REVIEW

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"Glide Path" in endodontics

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Maintenance of the original root canal morphology is mandatory during root canal preparation. The creation of a glide path is an important clinical procedure to pre-shape the root canal from orifice to apical foramen to prevent shaping errors. A successful glide path reduces torsional stress, creates a smooth and original shape for subsequent root canal preparation, and reduces procedural errors such as instrument failure, canal transportation, and ledge formation. The glide path preparation was usually realized with conventional stainless steel hand files; however, in recent years, numerous nickel-titanium rotary files have been specially designed for glide path preparation. This review aims to provide current information about the glide path, glide path preparation techniques, and glide path files.

Keywords: Glide path, nickel-titanium files, root canal instrumentation.

Introduction

Compared to nickel-titanium (NiTi) rotary files and stainless steel hand files, root canal preparation with NiTi rotary files is faster, easier and offers a better success rate by reducing preparation errors (1). The major disadvantage of conventional NiTi instruments, is that they do not show any physical changes during clinical use and break suddenly without clinical signs (2,3). The fracture of NiTi rotary files occurs by two mechanisms: Torsional or cyclical fatigue (4).

Glide path preparation is important to decrease torsional stress and consequently the chances of NiTi instruments' fracture (5–7). The glide path is defined as providing a regular opening from the root canal orifice to the apical foramen. It is also important for the cleaning and shaping procedure (8). This clinical step has been shown to increase the safety of the preparation with NiTi rotary files by reducing the incidence of instrument fractures (7,9).

The glide path can be created with conventional stainless steel hand files or with a smaller size, smaller taper angle NiTi rotary files (10). The glide path created using hand files can be difficult and time consuming for clinicians, especially for teeth with calcified and/or severely curved canals (11). The use of NiTi rotary files in the glide path preparation also facilitates root canal preparation. For this reason, NiTi rotary files have been recommended for glide path preparation in recent years. At the same time, it has been determined that the use of NiTi rotary files in the preparation of the glide path provides the preservation of the original root canal morphology, reduces post-operative pain after root canal treatment, and is effective in preventing instrument fractures (6,11–13).

"Glide Path" in Endodontics

The glide path is defined as a regular opening from the orifice of the root canal to the apical foramen; any glide path instrument should follow smooth canal walls uninterrupted (7). Determining the root canal and creating the glide path are the first steps of the chemomechanical

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procedure. It is considered the most important stage of root canal preparation to establish the glide path, evaluate the root canal anatomy, and provide unobstructed access to the apical part of the canal (14). In the root canal anatomy, if there is an existing glide path for rotary files to follow, this should be verified with hand files, or if there is no glide path, it should be prepared from the beginning. In root canal anatomy, the glide path can be short or long, narrow or wide, essentially straight or curved (15). Protecting the glide path means having a straight path that can be repeated after the instruments are used sequentially in the canal (9).

The Importance of the Glide Path in Endodontics

Maintaining the original anatomy of the canal is particularly difficult when preparing root canals with severe curvature. Previously, K-type hand files were used for pre-preparation of root canals, but K-type hand files for pre-preparation caused significant transportation of the coronal and apical curvatures and significant deviations in the original root canal anatomy (6). NiTi rotary files, which have recently been used in pre-preparation, have a risk of fracture when exposed to excessive load and tension in clinical use (16). The effect of bending stresses created by the original anatomy of the root canals is high causing the fracture of NiTi rotary files.

Bergmans et al. (17) reported that during root canal preparation, a rotary instrument should not be used without inserting a hand file into the root canal. In addition, studies have reported that creating a glide path reduces the incidence of instrument fractures and when a suitable glide path is created, file fractures do not occur even when high forces are applied in narrow canals (18,19). It has been shown that the creation of an effective glide path can extend the average life of a NiTi rotary file by almost 6 times as well as reduce torsional stress (20). In addition, a previous study suggested to create an glide path with small numbered hand files to reduce the separation of NiTi rotary files (21). Creating a glide path with small hand files or checking if the glide path increases the safety use of NiTi rotary files for the next steps (21).

NiTi files with unequal forward and backward reciprocation movements are current method that reduces the risk of instruments' separation (22). It was found that WaveOne files (Dentsply, Maillefer, Ballaigues, Switzerland) reached the working length more easily and significantly less change occurred in root canal morphology when the glide path was prepared (23). In another study, it was found that when the glide path was established, the rate of transport was lower and the rate of staying in the center of the root canal was higher (24). It has been reported that NiTi rotary files progressed more easily to working length when the glide path was prepared (25). In addition, it has been reported in a study that creating an glide path significantly reduces the amount of apical debris extrusion (26).

Glide Path Preperation Techniques

K-Files

Several authors have recommended using stainless steel K-files for preparing the glide path (7,20,22).

The advantages of using stainless steel hand files and K-files compared with rotary NiTi files for creating the glide path are as follows:

- K-files provide better tactile sensation and less potential for separation (27)
- When a small size K-file is removed from the canal, the file often retains an impression of the canal that can alert- the operator to the curvatures present in the canal (20,27,28)
- The stiffness of stainless steel hand files aids in path finding and in negotiating blockages and calcifications (28)
- It is lower in cost and does not require the use of a special endodontic motor (30)

The disadvantages of preparing a glide path with hand instruments are as follows:

- Operator fatigue and hand fatigue (30)
- Time required in the preparation of the glide path (6)
- Risk of the introduction of canal aberrations with larger file sizes (6,12)
- Greater change to original canal anatomy (31)

It is advocated that the canal diameter after the glide path preparation should be at least one size larger than the tip diameter of the first rotary file to be used (20). West suggested a minimum size of # 10 K-type file for the glide path that does not get stuck in the canal (7). It is recommended to use "balanced force" motion to minimize the risk of creating steps for instruments with a diameter of #15 and larger if a glide path larger than the diameter of a #10 K-type hand file is required (32). This involves turning the handle of the file clockwise, and then turning it counter-clockwise using slight apical pressure so that the file does not "unscrew" its way out of the canal. The instrument cannot get over of the root canal. During the clockwise motion, the file blades cut into the dentine and during the apical counter-clockwise motion, the loose dentine is collected into the file's flutes. This motion can be repeated several times as the file is advanced apically.

After having carved a wider glide path, the file is turned clockwise and removed (7).

In 2006, West proposed the use of a K-type file in a clockwise motion to remove dentine in narrow canals, followed by a 1 mm amplitude reciprocating motion in the vertical direction. The author suggested that the movement in the vertical direction should be gradually increased until the dentin in the canal walls is removed and the file moves smoothly in the apical direction, and recommended that the smallest "glide path" file before using the rotary file be the number 10 K-type file that does not get stuck in the canal (33).

On the other hand, Van der Vyver (2010) argues that a #15 or #20 K-type hand file should easily reach the working length to verify that a glide path has been created (28). A #15 or #20 K-type file should advance to the working length from a distance of 1 mm without being subjected to any strain. After this stage, it should advance to the working length from a distance of 2 mm without any strain. Likewise, if the file advance to the working length at a distance of 5 mm without any strain, the presence of the glide path is approved.

Other hand files recommended for path finding and glide path formation include the Antaeos Stiff "C" file (Schwed, Kew Gardens, NY), C file (Dentsply/Tulsa Dental Specialities, Oklahoma, USA), C file (Roydent, Hoboken, NJ), C+ file (Dentsply/Maillefer Ballaigues, Switzerland), D finder (Mani, Tochigi-ken, Japan), Hi-5 file (Miltex, York, PA), Pathfinder CS (SybronEndo, Glendora, CA), Pathfinder SS (SybronEndo, Orange, California, USA), S finder (JS Dental, Sendoline, Ridgefield, CT), Stiff K-file (Brasseler, Savannah, GA), Flexofile (Dentsply/Maillefer), and Senseus ProFinder (Dentsply/Maillefer). The aforementioned instruments have varying tip dimensions, cross sections, tapers, pitch, and flute design (34).

Hand Files in Reciprocating Hand Piece

This technique involves preparing the glide path with small numbered K-type files mounted on reciprocating contra-angle handpieces (35). Before mounting it on the handpiece, the working length is determined using a small size K-type file. With a K-type file, a reciprocating motion is performed for approximately 15–30 s for each canal. Then, successively larger sized K-type files are mounted in the canal, respectively, to reduce the risk of obstruction in the apical region. Due to the relative hardness of the files, Van der Vyver recommends mounting a # 20 K-type file into the canal, 1 mm shorter than the apex, during glide path preparation to prevent apical transport (28). The M4 reciprocating hand piece (SybronEndo) and Endo-Express reciprocating hand piece (Essential Dental Systems, NJ, USA) have a 30° equi-angle arc of reciprocation (5 min on a clock face). The NSK Ti-Max Ti35L 10:1 reciprocating hand piece (NSK, Nakanishi, Japan) has a 90 degree angle of reciprocation (28).

The advantages of using a stainless steel K-file in a reciprocating hand piece for glide path preparation are as follows:

- Reduced preparation time
- Reduced operator fatigue
- Reduced hand fatigue, especially in canals with multiplanar curves
- Reduced risk of instrument separation compared with rotary NiTi methods.

The disadvantages are as follows:

- The need for a special handpiece
- Apical transport risk when using instruments larger than #15 K-type handpieces (35)
- Increased risk of dentin removal as a result of the clinician working in the root canals for longer than necessary (36)
- Reduced tactile sensation
- Risk of debris extrusion from the apical region due to the insertion of the handpiece by applying force to the apical region (35).

Rotary Niti Files For Glide Path

NiTi rotary files have recently been introduced to the market as they are appropriate for glide path preparation and are more effective (37). It has been stated that the glide path created with NiTi rotary files facilitates the use of larger sized NiTi files and increases their performance, and the amount of dentin removed and transport is less (13). When NiTi rotary files and manually created glide paths were compared, it was observed that less post-operative pain occurred and symptoms decreased more rapidly after the glide path created with NiTi rotary files (12). Similarly, when the glide paths created with NiTi rotary files and stainless steel K-type hand files were compared, it was found that the glide path created with NiTi rotary files caused less transportation in the canal and less modification in the original root canal morphology (6,38). It has been stated that the operator's experience is not important in the creation of the glide path with NiTi rotary files, and the inexperienced physicians create a more conservative preparation compared to the experienced physicians that created glide path with hand files (6).

The advantages of using NiTi rotary instruments for glide path preparation are as follows:

- Reduced operating time (9)

- Less modifications in the original morphology of the root canal and less iatrogenic errors in the root canals (step, apical transportation, and zip formation) (6,12)
- Less operator fatigue and less hand fatigue
- Reduced apical extrusion of debris (31)
- Less post-operative pain after root canal treatment (12)
- It is an easy technique to learn by physicians (6)

The disadvantages of using NiTi rotary instruments for glide path preparation are as follows:

- Additional costs
- Increasing the risk of instrument fracture
- It causes decreased tactile sensitivity.

NiTi rotary files manufactured to produce a glide path:

PathFile NiTi rotary files (Dentsply/Maillefer) were introduced in 2009 specifically for glide path preparation. This file system consists of three files. Later, ProGlider, consisting of a single file, was introduced to the market by the same company.

The G Files file system is a file system produced by Micro-Mega (Besançon Cedex, France) in 2011 with 3% taper and tip diameters G1 ISO 12, G2 ISO 17. The asymmetrical tip facilitates the advancement of the file in the canal. Its horizontal cross-section consists of cutting edges of three different radii. This feature increases debris removal and cutting efficiency. The file surface has been "electropolished" to increase efficiency in advancing towards the apical (39).

The One G file has been produced by Micro-Mega for glide path preparation with a single file. The file has a 0.14 mm tip diameter and a 3% taper angle. Manufacturer argues that the asymmetric cross-section of cutting edges with three different radii provides better debris elimination and the variable groove design between cutting edges reduces the screwing effect (39).

The EndoWave Mechanical Glide Path (MGP) (J Morita, California, USA) consists of three files to enlarge the glide path. EndoWave MGP file No. 1 (purple) has a #10 tip size, file No.2 (white) has a #15 tip size, and file No.3 (yellow) has a #20 tip size. All three devices have 2% fixed taper and can be rotated at 800 rpm with 30 gcm or 0.3 Ncm of torque. The files were treated by electrochemical surface treatment to remove surface roughness due to the production process (30).

The X-Plorer Canal Navigation NiTi Files (Clinician's Choice Dental Products Inc., New Milford, AB) series ware produced in 2010 and consist of three files. The cutting surface length is 10 mm at the apical and this short cutting part reduces the surface contact with the tooth and torsional compression. The non-cutting tip has a 75 point angle. The manufacturer recommends using #8 and #10 files after reaching the apical. The first file has a #15 tip diameter and a 1% taper angle with triangular cross-section. The second file is square, has a 1% taper angle and a #20 tip diameter. The third file has a #20 tip diameter with 2% taper angle and a square section. The reduced taper angle increases flexibility, making it easier for the file to reach the apical (40).

Scout-RaCe (FKG) (FKG Dentaire, La Chaux-de-Fonds, Switzerland) file system has a triangular horizontal cross-section and a taper angle of 2%, and consists of instruments that have been treated with "Electropolishing" to remove any production irregularities. This system consists of three instruments. These three instruments have ISO tip diameters of #10 (purple), #15 (white), and #20 (yellow), respectively. Manufacturers recommend using Scout-RaCe (FKG) instruments after reaching the working length with an instrument size #06 or #08 (30).

RaCe #10 (FKG Dentaire) is another system from FKG and consists of three files that progressively increase in taper: 2% (yellow disc), 4% (black disc), and 6% (blue disk). All have the same apical diameter of 0.1 mm. The files are treated as "Electropolishing." The main indications for the use of these instruments are narrowed and obliterated root canals as well as canals with severe corona curvatures. These files will scout the canal and also create coronal preflaring because of the increasing taper of the instruments (41).

HyFlex GPF (Coltene/Whaledent, Altstatten, Switzerland) is a glide path file produced from CM Wire. It consists of three files in total, #15 apical tip diameter .01 and .02 taper angle and #20 tip diameter .02 tapered file. Its horizontal cross-section is square shaped (42).

The HyFlex EDM glide path file (Coltene/Whaledent, Altstatten, Switzerland) is also manufactured from CM Wire like HyFlex GPF files. The production method is called electro-erosion method and it is a method used quite frequently in the field of medicine but for the 1st time in endodontics. The surface of the file is characterized by the crater-like dimpled appearance typical of this method (43). The HyFlex EDM access file consists of a single file with an #10 apical tip diameter and a taper angle of 0.05 (44).

ProGlider (Dentsply Sirona, Ballaigues, Switzerland) is manufactured from a heat-treated M-Wire NiTi alloy that improves the cyclic fatigue resistance and flexibility of the instrument (45). ProGlider has a progressive taper angle ranging from 2% to 8% over the working length and a square cross-sectional shape. The progressive taper

provides a wider coronal pre-expansion for the subsequent use of rotary instruments after glide path preparation (46).

Reciprocating NiTi Files For Glide Path

R-Pilot (VDW, Munich, Germany) is also manufactured from M-Wire NiTi alloy similar to ProGlider and has S-shaped cross-sectional design similar to Mtwo. However, the R-Pilot is the first glide path instrument operated with reciprocating motion. The R-Pilot has a constant 0.04 taper angle and a 0.125 mm tip diameter with non-cutting tip (47).

Another reciprocating glide path instrument, the WaveOne Gold Glider (Dentsply Sirona; Ballaigues, Switzerland), has a 0.15 mm tip diameter and variable 2–6% tapers with maximum flute diameters at D1 of 0.170 mm, D8 0.413, and D16 0.850 mm (48). The WaveOne Gold Glider is manufactured from gold wire that received a thermomechanical treatment and has a parallelogram-shaped cross-section, as do all of the WaveOne Gold instruments.

It should also be noted that reciprocating glide path instruments have greater cutting efficiency, reduced amounts of apically extruded debris, and better root canal shaping efficiency than those in continuous rotation. From a clinical point of view, the use of glide path instruments with reciprocating motion in teeth with curvatures and specifically periapical lesions may be recommended, as the apical 1 mm region is an area of concern that can affect the overall success of endodontic treatment (49).

In 2011, Van der Vyver also defined a combined method for glide path preparation. Stainless steel K-type files (from file number #6 to #10) are advanced to the working length by clockwise movement in sequence, the instruments are then placed in a reciprocating handpiece and used in the canal to create the first stage glide path. The next step is to complete the glide path preparation using NiTi PathFile files (28).

Conclusion

The preparation of a glide path helps to reduce the risk of instrument separation and conveys to the clinician an important knowledge of the complex anatomy of the canal from the orifice to the terminus. The information collected during glide path preparation permits clinicians to adapt their shaping strategy to the nuances of the canal anatomy of each individual canal. While novel mechanical methods of glide path preparation serve to increase the efficiency of this essential prerequisite of canal shaping, the role of hand instruments should not be overlooked.

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