Torsion and Bending Properties of OneShape and WaveOne Instruments

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Abstract

Introduction: The purpose of this study was to compare the torsion and bending properties of OneShape (OS; Micro Mega, Besançon, France) and WaveOne (WO; Dentsply Maillefer, Ballaigues, Switzerland) single-file systems. **Methods:** The torsional strength of OS size #25, 0.06 taper and WO primary size #25, 0.08 taper was measured by using a torsiometer after fixing the apical 5 mm of the instrument rigidly. A scanning electron microscope was used to characterize the topographic features of the fracture surfaces of broken files. The files were tested for bending resistance by using the cantilever bending test. Data were statistically analyzed using the independent *t* test. Statistical significance level was set at $P < .05$. **Results:** WO had a significantly higher torsional resistance than OS ($P < .001$). The average bending resistance as measured by the maximum force (gf) to bend instruments revealed that the WO had a significantly lower resistance to bend than OS ($P < .001$). Scanning electron microscopic analysis of the fractured cross-sectional surfaces revealed typical features of torsional failure including skewed dimples near the center of the fracture surface and circular abrasion streaks. **Conclusions:** The WO single-file system showed higher torsional resistance and flexibility than the OS single-file system. Different cross-sectional geometry and the alloy from which the instrument is manufactured could have significant influence on the torsional resistance and flexibility of the instruments. *(J Endod 2015;41:544–547)*

Key Words

Flexibility, M-wire, OneShape, torsional resistance, WaveOne

Nickel-titanium (NiTi) rotary endodontic instruments have become popular because of their typical property of superelasticity, cutting ability, and enhanced root canal preparation (1, 2). However, during canal preparation, NiTi rotary endodontic instruments are subjected to torsional and bending stresses as a result of friction between the instrument and the canal wall and the curved passage of the root canal (3).

Torsional strength reveals the capability of the file to twist before fracture and is required in the preparation of narrow and constricted canals because the file is susceptible to high torsional loads (4). Likewise, flexibility is an important property while preparing curved canals. An instrument with high flexibility may result in fewer undesirable changes in the shape of curved canals (5). Consequently, the knowledge of these properties is essential, particularly for newer file systems that are introduced to the dental market (4).

Technological innovations in NiTi rotary endodontic instruments have resulted in new design concepts and different kinematics with easier and faster techniques that maintain the original canal shape with considerably less iatrogenic error (6, 7). A new concept for NiTi rotary instruments has been developed including different working motions that prepare root canals with only 1 instrument (7, 8). WaveOne (WO) (Dentsply Maillefer, Ballaigues, Switzerland) is 1 of these single-file systems using a reciprocating motion. The reciprocating motion is based on a counterclockwise (CCW) (cutting direction) and a clockwise (CW) motion (release of the instrument) (9). The angle of the CCW cutting direction is greater than the CW one; and, hence, the CCW permits the instrument to proceed in the canal and engage the dentin to cut it, whereas CW permits the file to be immediately disengaged and safely progress along the canal path while decreasing the propensity for screwing in and fracture (9, 10). WO instruments have a modified convex triangular cross section at the tip and a convex triangular cross section in the middle and coronal portion of the instrument (10, 11). Additionally, WO is manufactured using M-wire NiTi to enhance the flexibility and fatigue resistance of the instrument (1, 12).

The OneShape (OS) (Micro Mega, Besançon, France) instrument is another single-file NiTi rotary system that was introduced to the dental market. However, it is used in continuous CW rotation. The OS instrument is manufactured from a conventional austenite 55-NiTi alloy. It is available only in 1 instrument, which has a tip size of 25 and a constant taper of 0.06. It consists of 3 different cross-sectional zones over the entire length of the working part. In the first zone at the tip region, the cross section is characterized by a 3–cutting edge design, which is transformed progressively in the middle zone to 2 cutting edges. In the last zone at the shank, the S-shaped cross section shows 2 cutting edges (8, 9, 13). Additionally, the OS instrument has a variable pitch length along the working part, which is claimed by the manufacturer to reduce the instrument screwing effects (13).

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The aim of this study was to compare the torsion and bending properties of OS and WO single-file systems. The null hypothesis tested was that no differences are present in the torsion and bending properties between the 2 instruments.

Materials and Methods

Two NiTi rotary single-file systems (ie, OS size #25, 0.06 taper and WO primary size #25, 0.08 taper) were used in this study. Each file was examined for defects before the test with a dental operating microscope (Global Surgical, St Louis, MO). Twenty files from each brand were evaluated per test.

Torsional Resistance

The torsional resistance of the files was evaluated as described by Park et al (14) and Yum et al (15). Briefly, repetitive torsional stress was applied to the file without bending (ie, in a straight state) to assess the pure torsional resistance and eliminate the influence of flexural fatigue. Torsional resistance was evaluated using a custom-made metal block with a cubical hole (5 mm × 5 mm × 5 mm). Five millimeters of the tip of each file was securely held in place by filling the mold with a resin composite (Filtek P60; 3M ESPE, St Paul, MN) and light cured with the Elipar S10 unit (3M ESPE, light output: 1200 mW/cm^2) for 80 seconds. After that, a uniform rotation at 2 rpm was applied to the files in a straight state by using a torsion tester (Digital Torque Gauge, Series TT03; Mark-10 Corporation, Long Island, NY). The torque was applied in a CCW direction for WO and in a CW direction for OS instruments. The maximum torsional load (Ncm) was recorded during loading until the file succumbed to the torsional load (16).

Scanning Electron Microscopic Analysis

A scanning electron microscope (JSM-6510LV; JEOL Ltd, Tokyo, Japan) was used to characterize the topographic features of the fracture surfaces of broken files. All broken segments were ultrasonically cleaned (Bandelin Sonorex; Bandelin, Berlin, Germany) in absolute alcohol for 5 minutes.

Bending Resistance

The files were tested for bending resistance using the cantilever bending test as described previously (17, 18). The load was applied using a stainless steel wire (length of 40 cm and diameter of 0.34 mm), with 1 of the terminus fixed to the universal testing machine (Model TT-B; Instron Corp, Canton, MA) and the other end fixed 3 mm away from the tip. The bending test was performed until the tip of each file underwent an elastic displacement of 45°. The load cell used was 20 N, and the crosshead speed was 15 mm/min.

Statistical Analysis

Statistical analyses (SPSS 15.0; SPSS Inc, Chicago, IL) of the torsional and bending resistance data were analyzed using an independent *t* test. The data were first verified with the Kolmogorov-Smirnov test for the normality of the data distribution and the Levene test for the homogeneity of variances. The statistical significance level was set at $P < .05$.

Results

The mean and standard deviations of the torsional and bending resistance for each brand are presented in Table 1. WO had a significantly higher torsional resistance compared with OS ($P < .001$). The average bending resistance as measured by the maximum force (gf) to bend instruments revealed that the WO had a significantly lower resistance to bend than OS ($P < .001$).

TABLE 1. Mean ± Standard Deviation (SD) of Torsional and Bending Resistance of Brand Systems

Brand systems	Torsional resistance (Ncm) mean ± SD	Bending resistance (gf)* mean ± SD
OneShape	2.81 ± 0.21	53.40 ± 4.73
WaveOne	3.42 ± 0.26	33.10 ± 3.04
P value†	<.001	<.001

*The maximum force to bend the instruments.

†Statistically significant at $P < .05$.

Scanning electron microscopic (SEM) analysis of the fractured cross-sectional surfaces revealed typical features of torsional failure including skewed dimples near the center of the fracture surface and circular abrasion streaks (Fig. 1*A–F*).

Discussion

Despite the fact that NiTi rotary instruments have provided increased flexibility and strength when compared with stainless steel instruments, a high risk of fracture continues to be a problem during endodontic therapy (19, 20). The mechanism of NiTi rotary instrument fracture has been attributed to torsional failure and cyclic fatigue fracture (21). It has been reported that a high prevalence of torsional failure occurred in NiTi rotary files compared with cyclic fatigue (55.7% vs 44.3%, respectively) (22). New systems of NiTi rotary instruments have been developed that shape the root canals with only 1 file used in either a reciprocating motion or continuous rotation. It has been claimed by their manufacturers that clinicians can save time and cost for endodontic treatment. On the other hand, the instrument will be subject to a high level of stress because the root canals are shaped with only 1 file (16). Consequently, it should have an adequate resistance to fracture (16).

This study compared the torsion and bending properties of the OS single-file system made of conventional NiTi alloy with the WO single-file system manufactured from M-wire alloy. The results of this study require the rejection of the null hypothesis because WO showed significantly higher torsional resistance and flexibility compared with OS instruments under the conditions of the present study (Table 1).

There are several factors that have a considerable influence on the torsional behavior and stress distribution of NiTi rotary files including cross-sectional design, chemical composition of the alloy, and the thermomechanical process applied during manufacturing (3, 14, 23). It has been reported that increasing the central core diameter of the file cross section will improve the resistance of a rotary file to the torsional stress (3, 14, 24, 25). In a supplementary examination, the cross section of each instrument was captured at D5 under a scanning electron microscope, and the area was measured with ImageJ software (http://rsbweb.nih.gov/ij; National Institutes of Health, Bethesda, MD). OS was found to have the biggest area (approximately 523,125 μm^2) and WO the smallest area (approximately 334,212 μm^2). OS had a larger cross-sectional area compared with WO but revealed a lower torsional strength. This could be attributed to the mechanical characteristics of the NiTi alloy. WO is manufactured using M-wire NiTi, whereas the OS instrument is manufactured from a conventional austenite 55-NiTi alloy (8, 9). It has been reported that M-wire technology provides more resistance to fracture than traditional NiTi rotary instruments (16, 24). It has been postulated that the small grain size of martensite observed in M-wires