A COMPARISON OF THE EFFECTS OF THREE GLIDE PATH TECHNIQUES IN APICAL TRANSPORTATION OF CURVED ROOT CANALS PREPARED WITH PROTAPER NEXT

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ABSTRACT

Introduction: During the preparation of curved root canals, various complications may occur as a change in original path and apical transportation. Securing a glide path has a good effect on alleviating these complications.

Objectives: This study aimed to compare three glide path techniques, including K-file Manual, ProGlider, and PathFile in the apical transportation of curved root canals prepared with ProTaper Next.

Material and methods: In a laboratory study, 40 canals of upper and lower molars with a curvature ranging from 25 to 45 degrees have been selected for this study. Specimens were divided randomly into four groups, with ten canals each. Each group achieved a glide path with one of the systems mentioned above, while the fourth group remained without any glide path achievement. Then, the canals were prepared using ProTaper Next system. Radial images were taken pre- and post-instrumentation, and analyzed in AutoCAD, 2018 software. Data were examined statistically using SPSS version 25 software.

Results: Thee ProGlider group (PG) showed the lowest apical transportation, and no statistically significant differences were found between the Manual K-file (M) and PathFile (PF) groups in terms of decreasing the apical transportation, with $p = 0.001$.

Conclusions: The ProGlider file combined with the ProTaper Next system showed reduced apical transportation compared with PathFile and Manual K-file, which presented a similar effect in apical transportation.

Key words: glide path, apical transportation, curved root canals.

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INTRODUCTION

In many studies based on the description of root canals and their anatomical forms, most root canals have different degrees and levels of curvature, and are rarely quite straight [1]. These various anatomical complications of the root canals, coupled with limited capabilities of treatment devices, have imposed many difficult challenges, with negative effects on the outcome of endodontic treatment [2]. Therefore, errors of canal preparation in root canals are especially frequent in the curved root canals, and the most apparent error is an increased expansion due to the use of tools with large measurements, or excessive use of small measurement tools in the curved apical section of the root canal. Moreover, there are many other errors, such as loss of working length and change in the path of the root canal, blockage, perforations, and broken files, in addition to this ledge

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and apical transportation in curved root canals, due to difficulty of the treatment tools reaching full working length [3]. Therefore, many new tools and techniques have been proposed in the past few years to overcome the difficulties faced during the root canal preparation of the curved canals. The expansion and pre-preparation of the coronal part of the root canal, and creating a glide path before starting preparation of the curved apex part of the root canal, has a great role in reducing errors in the following preparation [4].

The process of creating a glide path has been defined as securing a smooth tunnel from the beginning of the root canal orifice in the floor of the pulp chamber, up to the last point of the working length of the apex of the root canal, which must follow original anatomy of the root canal and maintain its' primary pathway. Hence, it can be short or long, wide or narrow, straight or curved [5]. It is accomplished when the file that makes a glide path can pass from the root canal orifice to the foramen smoothly, and without obstructions [6]. Creating a glide path is to achieve soft walls that are repeatable by files used in succession in the root canal [7]. All Ni-Ti rotary files have non-active tips [8], and in addition to their high flexibility, they cannot be used as a primary scouting tool for the root canal [9]. Therefore, it was suggested that a slippery path of the root canal should be secure with a K-file instrument size 10 as a minimum before introducing any rotary preparation file [6]. Glide path preparation is an important step to decrease torsional stress and consequently, chances of Ni-Ti instruments' fracture [5]. Thus, the main condition for the preparation of root canals with Ni-Ti rotary files provides a glide path and ascertains its' influence [10]. This process is a basic step for optimal preparation and formation of walls, efficient cleaning and irrigation, and three-dimensional filling of the root canal system [11]. The emergence of nickel-titanium rotary files (Ni-Ti) and their use in creating a glide path in the root canal resulted in shortening working time and reducing dentist fatigue, especially in narrow and curved root canals, compared with manual use of stainless steel files [12].

Many manufacturers produce various forms of nickel-titanium (Ni-Ti) rotary files used to create a glide path in the root canal, including:

- PathFile system: Consists of three main files manufactured from a traditional Ni-Ti alloy, with 0.13, 0.16, and 0.19 mm diameter's tip, a taper of 2%, and a square cross-section [13].
- ProGlider system: It has the advantage of a single file manufactured from heat-treated nickel-titanium alloy (M-wire), with diameter at the apex of 0.16 mm, a variable taper of 2-8%, and a square cross-section. As a result of being a single-file, it reduces working time and eliminates the need to switch files while working [14].

OBJECTIVES

This study aimed to assess the ability of three glide path techniques: Manual K-file, ProGlider, and PathFile instruments in terms of preventing the apical transportation of curved root canals prepared with ProTaper Next. The null hypothesis of the study was: There are no differences between these three groups of glide path files used in this study in preventing the apical transportation of curved root canals prepared with ProTaper Next system.

MATERIAL AND METHODS

The protocol of this *in-vitro* study was approved by the Research Ethics Committee of Damascus University (ethical approval number: 1380/2016). Research sample consisted of 40 root canals of the upper and lower molars, freshly extracted for periodontal reasons, and kept in formalin liquid at a concentration of 10% for 24 hours; they were placed in a saline solution to replace the fluids until used [15]. The root canals had curvatures of 25-45 degrees, with working lengths ranging from 18-22 mm and diameters that allow No. 10 K-file instruments to reach the entire working length with a slight obstruction, and then run out of the apical foramen for 0.5 mm; they were not subjected to a previous root canal treatment. After pulp chambers opening, a number 10 stainless steel manual K-file (Dentsply Maillefer, Ballaigues, Switzerland) was inserted through the root canal to ensure apical patency. Working length was measured as 1 mm short from the apex, when the instrument's tip was observed at the apical foramen. Then, acrylic cubes were formed and made by a plastic mold. The plastic mold was attached to X-ray film holder to ensure that X-ray images were obtained in a consistent reference position before and after study procedures (Figure 1). K-file #10 was inserted into the full working length; then, the acrylic cube was placed in the plastic mold and initial radiograph was taken in a position similar to the tooth position in the oral cavity. Radiogram was saved for two purposes: the first to measure the angle of curvature of the root,

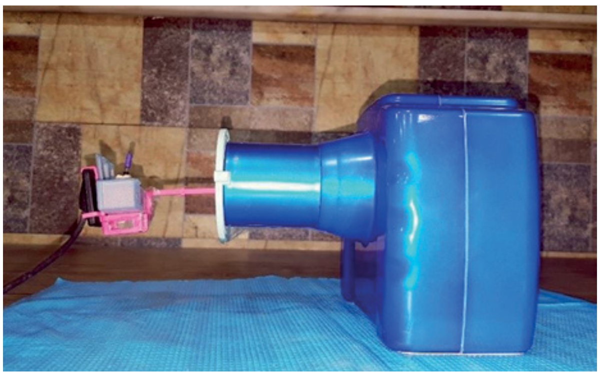

FIGURE 1. Reference position

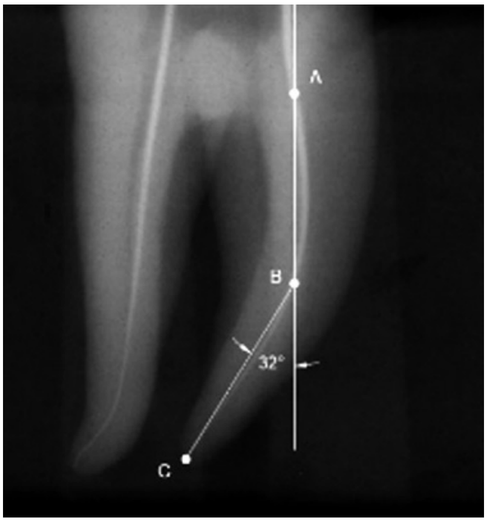

FIGURE 2. Root curvature angle

and the second to compare it later with its' counterpart after preparing the root canals. The root curvature angle was determined according to Schneider (1971), using AutoCAD 2018 by following a straight line parallel to the longitudinal axis of the root, starting from point A and another straight line starting from the apex root at point C, and meeting the first straight line at point B, where the canal begins moving away from the longitudinal axis of the root canal. The acute angle formed between the two lines was the required angle of curvature of the root [16] (Figure 2).

The root canals were prepared in four groups as follows:

- The first group was the manual glide path, symbolized by (M): manual use of stainless steel files (SS) K-file # 10, # 15, # 20 (Dentsply Maillefer, Ballaigues, Switzerland).
- The second group was using PathFile, symbolized by (PF): rotary use of PathFile systems #1, #2, and #3 (Dentsply Maillefer, Ballaigues, Switzerland).
- The third group was ProGlider, symbolized by (PG): rotary use of the ProGlider system (Dentsply Maillefer, Ballaigues, Switzerland).
- The fourth group was using no glide path, symbolized by (0).

All four groups' root canals were prepared using ProTaper Next rotary files #X1, #X2 (Dentsply Maillefer, Ballaigues, Switzerland), according to the manufacturer's instructions.

Root canals were prepared to size #X2, but not bigger than that, because the root canals were curved and there was a fear of breaking an instrument or changing the curve of the root canal into a straight one. Each instrument was used in three root canals and then discarded. The rotary file systems were performed with an electrical motor (X-smart, Dentsply Maillefer, Ballaigues, Switzerland), and were used up to their total working length. Irrigation was performed with 5.25% NaOCl solution between each changing file; 17% EDTA was applied for three minutes followed by final irrigation with distilled water, then paper points were applied to dry the root canals. After completion of the preparation, a radiogram was taken in the same position as the primary image, the ProTaper Next # X2 file inside the prepared root canals, with the entire working length and saved for later use. Radiographs were entered for each root canal from each group before and after preparing with AutoCAD 2018 program. Then, a curved line was drawn that applied to the curvature of the apical third of the root canal in both images. The tangent was drawn for this curved line in both images, and it was copied from image before preparation to image after preparation. It was then fixed at the same apical point, and measured angle was

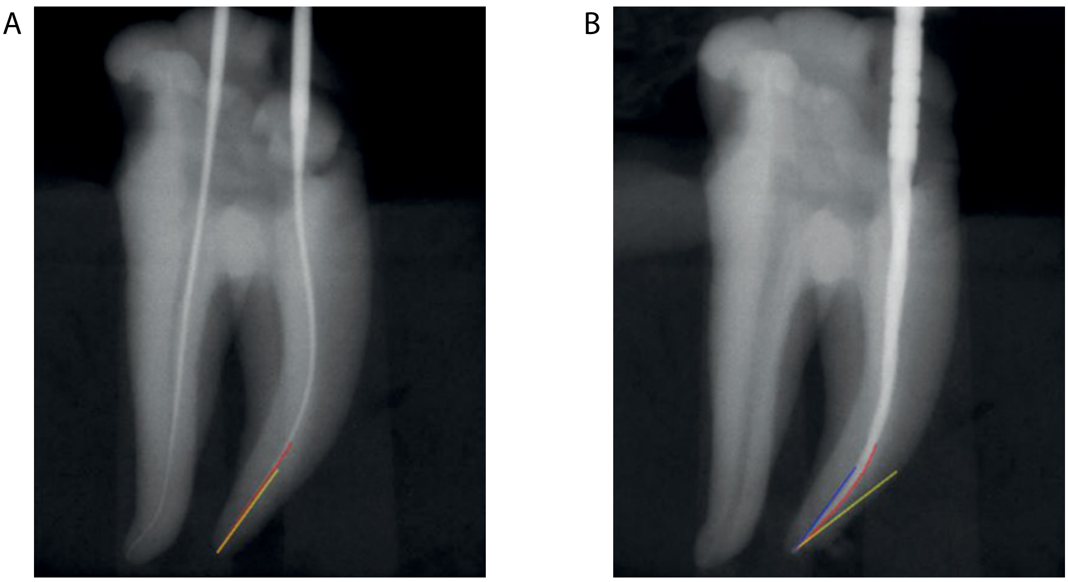

FIGURE 3. Measuring of apical transportation

TABLE 1. Main changes in values of apical transportation between the groups

Group	Number	Maximum value	Minimum value	Arithmetic average	Standard deviation	Standard error
M	10	17	12	14.20	1.55	0.49
PF	10	19	8	14.00	3.65	1.15
PG	10	9	1	5.10	2.51	0.80
0	10	24	9	18.60	4.06	1.28

formed between the two tangents in blue and yellow as the amount of the apical transportation (Figure 3). Data were analyzed using SPSS for Windows, version 25, and the following statistical tests were used:

- Kruskal-Wallis test: A statistical test used to compare average grades for more than two groups based on *p*-value; if it was bigger than the level of statistical significance ($\alpha = 0.05$), the difference was not statistically significant, but if *p*-value was smaller than the statistical significance level, it indicated statistically significant differences between comparative groups. This test was used to compare the changes in the apical transportation variables. In case of a significant difference, pair-wise comparisons were carried out using Wilcoxon test.
- Wilcoxon test: A statistical test used to compare average grades for only two groups based on *p*-value; if it was bigger than the level of statistical significance ($\alpha = 0.05$), the difference was not statistically significant, but if *p*-value was smaller than the statistical indication level, it indicated statistically significant differences between the two groups. All analyses were performed with a confidence interval (CI) of 95%. *P*-value < 0.05 was considered statistically significant.

RESULTS

The samples were randomly divided into four equal groups, 25% for each group, each group contained ten root canals, according to a technique used to create a glide path (K-file Manual glide path, PathFile, ProGlider, and no glide path). As shown in Table 1, the average amount of apical transportation for the group M was 14.20 ± 1.55, for the group PF, it was 14.00 ± 3.65, the group PG, it was 5.10 ± 2.51, and the group 0, it was 18.60 ± 4.06 (Table 1). As shown in Table 2, Kruskal-Wallis test was used to compare the changes in the apical transportation variable and $p = 0.001$, which was less than the level of statistical significance $\alpha = 0.05$. Therefore, at 95% confidence level, there were statistically significant differences between the amount of apical transportation in the study groups (Table 2). As shown in Table 3, Wilcoxon test was used to evaluate the differences in the amount of apical transportation. The probability value to compare the apical transportation amount

TABLE 2. Results of Kruskal-Walls test comparing the amount of apical transportation according to study groups

Group	Number	Ranks average	χ^2	*p*-value
M	10	21.60	27.17	0.001
PF	10	22.05		
PG	10	5.70		
0	10	32.65		

between the two groups M and PG, $p = 0.001$ and was less than $\alpha = 0.05$, which means that there were statistically significant differences in the group M. In comparison between M and 0, $p = 0.003$ and was less than $\alpha = 0.05$, which means there were statistically significant differences in the group 0. On the other hand, $p = 0.001$ was found in comparison between PG and PF groups and it was less than $\alpha = 0.05$. Therefore, there were statistically significant differences in the group PF. In a comparison between 0 and PF, $p = 0.011$, which was less than $\alpha = 0.05$. It means that there were statistically significant differences in the group 0. In the final comparison between 0 and PG groups, $p = 0.001$ and was less than $\alpha = 0.05$, which means that there were statistically significant differences in the group 0. Therefore, it was found that the ProGlider group outperformed the rest of the groups clearly in terms of reducing the amount of apical transportation occurring, followed by the two groups of PathFile and Manual glide path, without any significant differences between them, while the group no glide path was the most induced for the apical transportation between the four groups.

DISCUSSION

This study found that the best results obtained with ProGlider instrument in reducing the amount of apical transportation. Preparing root canals with ProTaper Next only without a glide path was found the worst in preventing apical transportation. This result may occur because the single instrument ProGlider with a small size #16 reached a full working length, and was keeping the apex position better than other three instruments with larger measurements in PathFile #13, #16, and #19, manual K-file files with measurements #10, #15, and #20.

TABLE 3. Results of Wilcoxon test comparing the amount of apical transportation

Group	Number	Ranks average	Total ranks	Wilcoxon test	*p*-value
M	10	10.45	104.5	104.5	0.970
PF	10	10.55	105.5		
M	10	15.50	155.0	55	0.001
PG	10	5.50	55.0		
M	10	6.65	66.5	66.5	0.003
0	10	14.35	143.5		
PF	10	15.35	153.5	56.5	0.001
PG	10	5.65	56.5		
PF	10	7.15	71.5	71.5	0.011
0	10	13.85	138.5		
PG	10	5.55	55.5	55.5	0.001
0	10	15.45	154.5		

The M-Wire alloy in the ProGlider instrument increased the flexibility, reducing its' attempt to re-gain its' original shape in the canal, thereby reducing apical transportation compared with traditional Ni-Ti alloy in PathFile files and stainless steel in Manual K-file. An evaluation was done in similar laboratory studies in several ways, including natural extracted teeth and artificial canals of acrylic resin blocks, tissue sections, with comparisons of radiography and CBCT [17]. This study relied on the extracted natural teeth, as it is considered one of the best ways to evaluate the performance of endodontics treatment files, because of its' accuracy and simulation of reality of the clinical cases, despite existence of some difficulties in standardizing the degree of curvature, initial diameter of the canal, and hardness of the dentine [17]. The use of artificial canals of acrylic resin blocks was avoided because of their inability to simulate the anatomical complexities of the root canal system [18].

Accordingly, there is no exact alternative to the natural extracted teeth, and no comparison between the hardness of dentine and the hardness of the resin. Instead, when using artificial canals of acrylic resin blocks, the heat generated during preparation dissolves the resin, which may interfere with the amount of real preparation in the canal [19]. According to previous studies [20-22], a radiography method was adopted to evaluate the shape of the root canal before and after preparation, with a radiogram taken for each tooth before and after preparation and in the same position, compared with AutoCAD, 2018 program, and to investigate the change in the shape of the canal. Glide path preparation is an important step before rotary instrumentation, which prevents instrument wear and its' separation rate [23-25].

Recent studies [21, 26-28] have shown that in statistical analysis, there were no significant differences between the manual glide path and PathFile in terms of reducing the incidence of apical transportation.

Other studies [29, 30] found that the ProGlider system have a greater ability to mitigate apical transportation compared with the manual K-files. On the other hand, another study [31] showed that the effect of the ProGlider system was similar to the effect of PathFile system in the amount of apical transportation without any differences between them.

CONCLUSIONS

Within the limitation of the present study, it was concluded that preventing apical transportation from occurring has a close relationship with a glide path system used, while preparing the root canals without using any glide path system leads to a largest apical transportation. Using the PathFile system and manual K-File prevents apical transportation in the same amount, while using the ProGlider system presented superior effect in reducing apical transportation.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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