ORIGINAL ARTICLE

Turk Endod J 2023;8(3):143–150
doi: 10.14744/TEJ.2023.15238

Canal transportation and instrumentation time efficacy of pediatric rotary files with or without glide path

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Purpose: This study aimed to investigate the canal transportation and instrumentation time of pediatric rotary files with or without a glide path.

Methods: Fifty simulated resin blocks were randomly assigned to one of five experimental groups (n = 10): Group K is a K-type hand file (control), group P is a Kiddy files rotary system, group OP is a One G glide path file and a Kiddy files rotary system, group F is an AF baby tooth file (AFB) rotary system, and group OF is a One G glide path file and an AFB rotary system. The instrumentation time was recorded after preparing simulated canals. Image J software was used to calculate canal transportation at various canal levels.

Results: The group K had the longest preparation period ($p < 0.05$) and the greatest apical transportation scores (0.35 ± 0.23). It was followed by groups F (0.18 ± 0.26), OF (0.03 ± 0.09), OP (0.03 ± 0.03), and P (0.02 ± 0.01). The difference between the K and P groups, the K and OP groups, and the F and P groups was statistically significant ($p < 0.05$).

Conclusion: Using a glide path during canal preparation by rotary systems could reduce procedural errors. For root canal preparation, Kiddy files with or without a glide path may be advised.

Keywords: Canal transportation; glide path; Ni-Ti files; primary teeth; rotary systems.

Introduction

Primary tooth retention until physiological exfoliation minimizes harmful behaviors in children and improves esthetics, phonation, and mastication. Changes in the eruption sequence and chronology of permanent teeth may result from the early loss of primary teeth (1). Endodontic therapy should, therefore, be used to guarantee the continuity of primary teeth with necrosis or pulpitis (2).

The primary purpose of root canal therapy is to eliminate diseased tissue remnants as well as bacteria. This is possible with chemomechanical preparation. During root canal preparation, complications such as apical transportation, zipping, and ledging are common errors (3). Due to the damage of the root's integrity and insufficient cleaning of the root canals, transportation in the apical third of the root canal encourages the harboring of residual bacteria and debris (4). Manual or rotational instrumentation used to create a glide path efficiently preserves root canal anatomy (5). The tip of the first spinning instrument is

Cite this article as: Özdoğru H, Keskin G. Canal transportation and instrumentation time efficacy of pediatric rotary files with or without glide path. Turk Endod J 2023;8:143-150.
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Submitted: August 03, 2023 Revised: October 09, 2023 Accepted: October 13, 2023

monitored by a smoothly centered glide path from the canal orifices to the physiological terminus, allowing root canal preparation (6). Thus, canal transportation could be avoided.

Another method for minimizing canal transportation is to utilize nickel-titanium (Ni-Ti) rotary instruments, which are commonly employed in permanent teeth and keeps the original canal space during root canal preparation. Ni-Ti instruments provide faster canal preparation while reducing procedural errors (7-9). Barr et al. (10) described the first case of biomechanical preparation using rotary files (Profile 0.04 taper rotary instruments) in primary teeth. The previous research found that using instruments in primary teeth enhanced cleaning capacity (11), reduced debris and smear accumulation (12), improved obturation quality (13), and increased obturation volume (14). However, due to the ribbon-shaped morphology of primary teeth, adopting techniques designed for permanent teeth to primary molars is extremely difficult. Furthermore, soft- and low-density dentin, thin, short, curved roots, and undetected root resorption can result in lateral perforation on the inner root surface, particularly in molar roots (15). As a result, the development of pediatric rotary file systems designed specifically for primary teeth is critical. There are a limited number of pediatric rotary files on the market, and there have been a limited number of studies assessing the effect of pediatric rotary files on canal transportation (16-18). Therefore, the purpose of the study was to compare the instrumentation time and canal transportation ability of two pediatric rotary files with or without glide path file usage. The study's null hypothesis was that the groups would result in similar findings.

Materials and Methods

Sample Preparation

Fifty single-canal simulated roots (45°, 19 mm length) in resin blocks (VDW, Germany) were tested in the present study. To standardize root length at 13 mm, the coronal part of resin blocks was trimmed with a low-speed cutting machine (Isomet, Buehler Ltd, Lake Bluff, IL, USA). The sample size was estimated using the Aydin et al. (3) study; ten samples were chosen for each group with a power of 0.90 and a 0.05 significance level. The blocks were divided into five groups:

Group K

K-type hand file group (Dentsply Maillefer, Ballaigues, Switzerland): Simulated canals were manually prepared to the working length (WL) with ISO #15, #20, and #25 K-type hand files.

Group P

Kiddy files (Perfect Medical Instruments, Shenzhen, China). The root canals were prepared in the following sequence: #20/0.04 and #25/0.04 with 350 rpm and 1.5 Ncm torque.

Group OP

One G (Micro Mega, Besancon, France) + Kiddy files. Firstly, canals were prepared with One G (#14/0.03) in continuous rotation mode (400 rpm; 1.2 Ncm). Subsequently, a #20/0.04 and #25/0.04 Kiddy files rotary instruments were used.

Group F

AF Baby Tooth File (AFB; Fanta Dental Material Co, Shangai, China). The root canals were prepared with the rotary system (350 rpm; 2 Ncm) in the following order: #17/0.08, #20/0.04, and #25/0.04.

Group OF

One G + AFB. Firstly, canals were instrumented with One G (#14/0.03) in continuous rotation mode (400 rpm; 1.2 Ncm). Following canal preparation, the #17/0.08, #20/0.04, and #25/0.04 AFB rotary systems were used.

The files were utilized in accordance with the manufacturer's recommendations. Table 1 shows the basic characteristics of the rotary files used in the study. A low-torque endodontic motor (X-Smart; Dentsply Maillefer) was used to run all rotary files. The operator only utilized the instruments once until the WL was reached. The preparation was carried out using gentle apical pressure and a pecking motion with an amplitude of 3–4 mm. After three motions, the instruments were cleaned with gauze, and patency was tested again with the #10 hand K-file. 2.5% sodium hypochlorite (NaOCl) irrigation was applied using a 27-gauge irrigation needle (Steri Tips; DiaDent, Chungcheongbuk-do, Korea) after each instrument was used in the root canal. The instrument motion was repeated until the predetermined WL was reached. A chronometer was used to record all procedures, including irrigation, instrument changes within the sequence protocol, and total active instrumentation to determine the instrumentation time. Each instrument was used to prepare a maximum of three samples. Instruments were inspected by a dental operating microscope after each preparation, and if any symptom of deformation was observed, the instrument was immediately replaced.

Stereomicroscope Analysis

All blocks were similarly visualized under a stereomicroscope (Leica MZ 12.5, Heerbrugg, Germany) with a magnification of ×10, before and after preparation. The images were then saved as tiff files. With a 1-mL syringe, ink

Table 1. Basic features of rotary files used in the study

File	Features	Manufacturer
Kiddy files	Range of tip sizes; 15–30 Tapers; 0.04/0.06 Cross-section; Convex triangular Speed range; 250–350 rpm, 1.50 N	Perfect medical instruments Co., Shenzhen, China
AF baby tooth file	Range of tip sizes; 25–35 Tapers; 0.04/0.06 Cross-section; Convex triangular Speed range; 250–350 rpm, 2–2.6 N	Fanta Dental Material Co., Shanghai, China
One G	Range of tip sizes; 12–17 Taper; 0.03 Cross-section; Asymmetrical file section Speed range; 250–400 rpm, 1.2 N	Micro-Mega, Besançon, France

(Pelikan, Germany) was injected into post-instrumentation simulated canals (Fig. 1). A random preparation sequence was devised for each of the five groups to ensure fair block distribution and to limit the bias of operator fatigue. Over the superimposed pictures, 10 sequential circles 1 mm apart were drawn, with the apical point of the canal in the center of each (Fig. 2). The sites at which root canals intersected with circles were measured and recorded. T0 was assigned to the block apexes (0 mm). T3 was regarded as 3 mm from the apex, T6 was considered 6 mm from the apex, and T9 was considered 9 mm from the apex. The value of each measuring point was derived by subtracting the outer side of curvature from the inner side toward the furcation. For computation (inner-outer), ImageJ software

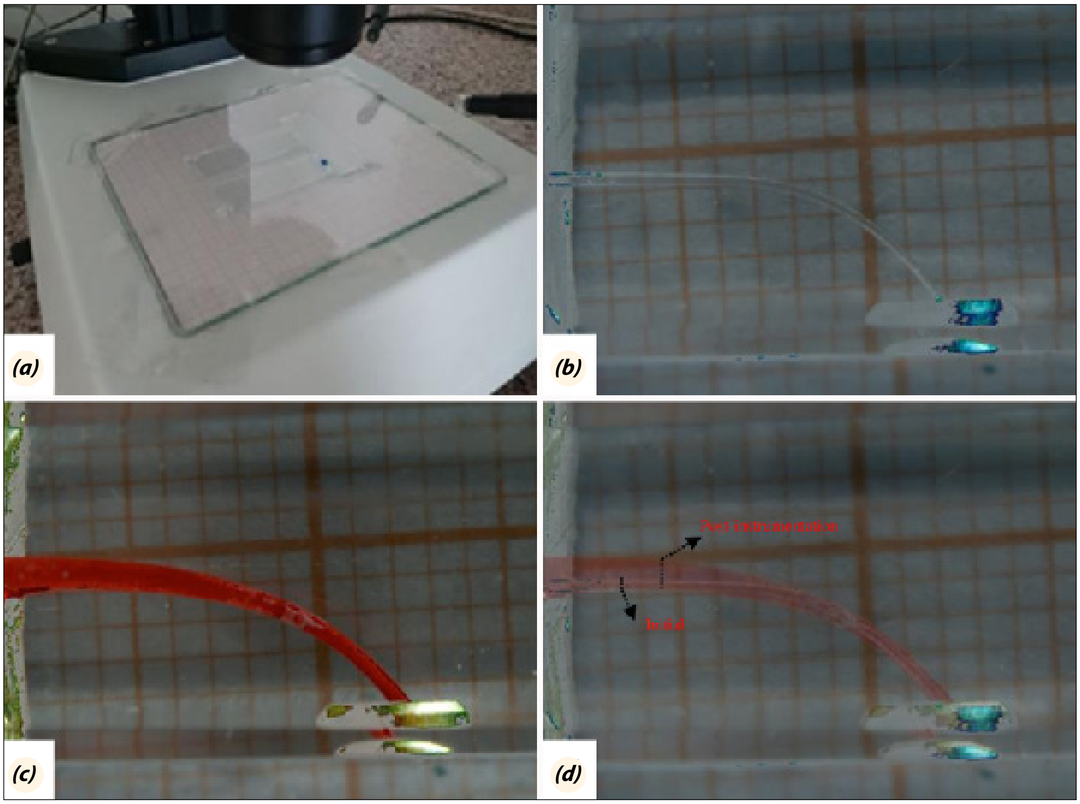

Fig. 1. Images of the experimental protocol related to simulated canal preparation and measuring canal transportation. **(a)** A mechanism made of glass lamellae that allows stereomicroscope images of resin blocks to be taken from the same angle at all time, **(b)** initial image of the resin block, **(c)** the post-preparation red-ink staining, and **(d)** the superimposition of initial and post-instrumentation images of simulated resin canals.

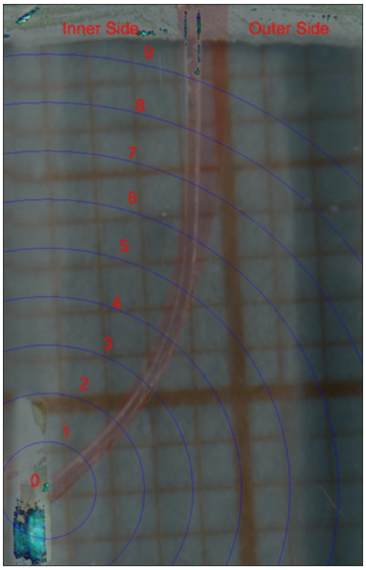

Fig. 2. Circles that were drawn to determine measurement points in the superimposed image.

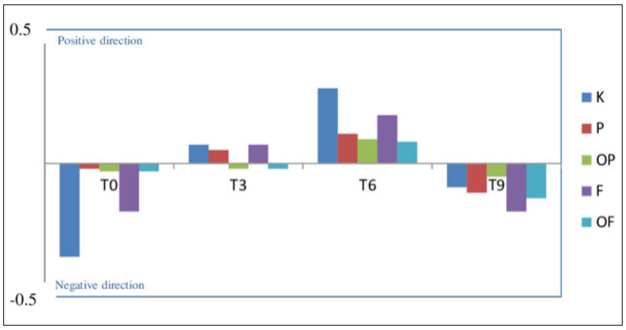

Fig. 3. Transportation directions and quantities (K: K-type hand file; P: Kiddy files; OP: One G+ Kiddy files; F: AF baby tooth file; and OF: One G+AF baby tooth file).

(1.48 version, National Institutes of Health, USA) with a precision of 0.01 mm was utilized. It was determined that if the inner side is less than the outer side, the canal transportation is negative, that is, the transportation direction is toward the canal curvature's outside half. It was determined that if the inner side is greater than the outer side, the canal transportation direction is positive, that is, the transportation direction is toward the inner section of the canal curvature.

Statistical Analysis

SPSS v22.0 (SPSS, Inc., Chicago, IL, USA) was used to analyze the collected data. The normality of the data was tested by the Shapiro–Wilk test. The instrumentation time was analyzed using a one-way ANOVA and followed by Tukey's test for multiple comparisons. Subsequently, the Kruskal–Wallis test was used to compare the canal transportation of the experimental groups at the different canal levels. $p < 0.05$ was considered significant.

Results

Table 2 shows the mean differences in canal transportation at various levels from the apical terminal. At the TO point, the Group K had the greatest canal transportation scores (0.35 mm ± 0.23). It was followed by groups F (0.18 mm ± 0.26), OF (0.03 mm ± 0.09), OP (0.03 mm ± 0.03), and P (0.02 mm ± 0.01). The difference between the K and P groups, the K and OP groups, and the F and P groups was statistically significant ($p < 0.05$). At the T3 and T9 points, there were no statistical differences between the groups ($p > 0.05$). At the T6 point, the highest transportation values were obtained from K (0.28 mm ± 0.09), F (0.18 mm ± 0.19), P (0.11 mm ± 0.09), OP (0.09 mm ± 0.09), and OF (0.08 mm ± 0.14) groups, respectively. There was a statistically significant difference between the K and P groups and the K and OP groups ($p < 0.05$).

Fig. 3 showed the canal transportation direction. At T0 and T9, all groups had negative values, while T6 had positive values. At T3, the K, P, and F groups demonstrated positive canal transportation, while the OP and OF groups demonstrated negative canal transportation.

In terms of instrumentation time (Fig. 4), the K group obtained the longest duration, followed by the F, OF, OP, and P groups, in that order. Only the difference between

Table 2. Mean differences of canal transportation at different levels from the apical terminus

	T0 (0 mm)	T3 (3 mm)	T6 (6 mm)	T9 (9 mm)	Time (s)
K	0.35±0.23 ѣ°	0.07±0.04	0.28±0.09* ѣ	0.09±0.18	294.46±27.53^{a}
P	0.02±0.01*ѣ	0.05±0.08	0.11±0.09*	0.11±0.20	115.44±9.71^{d}
OP	0.03±0.03°	0.02±0.05	0.09±0.09 ѣ	0.05±0.11	119.01±5.28^{d}
F	0.18±0.26*	0.07±0.04	0.18±0.19	0.18±0.14	183.66±14.09^{b}
OF	0.03±0.09	0.02±0.08	0.08±0.14	0.13±0.22	160.46±6.33^{c}

K: K-type hand file; P: Kiddy Files; OP: One G+ Kiddy files; F: AF baby tooth file; OF: One G+AF baby tooth file; s: Second. The same superscript symbols (*, ѣ, °) mean a statistically significant difference in each column ($p<0.05$). Different superscript lower case letters (a,b) mean a statistically significant difference in the time column ($p<0.05$).

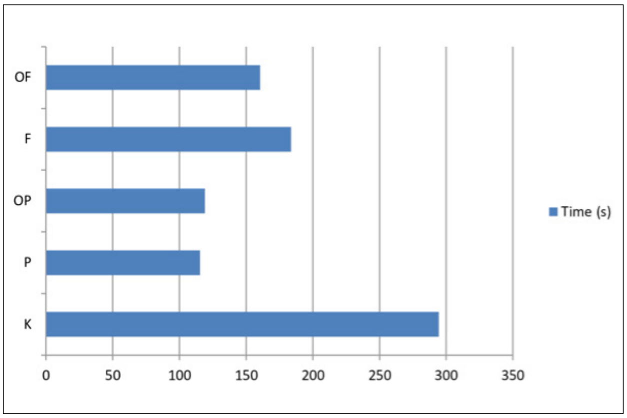

Fig. 4. Schematic illustration of the instrumentation time (K: K-type hand file; P: Kiddy files; OP: One G+ Kiddy files; F: AFB; and OF: One G+AF baby tooth file; s: Second).

the P and OP groups was not statistically significant ($p > 0.05$). There was a significant difference in time in other groups ($p < 0.05$).

Discussion

Significant differences were found between the groups at different root levels in the present study examining the efficacy of pediatric rotary and One G glide path files on canal transportation. The Kiddy files demonstrated less canal transportation than the K-type hand files and AFB rotary system, and the use of glide path files differed from the rotary file systems. Furthermore, when compared to K-type hand files, rotary systems reduced instrumentation time. As a result, the study's null hypothesis was rejected.

The apical outer half of the canal wall structure is removed since files tend to return to their original linear shape during canal preparation. This condition, which can result in perforations and ledge formation, is known as canal transportation (19). The number of publications (20) that report the transportation efficacy of various instrumentation approaches utilizing simulated canals or extracted teeth demonstrates the significance of root canal transportation. Simulated artificial root canals have several drawbacks because their hardness, surface texture, and different cross-sections compared to extracted teeth (21). However, each root canal in a natural tooth has a unique path that cannot be standardized (22). The use of artificial canals in resin blocks provides good consistency by preventing variations induced by anatomical differences, and its validity has been demonstrated by several studies (23). The scientific validity of the procedure was validated in this study since it allows for an objective comparison of the files' canal transportation effect. In this study, 2D pictures were employed to quantify canal transportation. This imaging method is effective for evaluating canal transportation in standardized resin blocks (3,23), but it has significant drawbacks, including the inability to analyze canal transportation in all directions. The capture of 3D images could allow for the examination of canal transit at any level and in any direction. However, due to the large amount of data in 3D evaluation, pooling measurements by canal thirds for applied analysis is difficult since it obscures the significant local variability of canal transportation (20).

Establishing a conical root canal shape in canal preparation with rotary instruments that encourage higher quality root canal filling enhances clinical success (7,8). The most recent research reveals that rotary files facilitate preparation with no or less transfer (24). However, there was a lack of information on the impact of pediatric rotary files on canal transportation. Haridoss et al. (16) examined the Kedo-S pediatric and Mtwo instruments regarding canal transportation and instrument centering capabilities. Both files provided comparable results. Waly et al. (17) examined the centering ability ratio, dentin thickness, and canal transportation of the Kedo-S pediatric file system, the AFB file system, and hand instrumentation. It was revealed that no significant differences in canal transportation or dentin thickness were noted through groups at all three levels of prepared canals. Another study comparing AFB and Zuanba pediatric files with manual instruments found no significant difference in canal transportation between the three groups, except at the apical level. The AFB rotary system showed greater transportation than the Zuanba rotary system and hand K-files in the apical portion of the canal (18).

The AFB rotary system includes one orifice opener file (tip size #17, taper 0.08, length 11 mm) and three shaping files with tip sizes ranging from #25 to #35. There are tapers of 0.04 and 0.06 available, as well as a length of 16 mm. The file has a convex triangular cross-section and suggested to be used in a torque-controlled endodontic motor at a constant speed of 250 to 350 rpm. The Kiddy files system, compared to the AFB rotary system, contains four shaping files with changeable tip sizes ranging from #15 to #30. The Kiddy files have identical tapers, lengths, and functioning principles to the AFB. Both file systems rotate indefinitely and have a triangular cross-section similar to that of a reamer. By increasing the contact of the file edges to the canal walls, this design tapering toward the apex may provide smooth intraradicular dentin surfaces (25). Depending on the first canal size, apical preparation to size #20–#30 with a moderately tapered preparation (0.04–0.06) should be sufficient in primary molars to avoid over-preparation of the canal walls (15). It has been indicated that there is a positive correlation between the file diameter and the tendency for canal transportation

(26). As a result, a taper higher than 0.06 should be avoided for apical expansion, particularly in curved canals. Root canal transportation of up to 0.15 mm was considered appropriate, with a maximum of 0.3 mm at the apical end (21). Only the K-type hand file demonstrated apical transportation higher than 0.3 mm in the present study. High canal transportation (0.18 mm on average) was identified in the apical area and 6 and 9 mm from the root apex in group F (AFB rotary system). However, these values were reduced when combined with the glide path file.

Various results were produced from investigations on the canal transportation characteristics of rotating instruments. These were related to file characteristics such as motion type, instrument taper, file alloy, and instruments' cross-sectional geometry (27). Furthermore, higher tapering, particularly on the apical region, has been reported to result in greater transportation due to less flexibility (28). In the present study, the contradictory results reported in two different pediatric rotary file systems with similar features could be attributed to the files' undefined metallurgical qualities.

Files have a tendency to cut throughout their entire length and then revert to their original shape. As a result, in multi-rooted teeth, there is a risk of over-preparing root canals toward the inner curve in the more coronal regions and the outer curvature in the apical area (29). Irregular foramen widening and outer apical transportation may result in poor sealing efficacy and a high incidence of debris extrusion, resulting in post-operative pain (30). While outer canal transportation was found in the apex, inner canal transportation was observed in all groups at a distance of 6 mm from the apex, as expected. The direction of transportation has moved outward at a distance of 9 mm from the apex.

The goals of creating a glide path are to prevent the engine-operated Ni-Ti instruments from breaking by allowing them to move passively in the canals and to reduce variations in the canal axis (29). Preparing a glide path has already been shown to prevent procedural errors during root canal treatment (31). In terms of apical transportation, preparing a glide path before the final shape is performed similarly (32) or much better (3) than not preparing a glide path. Using the One G glide path reduced canal transportation from 0.18 mm ± 0.26 to 0.03 mm ± 0.09 at the root apex in group F (AFB rotary system) of the present study. It decreased from 0.18 mm ± 0.19 to 0.08 mm ± 0.14 and from 0.18 mm ± 0.14 to 0.13 mm ± 0.22, respectively, at 6 and 9 mm from the root apex. It is possible to predict that if a prior gliding path was done, this could minimize root canal transportation by reducing excessive undesirable instrument rubbing on the canal walls (33). Furthermore, the glide path maintains the instrument's original trajectory throughout instrumentation and lowers frictional forces between the instrument and the root canal walls (34). Comparable canal transportation was obtained in the Kiddy files group, with or without the usage of the glide path. When employed without the glide path, this disparity may indicate that the AFB rotary system shows higher canal transportation than Kiddy files.

Time-efficient rotary instrumentation in primary teeth, when compared with conventional manual instruments requiring longer appointments, has been proven to be advantageous in pediatric patients. In the present study, rotary systems significantly reduced the instrumentation time, in line with the previously published studies (8,9). This reduction is probably because the engine-powered rotary files are faster and require fewer files in canal preparation (8). Creating a guide path is an additional step that may lengthen the overall preparation time. Coelho et al. (5) discovered that using a K-type hand file as a glide path file increased total preparation time. Similarly, using a K-type hand file to create a guide path before the Mtwo file increased preparation time, although this increase was not statistically significant (31). In this study, if the glide path file was used before using the Kiddy files, similar preparation times were obtained as if it was not used. Using a glide path file before the AFB file, reduced the preparation time significantly. Kırıcı et al. (6) also reported that using a glide path file before the WaveOne Gold file decreased total preparation time significantly. These various results presented in the literature show that the technical parameters of the file utilized have a substantial impact on the instrumentation time.

The present study includes the following limitations: (1) The fact that the pediatric rotary file systems used in the study are newly developed, and therefore, there is insufficient data previously reported in the literature to compare the results. (2) Although using standardized resin blocks in the evaluation of canal transport is a proven method, extrapolating the results to natural teeth must be cautious. (3) In vitro study design does not fully reflect clinical conditions.

Conclusion

Despite the study's limitations, Kiddy files may be suggested for root canal preparation because they have a lower canal transportation efficiency than K-type hand files and AFB. The glide path file reduced canal transportation in the AFB rotary system in this study. Therefore, it could be hypothesized that using a glide path prevents procedural errors during canal preparation by rotary systems. However, more research is needed to determine the full extent of the role that preparation of a glide path plays in treatment outcomes and the shaping of root canals when using these new systems.

Authorship Contributions: Concept: G.K.; Design: G.K., H.Ö.; Supervision: G.K.; Materials: H.Ö.; Data: G.K., H.Ö.; Analysis: G.K., H.Ö.; Literature search: G.K., H.Ö.; Writing: G.K., H.Ö.; Critical revision: G.K., H.Ö.

Acknowledgements: This article was prepared from the specialty thesis of Hakan Özdoğru.

Source of Funding: The study was supported by the Scientific Research Project Coordination Unit of Gaziantep University (DHF.UT.19.14).

Conflict of Interest: None declared.

Informed consent: Written informed consent was obtained from patients who participated in this study.

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