files' centering ability and reduced transportation. Keskin et al.[16] have found that the use of ProGlider glide path files before Reciproc Blue files reduced transportation and increased centering ability compared to the group without glide paths. Yilmaz et al.[27] have reported that the use of PathFile files to create a glide path increases the Wave One Gold centering ability. Since no study examining the shaping ability of using Scout Race and XPS files together in the literature was encountered, the results of this study could not be directly compared with other studies. However, in these studies, the use of guide files has increased the shaping ability of the files, and they are compatible with our study in this respect.

In some studies, on the other hand, it has been reported that creating a glide path does not affect the shaping ability of file systems[17,26]. Coelho et al.[17] have reported that creating a glide path with K-file did not affect the centering ability of Reciproc and Wave One files. In this study, glide path was created with K-file and digital radiography was used as the evaluation method. We think that this difference in results may be due to the glide path and evaluation method used because Zheng et al. [28] and Paleker et al. [29] have reported that rotary glide path files showed better centering ability and less transportation than K-type files. De Carvalho et al. [26] have reported that creating a glide path with K-file and Path File does not affect the apical transportation of the Reciproc system. The apical inclination of the teeth used in the related study has been selected between 20-30 degrees and CBCT has been used as the evaluation method. In our study, samples with a standard apical curvature of 70 degrees were used. The difference in results may be due to the apical curvature and the different assessment methods.

Bürklein et al. [20] have reported that the use of Path File files with rotational and reciprocal single file systems such as Reciproc, WaveOne, HyflexCM, F360, and OneShape did not affect transportation and centering abilities. In the related study, Path File was used as a glide path file and the study was performed on S-shaped resin blocks. We think that the difference in the results of the related study is due to the differences in the anatomical features of the glide path file and resin blocks used.

De-Deus et al. [30] have reported that using the XPS file at working times of 15, 30 and 45 seconds did not cause instrument breakage or procedural error. Velozo et al. [31] have reported that no file breakage was observed in the study comparing the shaping ability of the XPS system. Ateş et al. [32] have reported that the use of a glide path does not affect the fracture resistance of the XPS system. In our study, file breakage and procedural errors were not detected during root canal shaping in both groups. In this respect, it supports the results of the studies mentioned above. This may be due to the asymmetrical rotational motion of the file. In the rotation movement, XPS protrudes towards the walls of the root canal, expands or narrows while advancing in the root canals, adapting to the morphology of the root canal system[10,21].

Scout Race file was used as a glide path file in this study. De-Deus et al. [33] have reported that Scout Race files were more efficient in reaching the working length and more resistant to fracture than ProDesign, Mtwo, and ProGlider files. Ajuz et al. [34] have reported that Scout Race files preserve the original canal anatomy by causing less aberration in canal anatomy compared to K-file and Path File files. However, there is no study examining the effect of Scout Race files on the shaping ability of single file systems in the literature. For this reason, Scout Race system was used as a glide path file in this study.

Natural teeth and simulated resin block canals are used to compare the shaping abilities of NiTi files. However, in studies using natural teeth, it is very difficult to provide the standardization of anatomical differences such as root canal curvature angle, curvature length, microhardness, and initial canal width[24]. Peters et al. [35] have reported that when using natural teeth, variations in pre-preparation canal geometry have a greater effect on changes during preparation than NiTi files used. By standardizing the anatomical variability of simulated canals, the shaping capabilities of NiTi files are compared more easily with computer programs on pre-and post-operative images [22,24]. For this reason, simulated canals were used in this study to eliminate anatomical variations in natural teeth.

J-shaped canals are frequently encountered in endodontic treatments, and rates between 9% and 27% have been reported in different teeth in the study [36]. In the root canal treatment of J-shaped canals, transportation, and instrument breakage, iatrogenic errors which can complicate root canal shaping, can occur [37]. For this reason and considering these conditions, J-shaped simulated canals were used to reflect the difficulties in root canal anatomy.

In the present study, all procedures were done at 37°C to mimic in vivo conditions and the simulated canals were used to standardize samples. Although these measures, this study has some limitations. First, the resin blocks used in the present study cannot simulate the dentin micro-hardness of the human teeth. The other limitation of this study is that transportation and centering capability were not evaluated by micro-computed tomography, which is a three-dimensional method. However, resin blocks are a repeatable and frequently preferred method that allows two-dimensional measurements in standard [16]. The most important disadvantage of resin block is that its hardness is not the same as dentin. For these reasons, care should be taken when transferring the results of this study to clinical practice. It is recommended to confirm the results with future clinical and CBCT studies.

CONCLUSION

Within the limitations of the present study, performing a glide path with the Scout Race improved the XP-endo Shaper single-file systems centering ability and reduced canal transportation and amount of resin removed in J-shaped resin-simulated canals.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported

REFERENCES

1. Pasqualini D., Bianchi C.C., Paolino D.S., Mancini L., Cemenasco A., Cantatore G., et al. Computed micro-tomographic evaluation of glide path with nickel-titanium rotary pathfile in maxillary first molars curved canals. J Endod. 2012;38(3):389-393.

2. Aydın Z.U., Keskin N.B., Özyürek T., Geneci F., Ocak M., Çelik H.H. Microcomputed assessment of transportation, centering ratio, canal area, and volume increase after single-file rotary and reciprocating glide path instrumentation in curved root canals: A laboratory study. J Endod. 2019;45(6):791-796.

3. Berutti E., Cantatore G., Castellucci A., Chiandussi G., Pera F., Migliaretti G., et al. Use of nickel-titanium rotary pathfile to create the glide path: Comparison with manual preflaring in simulated root canals. J Endod. 2009;35(3):408-412.

4. Elnaghy A., Elsaka S. Evaluation of Root Canal Transportation, Centering Ratio, and

Remaining Dentin Thickness Associated with ProTaper Next Instruments with and without Glide Path. J Endod. 2014;40.

5. D'Amario M., Baldi M., Petricca R., De Angelis F., El Abed R., D'Arcangelo C. Evaluation of a new nickel-titanium system to create the glide path in root canal preparation of curved canals. J Endod. 2013;39(12):1581-1584.

6. Pasqualini D., Mollo L., Scotti N., Cantatore G., Castellucci A., Migliaretti G., et al. Postoperative pain after manual and mechanical glide path: A Randomized clinical trial. J Endod. 2012;38(1):32-36.

7. Nakagawa R.K.L., Alves J.L., Buono V.T.L., Bahia M.G.A. Flexibility and torsional behaviour of rotary nickel-titanium PathFile, RaCe ISO 10, Scout RaCe and stainless steel K-File hand instruments. Int Endod J. 2014;47(3):290-297.

8. Azim A.A., Piasecki L., da Silva Neto U.X., Cruz A.T.G., Azim K.A. XP Shaper, A Novel Adaptive Core Rotary Instrument: Micro-computed Tomographic Analysis of Its Shaping Abilities. J Endod. 2017;43(9):1532-1538.

9. Solutions X.-E. XP-endo Shaper. Published 2021. https://www.fkg.ch/xpendo/shaper

10. Elnaghy A., Elsaka S. Cyclic fatigue resistance of XP-endo Shaper compared with different nickel-titanium alloy instruments. Clin Oral Investig. 2018;22(3):1433-1437.

11. Azim A.A., Wang H.H., Tarrosh M., Azim K.A., Piasecki L. Comparison between single-file rotary systems: Part 1-efficiency, effectiveness, and adverse effects in endodontic retreatment. J Endod. 2018;44(11):1720-1724.

12. Alves F.R.F., Paiva P.L., Marceliano-Alves M.F., Cabreira L.J., Lima K.C., Siqueira J.F.J., et al. Bacteria and Hard Tissue Debris Extrusion and Intracanal Bacterial Reduction Promoted by XP-endo Shaper and Reciproc Instruments. J Endod. 2018;44(7):1173-1178.

13. Uslu G., Özyürek T., Yılmaz K., Gündoğar M., Plotino G. Apically Extruded Debris during Root Canal Instrumentation with Reciproc Blue, HyFlex EDM, and XP-endo Shaper Nickel-titanium Files. J Endod. 2018;44(5):856-859.

14. Alovisi M., Cemenasco A., Mancini L., Paolino D., Scotti N., Bianchi C.C., et al. Micro-CT evaluation of several glide path techniques and ProTaper Next shaping outcomes in maxillary first molar curved canals. Int Endod J. 2017;50(4):387-397.

15. Hage W., Zogheib C., Bukiet F., Sfeir G., Khalil I., Gergi R., et al. Canal transportation and centring ability of reciproc and reciproc blue with or without use of glide path instruments: A CBCT study. Eur Endod J. 2020;5(2):118-122.

16. Keskin C., Sarıyılmaz E., Demiral M. Shaping ability of reciproc blue reciprocating instruments with or without glide path in simulated s-shaped root canals. J Dent Res Dent Clin Dent Prospects. 2018;12(1):63-67.

17. Coelho M.S., Fontana C.E., Kato A.S., De Martin A.S., Da Silveira Bueno C.E. Effects of glide path on the centering ability and preparation time of two reciprocating instruments. Iran Endod J. 2016;11(1):33-37.

18. Bürklein S., Benten S., Schäfer E. Shaping ability of different single-file systems in severely curved root canals of extracted teeth. Int Endod J. 2013;46(6):590-597.

19. Maki K., Ebihara A., Kimura S., Nishijo M., Tokita D., Okiji T. Effect of different speeds of up-and-down motion on canal centering ability and vertical force and torque generation of nickel-titanium rotary instruments. J Endod. 2019;45(1):68-72.e1.

20. Bürklein S., Poschmann T., Schäfer E. Shaping ability of different nickel-titanium systems in simulated S-shaped canals with and without glide path. J Endod. 2014;40(8):1231-1234.

21. Velozo C., Albuquerque D. Microcomputed tomography studies of the effectiveness of XP-endo Shaper in root canal preparation: A Review of the literature. Sci World J. 2019;2019.

22. Saleh A.M., Gilani P.V., Tavanafar S., Schäfer E. Shaping ability of 4 different single-file systems in simulated S-shaped canals. J Endod. 2015;41(4):548-552.

23. Ersev H., Yılmaz B., Çiftçioğlu E., Özkarslı Ş.F. A comparison of the shaping effects of 5 nickel-titanium rotary instruments in simulated S-shaped canals. Oral Surgery, Oral Med Oral Pathol Oral Radiol Endodontology. 2010;109(5):e86-e93.

24. Ozyurek T., Yilmaz K., Uslu G. Shaping Ability of Reciproc, WaveOne GOLD, and HyFlex EDM Single-file Systems in Simulated S-shaped Canals. J Endod. 2017;43(5):805-809.

25. Dhingra A., Nagar N., Sapra V. Influence of the glide path on various parameters of root canal prepared with WaveOne reciprocating file using cone beam computed tomography. Dent Res J (Isfahan). 2015;12(6):534-540.

26. De Carvalho G.M., Sponchiado Junior E.C., Garrido A.D.B., Lia R.C.C., Roberti Garcia L.D.F., Franco Marques A.A. Apical transportation, centering ability, and cleaning effectiveness of reciprocating single-file system associated with different glide path techniques. J Endod. 2015;41(12):2045-2049.

27. Yilmaz A., Kucukay E.S., Istektepe M., Sisli S.N., Ersev H., Karagoz-Kucukay I. Comparison of the shaping ability of waveone reciprocating files with or without glide path in simulated curved S-shaped root canals. J Int Soc Prev Community Dent. 2017;7(7):S13-S17.

28. Zheng L., Ji X., Li C., Zuo L., Wei X. Comparison of glide paths created with K-files, PathFiles, and the ProGlider file, and their effects on

subsequent WaveOne preparation in curved canals. BMC Oral Health. 2018;18(1).

29. Paleker F., Van Der Vyver P.J. Comparison of canal transportation and centering ability of K-files, ProGlider file, and G-files: A micro-computed tomography study of curved root canals. J Endod. 2016;42(7):1105-1109.

30. De-Deus G., Belladonna F.G., Simões-Carvalho M., Cavalcante D.M., Ramalho C.N.M.J., Souza E.M., et al. Shaping efficiency as a function of time of a new heat-treated instrument. Int Endod J. 2019;52(3):337-342.

31. Velozo C., Silva S., Almeida A., Romeiro K., Vieira B., Dantas H., et al. Shaping ability of XP-endo Shaper and ProTaper Next in long oval-shaped canals: a micro-computed tomography study. Int Endod J. 2020;53(7):998-1006.

32. Ates A.A., Arican B., Ounsi H.F. Influence of rotational speed and glide path on cyclic fatigue resistance of XP-endo shaper. Niger J Clin Pract. 2020;23(10):1443-1448.

33. De-Deus G., Belladonna F.G., Souza E.M., Alves V. de O., Silva E.J.N.L., Rodrigues E., et al. Scouting ability of 4 pathfinding instruments in moderately curved molar canals. J Endod. 2016;42(10):1540-1544.

34. Ajuz N.C.C., Armada L., Gonçalves L.S., Debelian G., Siqueira J.F.J. Glide path preparation in S-shaped canals with rotary pathfinding nickel-titanium instruments. J Endod. 2013;39(4):534-537.

35. Peters O.A., Laib A., Göhring T.N., Barbakow F. Changes in root canal geometry after preparation assessed by high-resolution computed tomography. J Endod. 2001;27(1):1-6.

36. Beshkenadze E., Chipashvili N. Anatomo-morphologıcal feutures of the root canal system ın Georgıan populatıon - cone-beam computed tomography study. Georgian Med News. 2015;247:7-14.

37. Alfadley A., Alrajhi A., Alissa H., Alzeghaibi F., Hamadah L., Alfouzan K., et al. Shaping Ability of XP Endo Shaper File in Curved Root Canal Models. Fortunato L, ed. Int J Dent. 2020;2020:4687045.