Mechanical Properties of Glide Path Preparation Instruments with Different Pitch Lengths

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Abstract

Introduction: This study compared the effects of pitch length on the torsional resistance and cyclic fatigue resistance of glide path preparation instruments. **Methods:** G-File (G1 and G2; Micro-Mega, Besançon, France) and new generation G-File (NG1 and NG2, Micro-Mega) instruments were compared to evaluate the effects of the shorter pitch of the latter (25% shorter than G-File). G1 and NG1 have a #12 tip size, whereas G2 and NG2 have a #17 tip size. All the files have the same taper of 3%. For comparing the torsional resistances (n = 15), the file was fixed at 4 mm from the tip, and the clockwise rotation at a constant rotational speed of 2 rpm was adjusted until the file fractured. The maximum torsional load and distortion angle at fracture were recorded. For comparing the cyclic fatigue resistances (n = 15), the files were freely rotated in a simulated canal (radius, 3 mm; curvature, 90°) at a speed of 300 rpm in a dynamic mode. When the file fractured, the time elapsed was recorded using a chronometer. The number of cycles to failure was calculated by multiplying the total time to failure by the rotation rate. Fractured fragments were examined under the scanning electron microscope. **Results:** The NG2 instruments had significantly higher fatigue resistance and torsional strength than the G2 instruments ($P < .05$) and showed approximately the same fatigue resistance as the G1. Scanning electron microscopic examinations revealed the typical appearances of 2 failure modes. **Conclusions:** A shorter pitch design increased cyclic fatigue resistance and torsional strength of the glide path instruments. *(J Endod 2018;■:1–5)*

Key Words

Cyclic fatigue, glide-path, nickel-titanium rotary instrument, pitch, torsional resistance

Significance

Glide path preparation is an important procedure to reduce the mechanical failure of canal shaping instruments. Glide path establishing instruments with a relatively shorter pitch have increased cyclic fatigue and torsional fracture resistances than the longer pitch instruments.

Nickel-titanium (NiTi) rotary instruments for endodontic treatment have become more popular because of their higher shaping efficiency and success rate relative to manual instruments (1, 2). Despite the increased flexibility and strength of NiTi rotary instruments compared with stainless steel files (3), instrument separation is a primary problem associated with NiTi instruments (3, 4). Cyclic fatigue and torsional failures are 2 primary causes of instrument separation (4). Cyclic fatigue is caused by repetitive compressive and tensile stresses on the outer fibers of a file rotating in a curved canal, whereas torsional failure occurs when the tip of the instrument binds but the shank continues to rotate.

Creating a glide path during initial root canal preparation is an important step for reducing the fracture risk of NiTi rotary files. A glide path of sufficient size ensures a reduction in torsional stress and thus increases the life span of the rotary instrument used for canal preparation. Instruments used to establish a glide path should be flexible enough to follow the canal curvature and strong enough to resist torsional stress or fracture. The physical properties of the file are affected by the file's geometric design and manufacturing processes such as surface treatment and/or heat treatment. Various cross-sectional designs can affect the stiffness of the instrument and stress distribution during use (5).

The G-File system (Micro-Mega, Besançon, France) includes G1 (#12) and G2 (#17) files with a 3% taper. The cross section of this file system has blades on 3 different radii to aid in the removal of debris and the reduction of torsion, and the files have electropolished surfaces to improve efficiency. The files have been reported to have reduced resistance to buckling during the exploration of narrow curved canals. However, unwinding and torsional failures during initial flaring and/or glide path preparation may occur when using thin files with a small taper (6). Therefore, the new generation G-File (NG, Micro-Mega) was developed with a different pitch length (25% shorter) compared with the G-File in order to improve mechanical properties such as torsional resistance, cyclic fatigue, and resistance to screw-in force.

The aim of this study was to compare the effect of pitch length on the mechanical properties of torsional resistance and cyclic fatigue between the G-File (long pitch) and NG (short pitch) glide path preparation instruments.

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0099-2399/$ - see front matter

https://doi.org/10.1016/j.joen.2018.01.022

Materials and Methods

Two NiTi rotary systems for glide path preparation, G-File (long pitch) and NG (short pitch), were tested in this study (Fig. 1*A–F*). The files have the same asymmetric triangular cross section, and the study included 2 sizes, ISO tip size #12 (3% taper, G1 and NG1) and tip size #17 (3% taper, G2 and NG2). A total of 60 new files of each system were used for a cyclic fatigue test (n = 15) and torsional resistance test (n = 15). Before the test, the instruments were visually examined under a dental operating microscope (Zeiss Pico; Carl Zeiss MediTec, Jena, Germany), and any defective instruments were discarded.

The torsional resistance test was performed according to the modified technique by Yum et al (7) using a customized device (DMJ Systems, Busan, Korea). The file tip was fixed with polycarbonate blocks 4 mm from the tip. During the experiments, the files were kept straight, and the clockwise rotation at a constant rotational speed of 2 rpm was adjusted until the file fractured. During the rotation of the files, the ultimate strength (Ncm) and the fracture angle (°) were recorded at a rate of 50 Hz using customized software.

The cyclic fatigue resistance was tested with the same device using a simulated canal made of tempered steel, which is described similarly in Ha et al (8). The canal had a length of 17 mm, a radius of 3 mm, and an angle of curvature of 90°. The files were freely rotated in the canal at 300 rpm in a dynamic method. The speed of forward and backward movement was 4 mm per 0.5 seconds for each direction, and 50-millisecond dwell times were given. When the file fractured, the time elapsed until fracture was recorded using a chronometer. The number of cycles to failure for each instrument was calculated by multiplying the total time to failure (seconds) by the rotation rate.

After the torsional and cyclic fatigue tests, all fractured fragments were observed under a scanning electron microscope (SU8220; Hitachi High Technologies, Tokyo, Japan) to evaluate

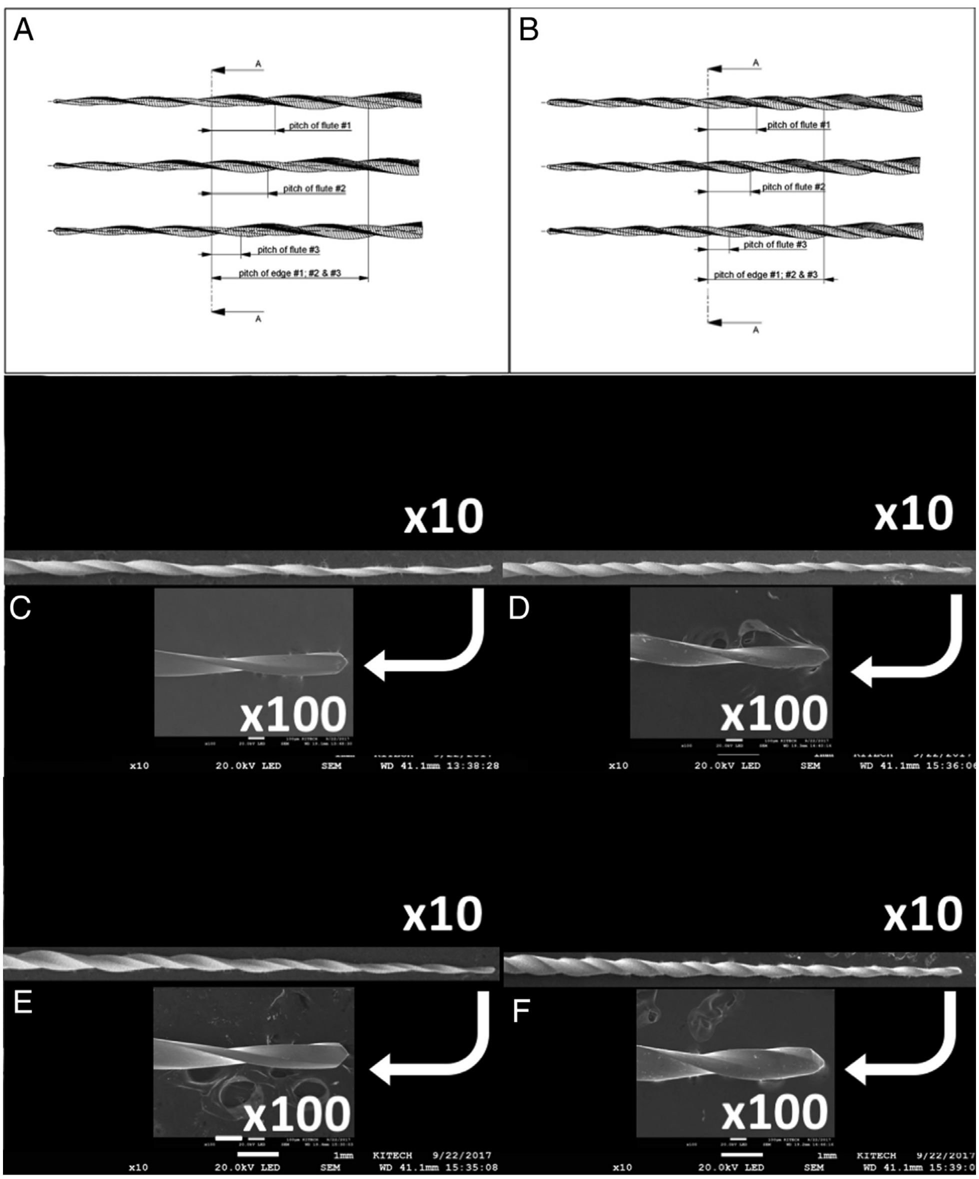

Figure 1. A structural drawing of (*A*) the G-File and (*B*) the NG. The NG has a shorter pitch length than the G-File. Representative scanning electron microscope images of (*C*) G1, (*D*) NG, (*E*) G2, and (*F*) NG2 specimens.