Cyclic Fatigue Resistance of XP-Endo Shaper, K3XF, and ProTaper Gold Nickel-titanium Instruments

Cangül Keskin, DDS, PhD, Uğur Inan, DDS, PhD, Duygu H. Guler, DDS, and Elif Kalyoncuoğlu, DDS, PhD

Abstract

Introduction: The aim of this study was to compare the cyclic fatigue resistance of the ProTaper Gold (PTG; Dentsply Maillefer, Ballaigues, Switzerland), K3XF (SybronEndo, Orange, CA), and XP-endo Shaper (FKG Dentaire, La Chaux-de-Fond, Switzerland) nickel-titanium rotary instruments at intracanal temperatures. **Methods:** Eighteen XP-endo Shaper (30.01), 18 K3XF (30.04), and 18 PTG F3 (30.09v) instruments were used to test the cyclic fatigue resistance at an intracanal temperature of $35^\circ \pm 2^\circ C$. The instruments were tested in a metal block that simulated a canal curvature angle of 60° and a curvature or radius of 5 mm. All instruments were operated until fracture occurred, and then the number of cycles to failure was calculated. The lengths of fractured fragments were measured with a digital caliper. The data were analyzed statistically using 1-way analysis of variance and the Tukey post hoc test with significance set at $P < .05$. **Results:** The XP-endo Shaper instruments showed a significantly higher number of cycles to fracture than the K3XF and PTG instruments ($P < .05$). There was no difference between the PTG and K3XF instruments ($P > .05$). **Conclusions:** The XP-endo Shaper instruments exhibited greater cyclic fatigue resistance compared with the other instruments at the intracanal temperature. *(J Endod 2018;■:1–4)*

Key Words

Intracanal temperature, nickel-titanium, static cyclic fatigue device

Significance

The investigation of the fracture resistance of newly developed NiTi rotary instruments is important to provide information for clinicians. The present study compared the cyclic fatigue resistance of the novel XP-endo Shaper with commonly used NiTi rotary instruments.

Nickel-titanium (NiTi) rotary instruments have gained popularity over hand instruments because they allow for faster and easier root canal preparation (1). Although the NiTi rotary instruments are flexible and have higher strength values, they possess a significant disadvantage of unexpected fracture during preparation (2). The unexpected instrument fracture occurs by 2 different mechanisms: torsional and flexural failure (3). Although torsional fracture occurs either when the torque generated by the contact between the instrument and the canal wall exceeds the torsional strength or when the tip of the instrument is screwed into the canal while the rest of the instrument continues to rotate (4), cyclic fatigue failure occurs when the instrument is rotated in a curved canal and exposed to repeated compressive and tensile stresses (5, 6). As a result, novel instrumentation systems with different alloys and designs have been developed to minimize the number of instrument fractures and to increase the fatigue resistance of root canal instruments (7). Various manufacturing processes have focused on modifying surface treatment, thermal treatment of the alloy, and the cross-sectional design of the instrument (8, 9).

Recently, ProTaper Gold (PTG; Dentsply Maillefer, Ballaigues, Switzerland) rotary instruments have been introduced, maintaining the geometric design and convex triangular cross-sectional shape of the ProTaper Universal rotary instrument systems and adding the advantage of the improved properties of gold wire (10). K3XF (SybronEndo, Orange, CA) is another rotary instrumentation system that has upgraded K3 instruments by using thermomechanically treated NiTi alloy and maintaining variable helical flute construction and an asymmetric constant taper. The thermomechanically treated alloy has been termed R-phase wire and is associated with increased flexibility and fatigue resistance of instruments (11, 12).

The XP-endo Shaper (XPS; FKG Dentaire, La Chaux-de-Fond, Switzerland) is a novel instrument that is claimed by the manufacturer to have high flexibility and fatigue resistance because of the use of the MaxWire (Martensite-Austenite Electropolishing-Flex, FKG Dentaire) alloy (13, 14). The design of XPS enables the instrument to adapt the root canal system 3-dimensionally during operation at body temperature via its snake-shaped motion, which expands or contracts according to the root canal morphology to improve cleaning and shaping. The MaxWire alloy changes its phases depending on the environmental temperatures. The instrument enables the preparation of a root canal with a single

Department of Endodontics, Faculty of Dentistry, Ondokuz Mayıs University, Samsun, Turkey

Address requests for reprints to Dr Cangül Keskin, Department of Endodontics, Faculty of Dentistry, Ondokuz Mayıs University, Samsun, Turkey. E-mail address: canglkarabulut@gmail.com

0099-2399/$ - see front matter

Copyright © 2018 American Association of Endodontists.

https://doi.org/10.1016/j.joen.2018.04.005

instrument to a final preparation size of at least 30.04 (13). According to the manufacturer, high-speed operation with minimum torque also creates minimal stress on the dentin walls (13).

Recently, the environmental temperature has been regarded as a contributing factor for the cyclic fatigue resistance of NiTi instruments as a result of studies that simulated the intracanal temperature. These studies reported that simulated body or intracanal temperature reflected clinical conditions more accurately and reduced the cyclic fatigue resistance of NiTi instruments produced with different methods (15–17). Additionally, to the authors' knowledge, no study has compared the cyclic fatigue resistance of XPS instruments with PTG F3 and K3XF (30.04). The present study aimed to evaluate the cyclic fatigue resistances of XPS (30.01), PTG F3 (30.09v), and K3XF (30.04) instruments at a simulated intracanal temperature. PTG F3 and K3XF were selected because they show similar dimensions at the D0 level and similar cross-sectional shapes to XPS. The null hypothesis tested was that there would be no significant difference among the instruments regarding their cyclic fatigue resistance.

Materials and Methods

After inspection at ×20 magnification under a stereomicroscope (SMZ 745T; Nikon, Tokyo, Japan), 18 XPS (30.01), 18 PTG F3 (30.09v), and 18 K3XF (30.04) instruments with no visible defects or irregularities were accepted for this study. The cyclic fatigue resistance was evaluated in a custom-made device. The cyclic fatigue testing block contained a stainless steel artificial canal showing a 60° angle of curvature, a 5-mm radius of curvature, a 1.40-mm inner diameter, and a 19-mm length. The block was mounted in a plastic container with dimensions of 15 × 10 × 4 cm, which was filled with 600 mL sterile saline heated to 35° ± 2°C via a submersible heater (Aquatop, Brea, CA) (Fig. 1). The temperature of the testing block and solution was measured with thermocouples and controlled via thermostats.

K3XF (30.04) and PTG F3 instruments were used with an endodontic motor (X-Smart; Dentsply Sirona, Ballaigues, Switzerland) at 300 rpm and 3 Ncm with a 16:1 reduction handpiece, whereas XPS instruments were operated with the same endomotor and handpiece at 800 rpm and 1 Ncm according to the manufacturers' instructions. All instruments were rotated until fracture occurred. Instrument fracture was detected audibly and visually. The time required for fracture in seconds was measured to the 1/100 second using a digital chronometer. The number of cycles to failure (NCF) was calculated using the following formula: NCF = the time required to fracture (s) × rotational speed/60. The lengths of the fractured fragments were also measured with a digital caliper. All cyclic fatigue testing procedures were performed by a single experienced operator. Fractured instruments were examined under a scanning electron microscope (JEOL JSM-7001F; JEOL, Tokyo, Japan), and photomicrographs of the fractured surfaces were obtained at different magnifications.

The assumption of normality for the data on cyclic fatigue resistance and the length of the fractured fragments was confirmed using the Shapiro-Wilk test. The data obtained on the lengths of the fractured fragments and the NCF data were subjected to 1-way analysis of variance and the post hoc Tukey test using SPSS v.21.0 (IBM Corp, Armonk, NY) with the significance level set at 5%.

Results

The mean and standard deviation values for the NCF and the fractured fragment lengths for each group are presented in Table 1. The XPS instruments showed significantly greater cyclic fatigue resistance values than the PTG F3 and K3XF 30.04 instruments ($P < .05$). There was no significant difference between PTG F3 and K3XF 30.04 instruments regarding their cyclic fatigue resistance ($P > .05$). The mean length of the fractured fragments also showed no significant difference among groups ($P > .05$). The scanning electron microscopic photomicrographs revealed fatigue striation marks because of the cyclic fatigue and crack surfaces (Fig. 2).

Figure 1. The experimental setup of the cyclic fatigue test device for the simulation of the intracanal temperature.

Discussion

Nowadays, different NiTi instrument systems have been renewed with the use of thermally treated novel alloys or designs to improve the torsional and cyclic fatigue resistance (18–20). To date, there has been no standardization for testing the cyclic fatigue of rotary NiTi instruments. Several testing devices with different designs have been used, including a 3-point bending technique, operation of instruments against an inclined plane, and testing in a curved metal simulated canal or a grooved block (21). It is important to minimize uncontrollable variables and standardize testing conditions for each specimen. In the present study, an artificial simulated canal made from a stainless steel block was used to test the instruments in a static cyclic fatigue model.

Environmental conditions have also been reported to contribute to the mechanical properties of NiTi instruments (16, 22). Previous

TABLE 1. The Mean and Standard Deviation Values for the Number of Cycles to Fracture (NCF) and the Length of the Fractured Fragment (mm) of the Tested Instruments

	NCF	Fragment length
XP-Endo Shaper	3194.0 ± 1328.3[a]	5.05 ± 0.44[a]
ProTaper Gold	885.2 ± 208.6[b]	4.91 ± 0.72[a]
K3XF	495.8 ± 116.8[b]	4.88 ± 0.48[a]

Different superscript lowercase letters in the same column indicate a significant difference ($P < .05$).

Download English Version:

https://daneshyari.com/en/article/8699465

Download Persian Version:

https://daneshyari.com/article/8699465

Daneshyari.com