Energy Consumption of ProTaper Next X1 after Glide Path with PathFiles and ProGlider

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Abstract

Introduction: Instrument failure caused by excessive torsional stress can be controlled by creating a manual or mechanical glide path. The ProGlider single-file system (Dentsply Maillefer, Ballaigues, Switzerland) was recently introduced to perform a mechanical glide path. This study was designed to compare the effect of a glide path performed with PathFiles (Dentsply Maillefer) and ProGlider on torque, time, and pecking motion required for ProTaper Next X1 (Dentsply Maillefer) to reach the full working length in simulated root canals. **Methods:** Forty Endo Training Blocks (Dentsply Maillefer) were used. Twenty were prepared with a mechanical glide path using PathFiles 1 and 2 (the PathFile group), and 20 were prepared with a mechanical glide path using a ProGlider single file (the ProGlider group). All samples were shaped with ProTaper Next X1 driven by an endodontic motor connected to a digital wattmeter. The required torque for root canal instrumentation was analyzed by evaluating the electrical power consumption of the endodontic engine. Electric power consumption (mW/h), elapsed time (seconds), and number of pecking motions required to reach the full working length with ProTaper Next X1 were calculated. Differences among groups were analyzed with the parametric Student t test for independent data ($P < .05$). **Results:** Elapsed time and electric power consumption were significantly different between groups ($P = .0001$ for both). ProGlider appears to perform more efficiently than PathFiles in decreasing electric power consumption of ProTaper Next X1 to reach the full working length. **Conclusions:** This study confirmed the ability of ProGlider to reduce stress in ProTaper Next X1 during shaping through a glide path and preliminary middle and coronal preflaring. *(J Endod 2014;40:2015–2018)*

Key Words

Electric power consumption, glide path, nickel-titanium, nickel-titanium rotary instrumentation, ProGlider

Nickel-titanium (NiTi) rotary instruments were introduced to reduce operator tiredness, shaping time, and the risk of procedural errors when performing root canal shaping (1). Although several studies have shown that shaping outcomes with NiTi rotary instruments are mostly predictable (1–3), mechanical failure is a major concern (4, 5). The life of an NiTi rotary instrument is proportional to its operational stress state (6–9). In clinical practice, the risk of instrument failure is mainly determined by bending and torsional stresses (10, 11). Canal curvature is the predominant risk factor for increased bending stresses, and this cannot be influenced by the clinician (12–14). Torsional stresses are proportional to the compression force applied by the operator to the handpiece (15) and the width of the contact area between the canal walls and the instrument cutting blade (16, 17). These significantly increase if the canal cross section is smaller than that of the instrument noncutting tip (18, 19). Although bending stresses are significant for cyclic fatigue, instrument failure is chiefly caused by excessive torsional stresses (20), and the clinician can drastically reduce these by creating a smooth glide path by either manual or mechanical preflaring (18–20). Previous studies suggest that mechanical instrumentation with the NiTi rotary PathFile (PF; Dentsply Maillefer, Ballaigues, Switzerland) represents an easier and less invasive method to provide an adequate glide path (21).

The new ProGlider (PG, Dentsply Maillefer) single-file system has been recently introduced to perform a mechanical glide path (22) (Fig. 1). Its exclusive design and mechanical features enable the glide path to be created by a single instrument of 1 size (tip size = 0.16 mm). Additional features include a progressive taper (.02 at tip level up to .085) with a cutting surface of 18 mm. To perform a glide path, the PG must be used in continuous rotation (suggested settings 300 rpm with a 2–5.2 Ncm torque). Because of its progressively tapered design, the instrument also provides a preliminary preflaring of the middle and coronal portions of the canal.

Dedicated endodontic motors for use in any rotary NiTi system must maintain a constant rotational speed, limit torque, and keep the instrument stress state within constant and acceptable levels (23). The handpiece is capable to withstand the lateral pressure on the revolving instrument by increasing the torque, without decreasing its speed and cutting efficiency (24). Thus, the engine increases torque when the instrument undergoes an increased workload in order to keep a constant speed (23, 24). Variations in torque result in different electrical power consumption by the endodontic engine (25, 26). Therefore, electric power consumption can be considered a reliable surrogate parameter to evaluate the stress state of the instrument during shaping (15, 25, 26). The aim of this study was to evaluate the influence of a mechanical glide path performed with rotary PFs and the PG on the electric power consumption of the endodontic engine during root canal shaping with ProTaper Next X1 (Dentsply Maillefer) in simulated root canals.

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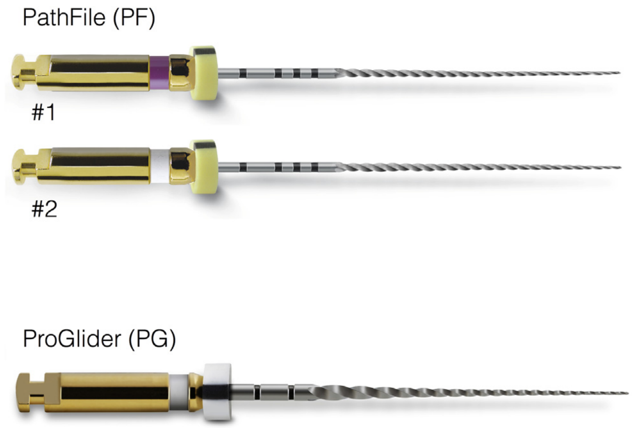

Figure 1. PG NiTi rotary system. A single instrument of 1 size (016, .02) and a progressive taper (up to .085) with an active part of 18 mm available in 3 different lengths: 21, 25, and 31 mm.

Materials and Methods

Forty standardized ISO 015 (apical), .02 taper, 40° curvature, 16-mm working length (WL) Endo Training Blocks (Dentsply Maillefer) were used for this study. Sample size calculation was performed in G*Power 3.1.4 (Kiel University, Keil, Germany) to set study power at 80%. One expert operator, previously calibrated for pecking speed and pressure on the handpiece, performed all the instrumentation phases of this study. The Endo Training Block canals were scouted up to the WL with a #10 stainless steel K-File (Dentsply Maillefer) and randomly assigned to 1 of 2 groups:

1. The PF group (n = 20): The mechanical glide path was performed with PF rotary instruments #1 (013, .02) and #2 (016, .02) according to the manufacturer's instructions before using ProTaper Next X1 at the WL.
2. The PG group (n = 20): The mechanical glide path was performed with PG rotary single files (016, .02 at tip level, with progressive taper up to .085) before using ProTaper Next X1 at WL.

The mechanical glide path was performed using Glyde (Dentsply Maillefer) as a lubricating agent and an endodontic engine (X-Smart, Dentsply Maillefer) with a 16:1 contra-angle at the suggested setting (300 rpm on display, 5 Ncm). New instruments were used for each Endo Training Block.

Prepared specimens from both groups were shaped with a new ProTaper Next X1 rotary file (017, .04) at the WL. The endodontic motor used for shaping was the Tecnika digital motor (ATR, Muggiò, Italy) with a 16:1 reduction handpiece. In all cases, the speed of rotation was set to 300 rpm and the torque to 5.2 Ncm. The endodontic motor was connected to a digital wattmeter (WT 20130 Digital Power Meter; Yokogawa, Tokyo, Japan) and an electronic schedule in order to evaluate the electric power consumption required to reach the full WL. The electronic schedule was designed to quantify and subtract the electrical and mechanical power disturbances. The electrical power consumption (mW/h), number of pecking motions, and time (s) required to reach the full WL with a ProTaper Next X1 was calculated for every specimen belonging to the 2 groups (PF and PG). The Kolmogorov-Smirnov test for normality revealed a normal data distribution, and differences between groups were analyzed using the parametric Student t test for independent data. Differences were considered statistically significant when P was <.05. All statistical analyses were performed using the SPSS for Windows 12.0 software package (SPSS, Inc, Chicago, IL).

Results

No damage or separation of PF and PG instruments occurred during the glide path phase. The PF system (#1 and #2) required the same number of total passes to reach apex (n = 1 + 2, respectively) as the PG single file (n = 3). Electrical power consumption during the shaping operations with ProTaper Next X1 was significantly different between the groups (P = .0001). The endodontic motor consumed 4.89 mW/h (standard deviation = .52) and 4.16 mW/h (standard deviation = .56) in the PF and PG groups, respectively (Table 1). The mean time required to reach the full WL with ProTaper Next X1 was also significantly different between the 2 groups (P = .0001) (Table 1). The mean time required to complete the shaping operation with ProTaper Next X1 in the PF group was 7.99 seconds compared with 5.91 seconds in the PG group. Pecking motion was not statistically different between groups (Table 1). No instrument unwinding or failure was recorded during the shaping operations with ProTaper Next X1.

Discussion

The risk of instrument failure is a concern when using NiTi rotary instruments, particularly the potential difficulty of removing instrument fragments and the perceived adverse prognostic effect of this procedural complication (5, 27). Prediction of this risk is a continued source of debate. After initial canal scouting with manual K-files to determine the first WL and to guarantee the foraminal patency, the creation of a glide path is mandatory to increase the shaping performances of NiTi rotary or reciprocating instruments (17, 18, 28). Instrument life is strictly related to the stress state, and failure may result from incorrect or excessive use (6–9, 29). A manual or mechanical glide path is necessary to reduce the effect of torsional stresses along the canal and the risk of instrument failure (5, 16–18). In order to avoid instrument failure from excessive torque, the root canal diameter should be larger than, or at least equal to, the noncutting tip of the first shaping instrument used. Previous studies have reported that the mechanical glide path is more effective at maintaining the original canal anatomy than the manual glide path with K-Files (21, 30). Moreover, the mechanical glide path may be less time-consuming and is associated with a lower prevalence and severity of postoperative pain, making it particularly suitable for inexperienced clinicians (21, 31).

This study compared PF and PG systems for performing the mechanical glide path. The electric power consumption required by the endodontic engine during canal root shaping for the full WL with ProTaper Next X1 was recorded in simulated root canals for both systems. ProTaper Next X1 is a new generation rotary shaping instrument designed to perform the same coronal and middle root canal shaping with a single file as the first 2 ProTaper Universal S1 and S2 instruments. Consequently, it may benefit from a preflaring of the middle and coronal portion of the root canal in order to decrease torsional stresses. Although results obtained from resin blocks do not fully reflect those in real teeth, where dentin is involved, the use of simulated root canals has shown the advantages of providing standardized experimental conditions as a reproducible and widely used model (3, 21, 32). Specific endodontic engines for NiTi rotary instruments have been developed (23, 24) to keep the same rotational speed (33, 34) by controlling the applied torque. NiTi rotary shaping instruments with a variable taper are designed to cut dentin in correspondence of their larger cross sections and require a larger torque (15), mainly because of dentin hardness, root canal anatomy, and the presence or absence of adequate preflaring (21, 23–25, 33, 34). The torque applied to the endodontic file driven in a continuous rotary mode is proportional to the power consumption of the endodontic engine (26). As a