

## GLIDE PATH PREPARATION WITH HAND K-FILES AND ROTARY PATHFILES IN SIMULATED CURVED ROOT CANALS – AN IN VITRO STUDY

### FORMIRANJE INSTRUMENTACIONE PUTANJE RUČNIM I MAŠINSKIM INSTRUMENTIMA U POVIJENIM KANALIMA - IN VITRO STUDIJA

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#### Abstract

**Introduction:** Preparation of glide path is an important precondition for the safe use of rotary NiTi instruments during endodontic treatment.

**Aim:** The aim of this study was to examine the duration of glide path preparation as well as all the changes in canal morphology and canal diameter after the use of hand K-files and NiTi rotary PathFiles.

**Material and methods:** This research was performed on a total of twenty Endo Training Blocks (Dentsply, Maillefer, Switzerland). The glide path was prepared using hand stainless steel K-files ISO #10-15-20 (Dentsply, Sirona, USA) (n = 10) and NiTi rotary PathFiles ISO #13, #16 and #19 (Dentsply, Sirona, Switzerland) (n = 10). The time required to establish the glide path was measured with an iPhone stopwatch (Apple Inc. Cupertino, California). The images of the apical segment of canals before and after glide path preparation were taken under the stereomicroscope (Boeco BSZ-405, Germany), and then images were analyzed and processed with Scopeimage 9.0 (Teleskop, Austria). Statistical analysis was performed with the Mann-Whitney test at the level of significance 5% ( $\alpha = 0.05$ ).

**Results:** A statistically significant difference was observed in terms of the time required for glide path preparation. The mean total time for glide path preparation was significantly longer with K-files ( $382 \pm 62$  s) than with PathFile ( $200 \pm 11$  s) ( $p < 0.05$ ). A statistically significant difference in terms of changing the morphology of the apical part of the canal ( $p > 0.05$ ) was not observed. The difference in the diameter of the root canal was at the limit of statistical significance ( $p \approx 0.05$ ).

**Conclusion:** Instrumentation with NiTi rotary PathFiles reduces the time required for glide path preparation. Preparing endodontic space for rotary instrumentation with hand K-Files and rotary PathFiles leads to similar changes in the morphology of the apical segment. A slightly larger diameter of the root canal was measured after preparation with the hand K-files.

#### Keywords:

glide path,  
curved canals,  
hand K-files,  
rotary NiTi  
PathFiles

## Sažetak

**Uvod:** Uspostavljanje instrumentacione putanje je važan preduslov za bezbednu primenu mašinskih *NiTi* instrumentata tokom oblikovanja kanalskih sistema.

**Cilj:** Cilj ovog rada je bio da se uporedi vreme potrebno za formiranje instrumentacione putanje, kao i promene u morfologiji apikalnog segmenta i prečniku apikalnog otvora kanala posle primene ručnih K-turpija i mašinskih *PathFile* instrumenata.

**Materijal i metode:** Istraživanje je realizovano na 20 „endo trening“ modela (*Dentsply Maillefer, Switzerland*). Instrumentaciona putanja je uspostavljena primenom ručnih K-turpija od nerđajućeg čelika (#10-15-20) (*Dentsply, Sirona, Switzerland*) ( $n = 10$ ), odnosno mašinskih *PathFile NiTi* instrumenata (*Dentsply, Sirona, Switzerland*) ( $n = 10$ ). Vreme potrebno za uspostavljanje instrumentacione putanje mereno je *iPhone stopwatch* (*Apple Inc. Cupertino, California*). Slike apikalnog segmenta kanala, pre i posle formiranja instrumentacione putanje, snimane su stereomikroskopom (*Boeco BSZ-405, Germany*), a zatim obrađene i analizirane u softverskom programu *Scopeimage 9.0*. Dobijeni podaci statistički su obrađeni Man-Vitnijevim (*Mann-Whitney*) testom ( $\alpha = 0,05$ ).

**Rezultati:** Uočena je statistički značajna razlika u pogledu vremena potrebnog za uspostavljanje instrumentacione putanje između ručnih K-turpija (6 min. 22 s) i mašinskih *PathFile* instrumenata (3 min. 20 s) ( $p < 0,05$ ). U pogledu morfologije apikalnog segmenta nisu uočene značajne razlike ( $p > 0,05$ ). Razlike u prečniku apikalnog otvora bile su na granici statističke značajnosti ( $p \approx 0,05$ ).

**Zaključak:** Primena mašinskih *PathFile* instrumenata rezultirala je bržim formiranjem instrumentacione putanje u poređenju sa ručnim K-turpijama. Obe ispitivane grupe instrumenata dovele su do sličnih promena u morfologiji apikalnog segmenta kanala. Nešto veći prečnik apikalnog otvora kanala izmeren je posle primene ručnih K-turpija.

### Ključne reči:

instrumentaciona putanja, povijeni kanali, ručni instrumenti, mašinski instrumenti

## Introduction

The modern, biological concept of instrumentation aims to form conical root canals that are suitable for hermetic three-dimensional obturation (1). The utilization of rotary NiTi endodontic files enabled easier and faster preparation of root canals but did not completely exclude the possibility of procedural errors (formation of steps, canal transportation, zipping, or instrument fracture), especially in complex root canal systems (2-7).

In order to avoid the mentioned errors, it is necessary to form the glide path before applying the rotary NiTi root canal instruments (8). An endodontic glide path is defined as a smooth passage from the coronal orifice of a root canal to the apical terminus (foraminal constriction) (8). An adequately created glide path provides the desired volume of endodontic space for the proper application of the first rotary NiTi instrument for root canal preparation. A successfully performed glide path significantly simplifies instrumentation by providing unobstructed access of the instrument tip to the most complex apical segment. Also, this procedure enables better centering of rotary instruments in the root canal, which respects the original root canal anatomy and minimizes torsional stress – together, it reduces the possibility of procedural errors (9-11). Also, forming the glide path is necessary due to the fact that many extreme flexibility NiTi rotary instruments with non-cutting tips do not have the ability to initially expand a root canal (2).

Glide path formation can be achieved with smaller diameter hand stainless steel K-files or with specially designed rotary NiTi files. According to West, the minimal

size of a K-file that can provide an adequate glide path for further root canal instrumentation is ISO #10 K-file (8). It is recommended, that during the forming of a glide path, larger diameter hand files should be used. According to Berutti and collaborators, the diameter of the prepared endodontic space should be corresponding or bigger to the size of the tip of the first NiTi rotary instrument used for canal treatment (12). Although in the case of simpler root canal systems adequate glide paths can be established with hand files, in narrow and curved root canals their application can be one of the greater challenges of the entire endodontic procedure.

Besides the fact that forming the glide path with stainless steel hand K-files in narrow root canals is time consuming, it can also result in apical canal transportation, ledge formations, canal perforations or blockage of the apical foramen and debris extrusion in periapical tissue (13, 14).

Special and innovative rotary NiTi instruments are being introduced to endodontic procedures today for forming glide paths, and the first such set of instruments was introduced by Dentsply Maillefer, in the form of a PathFile set of instruments (12). This set is made of NiTi alloy, and consists of three instruments PF1, PF2 and PF3, fixed taper (0.02) and increasing tip diameter of the instrument (ISO #13, #16 and #19).

Since the appearance of these special and innovative NiTi instruments, numerous studies have been conducted that aimed to compare the effectiveness of glide path preparation with these rotary files relative to manual instruments. In those studies, glide path preparation was mostly performed by experienced clinicians. However, as

the glide path represents an important phase of endodontic treatment, it is necessary that the procedure be simple to perform so that even inexperienced clinicians can perform it safely and quickly.

The aim of this study was to examine the duration of glide path preparation as well as all the changes in canal morphology and apical foramen diameter after the application of hand K-files and NiTi rotary PathFiles done by an inexperienced operator.

## Material and methods

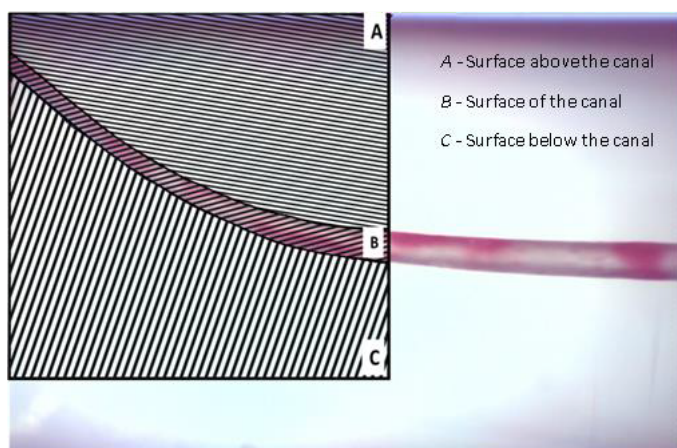
### Preparation of models

The study was conducted on twenty Endo Training blocks (Dentsply Maillefer, Switzerland), with an initial apical size of ISO #10, 0.02 taper, and with a curvature of 40°. The working length was 18 mm and was determined as 0.5 mm shorter than the length when the instrument K-file #8 appears on the canal foramen by passively slipping through the canal.

Each model was fixed in a plastic bracket which allowed a standardized, central position of the model under the microscope.

Before establishing the glide path, the apical segments of the models (5 mm length) were measured with a stereomicroscope with an integrated digital camera (Boeco BSZ-405, Germany), at x20 and x45 magnification. Digital images were saved as JPG format files and then were processed and analyzed in Scopeimage 9.0 software (Telescope, Austria).

The diameter of the apical foramen of a root canal on the model, the area above and below the root canal in the improvised square diameter of 5x5 mm, as well as the area of the root canal belonging to this square were measured (**figure 1**).



**Figure 1.** The surfaces analyzed with stereomicroscope: A - Surface above the canal; B - Surface of the canal; C - Surface below the canal.

Using a table with random numbers, the models were randomly divided into 2 groups (I and II), with 10 samples each (n = 10) and marked with a permanent color.

### Glide path preparation

The first group of models (n = 10) was subjected to the manual technique of glide path procedure using new stainless steel K-file size ISO #10, #15 and #20. One set of instruments was used for 5 Endo Training blocks. Instruments #10 and #15 were activated in the canals by clockwise movement while instrument #20 was activated clockwise but also by the movement of a balanced force technique.

The second group of models (n = 10), was subjected to the rotary technique of glide path preparation using new rotary PathFile NiTi instruments (Dentsply Maillefer, Tulsa, OK) after a hand #10 K-file (Dentsply, Maillefer, Tulsa, USA) has scouted the canal. The instrumentation of the canal was accomplished in accordance with the manufacturer's instructions, crown-down technique, and using an X-Smart Endodontic Rotary Motor (Dentsply, Maillefer, Austria). One set of instruments was used for 5 Endo Training blocks.

The time required to form the glide path is measured from the moment of application of the first instrument in the group (K #10 in both groups) till the completion of the preparation with the K #20 instrument in the first and PathFile #3 in the second group. The preparation time was measured with iPhone stopwatch (Apple Inc. Cupertino, California).

During the glide path preparation in both experimental groups (manual and rotary), the canal was irrigated with 2 ml of 2% NaOCl (CHLORAXID 2%, CerKamed, Polska), between each instrument.

The whole procedure was conducted by one inexperienced clinician - a research student. Prior to performing the experiment, the researcher had theoretical and practical training in PathFile NiTi instruments.

After preparation, all models were repositioned in the bracket and were measured with a stereomicroscope again, under the same conditions as before the instrumentation. The images measured the areas above and below the canal, as well as the surface of the canal itself (apical 5x5 mm of the model).

By comparing the pre- and post-preparation images during glide path formation by hand and rotary technique, changes in apical morphology were obtained, as well as changes in the diameter of the apical foramen.

### Statistical analysis

The obtained results were statistically processed by using nonparametric Mann-Whitney test at a confidence level of 5% ( $\alpha = 0.05$ ).

## Results

The results of this study are presented in **tables 1-3**.

A statistically significant difference was observed in terms of the time required for glide path preparation ( $p < 0.05$ ). The mean total time for glide path preparation was significantly longer with K-files ( $382 \pm 62$  s) than with

PathFile (200 ± 11 s) (p < 0.05) (**table 1**).

**Table 1.** Time required to establish glide path with hand (K-files) and rotary (PathFile) instruments (expressed in seconds).

Group	K-files	PathFile
N	10	10
Mean Values	382	200
Standard deviation	62	11
Minimum	320	185
Median	383	198
Maximum	531	216

N – number of models; Mean values were statistically different at p < 0.05.

No statistically significant differences were observed when comparing the areas of the models below and above the canal after the glide path procedure with hand and rotary instruments (p > 0.05). The area below the canal after the glide path instrumentation with hand K-files was 9.78 ± 1.41 mm<sup>2</sup> and after the glide path instrumentation with Pathfile instruments 9.83 ± 0.70 mm<sup>2</sup>. The area above the canal after the glide path instrumentation with hand K-files was 13.09 ± 1.78 mm<sup>2</sup> and after the glide path instrumentation with PathFile instruments 13.42 ± 0.72 mm<sup>2</sup> (**table 2**).

**Table 2.** Surfaces below and above the canal (mm<sup>2</sup>) before and after glide path instrumentation with hand K-files and rotary PathFile instruments.

	Group	Mean +/- SD
Surface below the canal (mm <sup>2</sup> )	Before glide path preparation	10.11
	After glide path preparation using K-files	9.78 +/- 1.41
	After glide path preparation using Pathfile	9.83 +/- 0.70
Surface above the canal (mm <sup>2</sup> )	Before glide path preparation	13.51
	After glide path preparation using K-files	13.09 +/- 1.78
	After glide path preparation using Pathfile	13.42 +/- 0.72

SD – Standard deviation; Mean values were not statistically different at p > 0.05.

When comparing the surface of the apical 5 mm of the canal, no statistically significant differences were observed (p > 0.05) when the glide path instrumentation was performed with hand K-files (1.94 ± 0.19 mm<sup>2</sup>) and with PathFile instruments (1.75 ± 0.13 mm<sup>2</sup>) (**table 3**). The diameter of the apical foramen after a glide path instrumentation with K-files was 0.64 ± 0.14 mm, and after a glide path preparation with PathFile instruments 0.53 ± 0.09 mm. The difference was at the limit of statistical significance (p

≈ 0.05) (**table 3**).

**Table 3.** Surface of the apical 5 mm of the canal (mm<sup>2</sup>) and the diameter of the apical foramen (mm) before and after glide path instrumentation with hand K-files and rotary PathFile instruments.

	Group	Mean +/- SD
Surface of the apical 5 mm of the canal (mm <sup>2</sup> )	Before glide path preparation	1.68
	After glide path preparation using K-files	1.94 +/- 0.19
	After glide path preparation using Pathfile	1.75 +/- 0.13
The diameter of the apical foramen (mm)	Before glide path preparation	0.39
	After glide path preparation using K-files	0.64 +/- 0.14
	After glide path preparation using Path file	0.53 +/- 0.09

SD – Standard deviation; Mean values were not statistically different at p > 0.05.

The original shape of the endodontic space (funnel shape) was observed after forming the glide path on all canals with rotary PathFile instruments, while after the application of hand K-files, a change in the shape of the apical foramen (hourglass shape) was observed in half of the samples (50%). During a preparation of glide path with K-files, a fracture of one K-file #20 occurred. Fractures of rotary PathFile instruments during a glide path preparation did not occur.

## Discussion

Several studies reported that a properly established glide path is crucial for safe endodontic instrumentation with rotary NiTi endodontic files, primarily due to preservation of the original canal shape, reduction of torsional stress and reduced possibility of protocolar errors (instrument screwing, canal transportation, deformation and breakage of instrument) (2, 8-10, 15, 16).

This study compared the efficiency of hand and rotary instruments in the glide path preparation (time required for preparation, changes in the apical morphology of the root canal and changes in the diameter of the apical foramen). For manual preparation of a glide path K-files #10 - 20 were used. The reasons for the long-term application of small-diameter stainless steel hand instruments in creating a glide path are primarily due to the good tactile feel and low file separation potential (8, 17-19).

The PathFile instrument set was used for rotary preparation of a glide path. The design of these instruments has a square cross-section, identical taper (2%), and a non-cutting tip with increasing diameter. This design makes them much more flexible and therefore significantly more resistant to cyclic fatigue and safe for use in complex canal systems (obliterated and bent) (20). Also, this design

enables safe and easy use for inexperienced clinicians during glide path preparation. The research was conducted on Endo training models to standardize experimental conditions such as canal length and curvature and apical foramen diameter. Due to the fact that the largest number of procedural errors occur in the apical portion of the endodontic canal, the changes that occurred after the manual and rotary instrumentation of the glide path were analyzed in the apical segment of the Endo training models. The research was conducted by one researcher, an inexperienced clinician, a final-year student at the School of Dental Medicine.

Time spent on endodontic procedure is an important factor in clinical practice. The results of this study indicate that a significantly longer time is required for the glide path preparation with hand files in relation to engine-driven instruments. Also, data from the literature show that experienced clinicians need less time for glide path preparation with rotary instruments compared to hand files (21). The results of the investigation by van der Vyver et al. (2015) indicated that a shorter time is required to prepare a glide path with different rotary instruments compared to stainless steel K-files. Also, the results of this investigation show that a shorter preparation time is required if the set of instruments contains fewer instruments (19). Similar results were presented by D’Amario et al. emphasizing that systems with fewer instruments are always faster (21). For this reason, in order to standardize the experimental conditions, this study analyzed a rotary set consisting of three instruments, as many as hand K-files were used.

Analyzing the surface of the apical 5 mm canal, as well as the surface of the Endo training block above and below this segment of the canal after forming the glide path with hand K-files and rotary PathFile instruments, no statistically significant differences were observed. However, it should be emphasized that the change in the shape of the apical segment of the canal (hourglass shape) was observed in half of the samples (50%) prepared by manual technique. These results can be explained by the high flexibility of NiTi PathFile instruments (2). The difference in the size of the apical diameter may be a consequence of the difference in the diameter of the last instrument in the manual (#20) and the rotary preparation of the glide path (#19). Although the difference is very small (0.01 mm), this data should not be ignored. The obtained results indicate that whether manual or mechanical instruments were used, similar changes appeared in the apical segment, which is in line with the results of D’Amario et al. and De Oliveira Alves et al. (21,22). Different data are available in the literature demonstrating more efficient preservation of the original anatomy of endodontic space after instrumentation with PathFile in relation to manual K-files, which was explained by better centering of rotary NiTi instruments in the canal (12,23-25). However, in a recent review study that analyzed the effectiveness of various instruments and systems in glide path shaping, Hartmann and collaborators concluded that most studies that have reported this issue have not actually identified significant differences in

centering ability or apical transportation between smaller diameter K-files and rotary instruments specially manufactured for glide path preparation (20).

Regarding the diameter of the apical foramen after manual and rotary preparation of the glide path, the obtained differences are at the very limit of statistical significance. A slightly smaller diameter of the apical foramen was measured in the PathFile group of instruments, which may be an indicator of better centering of these instruments. But also, the reason could be that the apical diameter at the start was 0.01 mm larger in the K-file group compared to Pathfile group. It could be expected, that on a larger sample, the results could be different. The size of the apical foramen preparation is also important from the aspect of debris extrusion. Thus the research of Pasqualini with his collaborators, as well as Pui-Yii and his team indicate a more frequent occurrence of periapical infections and postoperative pain after the preparation of a glide path with manual K-files compared to rotary NiTi instruments (23,26). The flexibility of PathFile provided by superelastic alloys of nickel and titanium and their specific design (primarily small taper .02) reduces the ability to transport the apical foramen and change its size (27). In a recent review study by Predin Đurić and his team of coworkers, he emphasized the importance of forming a glide path and preferred rotary instruments for this since their use results in less enlargement of the apical foramen and thus less ability of extrusion of debris. Although apical extrusion is significantly higher during canal treatment, it is also significant during the glide path preparation since in this initial phase of endodontic therapy, canal content can have greater toxicity (28).

In general, the results of this study indicate that the application of manual K-files can form an adequate glide path and prepare root canals for safe further instrumentation. The fact that in this research a student without previous experience in working with rotary NiTi instruments was successful in forming a glide path using PathFile instruments, indicates that this system is „relatively“ safe and easy to use. Cassim and his collaborators also wrote that the application of this set of instruments is less dependent on the expertise of the clinician than is the case of manual K-files (15).

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## Conclusion

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The application of PathFile instruments resulted in faster creation of a glide path compared to manual K-files. Both examined groups of instruments led to similar changes in the diameter and morphology of the apical segment of the canal.

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