Preservation of root canal anatomy using self-adjusting file instrumentation with glide path prepared by 20/0.02 hand files versus 20/0.04 rotary files

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Abstract

Objectives: To compare the relative axis modification and canal concentricity after glide path preparation with 20/0.02 hand K-file (NITIFLEX®) and 20/0.04 rotary file (HyFlex™ CM) with subsequent instrumentation with 1.5 mm self-adjusting file (SAF).

Materials and Methods: One hundred and twenty ISO 15, 0.02 taper, Endo Training Blocks (Dentsply Maillefer, Ballaigues, Switzerland) were acquired and randomly divided into following two groups (n = 60): group 1, establishing glide path till 20/0.02 hand K-file (NITIFLEX®) followed by instrumentation with 1.5 mm SAF; and Group 2, establishing glide path till 20/0.04 rotary file (HyFlex™ CM) followed by instrumentation with 1.5 mm SAF. Pre- and post-instrumentation digital images were processed with MATLAB R 2013 software to identify the central axis, and then superimposed using digital imaging software (Picasa 3.0 software, Google Inc., California, USA) taking five landmarks as reference points. Student’s t-test for pairwise comparisons was applied with the level of significance set at 0.05.

Results: Training blocks instrumented with 20/0.04 rotary file and SAF were associated less deviation in canal axis (at all the five marked points), representing better canal concentricity compared to those, in which glide path was established by 20/0.02 hand K-files followed by SAF instrumentation.

Conclusion: Canal geometry is better maintained after SAF instrumentation with a prior glide path established with 20/0.04 rotary file.

Keywords: Canal deviation; glide path; HyFlex™ CM; NITIFLEX®; rotary file; self-adjusting file

INTRODUCTION

Nickel–titanium (NiTi) rotary instruments were introduced to improve root canal preparation. Repetitive load acting on an instrument results in fatigue failure (bending normal stress), material removal by shearing action, and torque failure (torsional shear stress), leading to breakage of the instrument in clinical practice.[1-3] Various other factors might contribute to increase these stresses such as excessive pressure on the handpiece,[4] a wide area of contact between the canal walls and the cutting edge of the instrument or, if the canal section is smaller than the dimension of the nonactive or noncutting tip of the instrument,[5,6] the latter case might lead to a taper lock, especially with regularly tapered instruments.[7] The risk
of a taper lock might be reduced by performing coronal enlargement and by creating a glide path before using NiTi rotary instrumentation, both manual and mechanical.

To minimize iatrogenic complications, precurved stainless steel files (usually size 6, 8, and 10 files of 0.02 taper) should be used to explore the root canal system. Once canal patency is obtained, the canal can be enlarged with larger hand files (size 15 and 20 files of 0.02 taper) to establish a “glide path” before the first crown-down rotary instrument is introduced into the canal.

A glide path is defined as a smooth, though possibly narrow, tunnel or passage from the coronal orifice of the canal to the radiographic terminus or electronically determined portal of exit. Maintenance of a glide path means having a smooth passage that is reproducible by files used successively in the canal. All available NiTi rotary instruments have noncutting tips, and because of their extreme flexibility, these instruments are not designed for initial negotiation of the root canal. For root canal preparation, a rotary instrument should not be used, unless a hand instrument has been placed before.

Glide path preparation is, therefore, commonly recommended when using many rotary and reciprocating file systems. Using small stainless steel hand files, a glide path must be created to create or verify that within any portion of the root canal, there will be sufficient space for a rotary instrument to follow. Moreover, before using NiTi rotary instrumentation, the root canal should be manually preflared to create a glide path. Numerous studies have proposed that the root canal diameter should be at least one size larger than the tip of the first rotary instrument to be used in that root canal. Such preparation is especially important in curved canals, where the glide path aims to minimize the risk of procedural errors such as canal transportation, ledging, and file fracture. In the case of the self-adjusting file (SAF) system (ReDent-Nova, Ra’anana, Israel), glide path preparation is especially important because this file, as opposed to most rotary and reciprocating files, has no penetration ability per se. This study was designed to compare the relative axis modification and canal concentricity after a glide path prepared with two types of files such as 20/0.02 hand K-file (NITIFLEX®, Dentsply Maillefer, Ballaigues, Switzerland) and 20/0.04 rotary file (HyFlex™ CM NiTi File, Coltene-Whaledent, Switzerland) in simulated root canals of resin blocks with 1.5 mm SAF.

MATERIALS AND METHODS

Simulated canals
One hundred and twenty Endo Training Blocks (ISO 15, 0.02; Dentsply Maillefer, Ballaigues, Switzerland) with an apical diameter of 15 mm and working length (WL) of 16 mm were acquired. The patency of these simulated canals was confirmed by passing a size 10 K-file just beyond the apex. After coloring each simulated canal with red ink (Quink, Parker, France) injected with a syringe, five landmarks were marked in each block. Each specimen was mounted on a stable support consisting of a rectangular slot of the size of the specimen (30 mm × 10 mm). Support for a digital camera (Nikon D90, Tokyo, Japan) was positioned centrally and at 90° to the specimen. Digital images of all specimens before instrumentation were obtained and saved as TIFF format files.

Materials
Two files were used for establishing glide path before SAF instrumentation: 20/0.02 NITIFLEX® hand K-file (Dentsply Maillefer, Ballaigues, Switzerland) and 20/0.04 rotary HyFlex™ CM file (Coltene-Whaledent, Switzerland).

Study design
The acquired 120 Endo Training Blocks were randomly divided into the following two groups:

- Group 1: 20/0.02 glide path preparation followed by SAF instrumentation
- Group 2: 20/0.04 glide path preparation followed by SAF instrumentation.

The concept of the study design was to test a recently proposed protocol for SAF instrumentation by Kfir et al. (2015) and its effect on the canal geometry.

Instrumentation of the canals
A new instrument was used for each canal in all the groups. Glyde™ File Prep (Dentsply Maillefer, Ballaigues, Switzerland) was used as a lubricant before the utilization of each instrument, and saline was used for irrigation during preparation. The canals were instrumented by SAF (1.5/21 mm) described in the following sections with glide path preparation prepared using either 20/0.02 hand K-file or 20/0.04 rotary file.

Group 1: 20/0.02 hand K-file glide path + self-adjusting file instrumentation
Glide path in sixty training blocks was established till #20 hand files using NITIFLEX® (Dentsply Maillefer, Ballaigues, Switzerland). Glyde™ File Prep (Dentsply Maillefer, Ballaigues, Switzerland) was used as a lubricant before the utilization of each instrument, and saline was used for irrigation during preparation. A SAF 1.5 mm file (ReDent-Nova, Israel) was introduced into the canal to the apex, using an RDT3 handpiece head (ReDent-Nova, Israel) with a torque control motor (X-smart Plus™, Dentsply Maillefer, Ballaigues, Switzerland,) at a frequency of 83.3 Hz (5000 movements per minute) with an amplitude of 0.4 mm. It was used for 4 min in a pecking motion according to manufacturers’ instructions. The SAF was
connected to a VATEA System Irrigator (ReDent-Nova, Israel) that pumped saline at the rate of 5 mL/min in a continuous flow. A total of 20 mL saline was used for each root. No accurate final diameter or taper of the preparation could be assumed because the SAF has no specific size or taper.

**Group 2: 20/0.04 hand K-file glide path + self-adjusting file instrumentation**
Glide path for the sixty blocks in this group was prepared with 20/0.04 rotary files using HyFlex™ CM (Coltene-Whaledent, Switzerland). This file was used in the endo motor (X-smart Plus™) at a rotational speed of 500 rpm with torque set at 2.5 Ncm. Glyde™ File Prep (Dentsply Maillefer, Ballaigues, Switzerland) was used as a lubricant, and saline was used as an irrigant. Following establishment of glide path till WL, the canals were instrumented using 1.5 mm SAF in a similar way as described in Group 1.

After the completion of instrumentation of both the groups, black ink (Quink, Parker, France) was injected in the instrumented training blocks, which were repositioned in the slot and photographed, as earlier described and postoperative images were acquired.

**Image analysis and assessment of canal preparation**
The pre- and post-instrumented images were magnified and cropped to focus on the canal geometry [Figure 1, Stage 1]. These images were imported into MATLAB R 2013 software (The MathWorks, Inc., Natick, MA, USA) for image processing, where a software program was written in MATLAB code to convert the images to grayscale images, automatically identifying the mean axis of each canal [Figure 1, Stage 2]. These final grayscale images were then saved in jpeg format with a pixel size of 1504 × 3504. Using digital imaging software (Picasa 3.0 software, Google Inc., California, USA), the preinstrumentation digital images were superimposed on the postinstrumentation images, taking the landmarks as reference points [Figure 1, Stage 3].

Measurements in millimeters were carried out at five different points: at the canal orifice (A), half-way to the orifice in the straight section (B), the beginning of the curve (C), the apex of the curve (D), and the end point (E) [Figure 2].

**Data presentation and analysis**
This evaluated the deviation of the simulated canals in the Endo Training Blocks after SAF instrumentation with glide paths prepared either using 20/0.02 hand K-files or 20/0.04 rotary files at five points. Student’s t-test was applied to each of the five points in the two groups with the significance level set at $P < 0.05$ (SPSS software Version 20; IBM Corp., Armonk, NY, USA).

**RESULTS**
The results are summarized in Table 1. Group 1 (20/0.02 NiTi hand file with SAF) showed more deviation in canal axis at any measured point. Group 2 (20/0.04 NiTi rotary file with SAF) showed less deviation in canal axis at all five points; A, B, C, D, and E [Figure 3]. At all the five points,
there was a significant difference in P value between these two groups [Graph 1]. No macroscopic deformations or fractures of any instrument occurred during the experiment.

**DISCUSSION**

The present study aimed at comparing the shaping performance of the SAF system in Endo Training Blocks, with 20/0.02 (hand) and 20/0.04 (rotary) initial glide path preparation. Coronal enlargement/funneling and prior creation of a glide path are essential for safe use of NiTi mechanized instrumentation.\[8,10,11\] A glide path is prepared, assuming it to maintain the patency of the root canal from the coronal opening to the apical foramen.\[17\] The SAF being a hollow file with extreme flexibility, cannot be forced into the canal per se; therefore, preparation of the glide path before using the SAF is important.

The SAF file is different from rotary and reciprocating file systems. The tip of the file has an asymmetrical shape.\[18\] It is located at the wall of the tube-like SAF as opposed to the symmetrical-centered tips found in the conventional NiTi rotary files. The file is claimed to bend more easily to the side at which its tip is located than to the other three sides,\[17\] thus making it easier for the file to follow curvatures in this direction.

Although many other file systems require the creation of a glide path to assist their instrumentation and prevent potential procedural errors,\[19\] the SAF cannot properly function in narrow curved canals without straight-line access and a glide path. In such cases, the SAF is impeded from reaching WL before the mechanized procedure begins,\[17,18,20\] If straight-line access is not established, the SAF file may buckle, and if an adequate glide path is not created, the file may fail to reach WL in narrow curved canals.\[17\]

In the current study, a new protocol of glide path preparation for SAF instrumentation in curved canals was tested,\[17\] for the performance of which, so far, there is no previous study. Canal scouting and preflaring are the first phases of root canal instrumentation.\[19\] The occurrence of canal modifications and aberrations seems to be significantly reduced when the glide path is previously created.\[10,11,21\] Using a small-size hand K-file followed by a more flexible and less tapered NiTi rotary file might be less invasive and also a safer method to construct a glide path that better maintains the original canal anatomy, compared with manual preflaring performed with a stainless steel K-file.\[22\]

It becomes clear from this study that the use of flexible NiTi hand instruments of a size larger than ten should be reduced when a predictable and repeatable scouting can be obtained using small stainless steel hand files (sizes 06, 08, and 10). A predictable glide path can be safely and effectively obtained with NiTi rotary instruments, precluding the increased transportation required for bigger and less flexible stainless steel instruments. When compared to a rotary 20/0.04 glide path and SAF instrumentation, a glide path created by using #20 NiTi hand files and subsequent SAF instrumentation resulted in greater deviation of the canal. In many earlier studies, rotary files used for glide path preparation for different file systems have been found more effective in preserving the root canal anatomy.\[22-26\]

![Graph 1: Canal deviation: 20/0.02 versus 20/0.04 glide path preparation](image)

*Figure 3: Representative image of both the groups showing overlapped (pre- and post-operative). (a) 20/0.02 glide path + self-adjusting file instrumentation; (b) 20/0.04 glide path + self-adjusting file instrumentation*

**Table 1: The mean, standard deviations, and the P values of the deviation of the central canals for both the groups**

| Points | Glide path | Mean (mm) | SD | P       |
|--------|------------|-----------|----|---------|
|        |            | 20/0.02   | 20/0.04 | 20/0.02 | 20/0.04 |
| Point 1| 8.78       | 5.47      | 3.66 | 2.13    | <0.05   |
| Point 2| 8.84       | 5.47      | 4.73 | 3.52    | <0.05   |
| Point 3| 13.9       | 6.79      | 4.01 | 3.28    | <0.05   |
| Point 4| 8.02       | 4.31      | 4.58 | 2.21    | <0.05   |
| Point 5| 6.21       | 2.59      | 3.07 | 2.18    | <0.05   |

SD: Standard deviation
Although simulated resin blocks fail to represent the anatomic variability of a human root canal system, they have been widely used to point out differences in performance of instruments under standardized experimental conditions. Studies suggest that the analysis of modifications in canal curvature after instrumentation is a reliable method to evaluate the tendency of a shaping technique to maintain the original canal anatomy or to straighten the curves.[21,27]

In this study, a quantitative analysis was performed by observing the changes between pre- and post-instrumentation curvature. Previous studies have demonstrated the reliability of the experimental method used as well as its effectiveness in representing changes in canal curvature and in providing acceptable results.[28]

CONCLUSION
Within the limitations of the current study, a rotary file with 20/0.04 size used for creation of a glide path followed by SAF instrumentation in curved canals maintains the original root canal anatomy with less deviation and better canal concentricity when compared to the glide path prepared by 20/0.02 hand NiTi files with subsequent SAF instrumentation. This study was an attempt to test the new protocol proposed for using SAF in curved canals, and further investigations should be carried out in ex vivo conditions.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES
1. Sattapan B, Nervo GJ, Palamara JE, Messer HH. Defects in rotary nickel-titanium files after clinical use. J Endod 2000;26:161-5.
2. Shen Y, Cheung GS, Biao Z, Peng B. Comparison of defects in ProFile and ProTaper systems after clinical use. J Endod 2006;32:61-5.
3. Cheung GS, Peng B, Biao Z, Shen Y, Darvell BW. Defects in ProTaper S1 instruments after clinical use: Fractographic examination. Int Endod J 2005;38:802-9.
4. Kobayashi C, Yoshioka T, Suda H. A new engine-driven canal preparation system with electronic canal measuring capability. J Endod 1997;23:751-4.
5. Blum JY, Cohen A, Machton P, Micaleff JP. Analysis of forces developed during mechanical preparation of extracted teeth using Profile NiTi rotary instruments. Int Endod J 1999;32:24-31.
6. Peters OA, Peters CI, Schönberger K, Barbakow F. ProTaper rotary root canal preparation: Assessment of torque and force in relation to canal anatomy. Int Endod J 2003;36:93-9.
7. Yared GM, Bou Dagher FE, Machton P. Influence of rotational speed, torque and operator’s proficiency on ProFile failures. Int Endod J 2001;34:47-53.
8. Roland DD, Andelin WE, Browning DF, Hsu GH, Torabinejad M. The effect of preflaring on the rates of separation for 0.04 taper nickel titanium rotary instruments. J Endod 2002;28:643-5.
9. Peters OA, Peters CI, Schönberger K, Barbakow F. ProTaper rotary root canal preparation: Effects of canal anatomy on final shape analysed by micro CT. Int Endod J 2003;36:86-92.
10. Berutti E, Negro AR, Lendini M, Pasqualini D. Influence of manual preflaring and torque on the failure rate of ProTaper rotary instruments. J Endod 2004;30:228-30.
11. Patiño PV, Biedma BM, Liébana CR, Cantatore G, Bahillo JG. The influence of a manual glide path on the separation rate of NiTi rotary instruments. J Endod 2005;31:114-6.
12. West J. Endodontic update 2006. J Esthet Restor Dent 2006;18:280-300.
13. Young GR, Parashos P, Messer HH. The principles of techniques for cleaning root canals. Aust Dent J 2007;52: Suppl: S52-63.
14. Bergmans L, Van Cleynerenheug J, Wevers M, Lambrechts P. Mechanical root canal preparation with NiTi rotary instruments: Rationale, performance and safety. Status report for the American Journal of Dentistry. Am J Dent 2001;14:324-33.
15. Blum JY, Machton P, Ruddell C, Micaleff JP. Analysis of mechanical preparations in extracted teeth using ProTaper rotary instruments: Value of the safety quotient. J Endod 2003;29:567-75.
16. West JD. The endodontic Glidepath: “Secret to rotary safety”. Dent Today 2010;29:86, 88, 90-3.
17. Kfir A, Golberger T, Koren T, Pawar AM, Abramowitz I. Can size 20,04 taper rotary files reproducibly create a glide path for the self-adjusting file? An ex vivo study in MB canals of mandibular molars. Int Endod J 2015;49:301-6.
18. Pawar AM, Pawar MG, Kokate SR. Meant to make a difference, the clinical experience of minimally invasive endodontics with the self-adjusting file system in India. Indian J Dent Res 2014;25:508-12.
19. Jafarzadeh H, Abbott PV. Ledge formation: Review of a great challenge in endodontics. J Endod 2007;33:1155-62.
20. Metzger Z. The self-adjusting file (SAF) system: An evidence-based update. J Conserv Dent 2014;17:401-19.
21. Berutti E, Paulino DS, Chiandussi G, Alovai M, Cantatore G, Castellucci A, et al. Root canal anatomy preservation of WaveOne reciprocating files with or without glide path. J Endod 2012;38:101-4.
22. 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;35:408-12.
23. Gamblin JM, Alder M, del Rio CE. Comparison of nickel-titanium and stainless steel hand-file instrumentation using computed tomography. J Endod 1996;22:369-75.
24. Glossen CR, Haller RH, Dove SB, del Rio CE. A comparison of root canal preparations using NiTi hand, Ni-Ti engine-driven, and K-Flex endodontic instruments. J Endod 1995;21:146-51.
25. Ajuz NC, Armada L, Gonçalves LS, Debegual G, Siqueira JF Jr. Glide path preparation in S-shaped canals with rotary pathfinding nickel-titanium instruments. J Endod 2013;39:534-7.
26. Elmayoglu AM, Elsakia SE. Evaluation of root canal transportation, centering ratio, and remaining dentin thickness associated with ProTaper Next instruments with and without glide path. J Endod 2014;40:2053-6.
27. Allen MJ, Glickman GN, Griggs JA. Comparative analysis of endodontic pathfinders. J Endod 2007;33:723-6.
28. Lim KC, Webber J. The validity of simulated root canals for the investigation of the prepared root canal shape. Int Endod J 1985;18:240-6.