Comparison of Cyclic Fatigue Resistance of WaveOne and WaveOne Gold Small, Primary, and Large Instruments

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Abstract

Introduction: To compare the cyclic fatigue of resistance of WaveOne (WO; Dentsply Maillefer, Ballaigues, Switzerland) and WaveOne Gold (WOG, Dentsply Maillefer) small, primary, and large instruments in simulated root canals. Each instrument was rotated until fracture occurred. **Methods:** One hundred twenty nickel-titanium endodontic instruments were tested in two different curved artificial canals with different angles and radii of curvatures. WO and WOG small, primary, and large instruments were evaluated (n = 10 for each curvature). Each instrument was rotated until fracture occurred. The time to failure was recorded, and the length of the fractured tip was measured. An independent Student'*t* test was used to compare the means between the 2 groups. One-way analysis of variance and Tukey' post hoc tests were used for multiple comparisons ($P < .05$). **Results:** At all the sizes tested and both curvatures, the cyclic fatigue resistance of the WOG instruments was higher than that of the WO instruments of corresponding sizes ($P < .001$). The WOG instruments were approximately twice as resistant to failure as the WO instruments were at a 60° angle of curvature, whereas the WOG instruments were 3 times more resistant at a 90° angle of curvature. The length of the fractured part of the instruments was similar among all the groups ($P > .05$). **Conclusions:** Within the limitations of this study, WOG instruments were more resistant to cyclic fatigue than WO instruments. *(J Endod 2017;■:1–5)*

Key Words

endodontics, M-Wire, reciprocating instruments, WaveOne Gold

Significance

To avoid the unfavorable results caused by instrument fractures, clinicians should know the cyclic fatigue resistance of new concepts and designs in NiTi alloys such as WaveOne Gold.

For the past 2 decades, nickel-titanium (NiTi) rotary instruments have been commonly used to shape root canals because of their high flexibility and cutting efficiency (1, 2). However, in root canal treatment, NiTi rotary files can have unfavorable results because of instrument fracture, especially when the root canal is curved or narrow (3, 4). File separation can occur as a result of cyclic fatigue or torsional fracture (5). Cyclic fatigue occurs because of tension-compression stress cycles at the point of maximum flexure, especially when preparing canals exhibiting curvature, finally leading to fracture (6–8). Torsional fracture occurs when part of the instrument is locked to the dentin while the shank maintains to rotate (7). Cyclic fatigue is a major cause of the separation of NiTi rotary instruments during clinical use (9). In general, the cyclic fatigue resistance of NiTi rotary files has been tested using static models because they provide standardized conditions for each tested instrument (10). New concepts and designs in NiTi alloys, including thermomechanical improvements, have improved the cyclic fatigue resistance of NiTi-based instruments (5, 11).

Single-file reciprocation concepts have gained popularity since the introduction of Reciproc (VDW, Munich, Germany) and WaveOne (WO; Dentsply Maillefer, Ballaigues, Switzerland) reciprocating instruments to the market in 2011. Both instruments are manufactured from heat-treated NiTi M-Wire technology. WO is a single-instrument system that uses 2 different working patterns, a counterclockwise motion (cutting direction) and a clockwise motion (release of the instrument), to prepare root canals. When engaging with dentin and advancing in the canal, the instrument uses a large angle of rotation in the cutting direction (counterclockwise). In contrast, in the opposite direction (clockwise), it uses a smaller angle of rotation for safe progression through the canal and to reduce the risk of fractures and so-called "screw-in" tendency (12). Recently, WaveOne Gold (WOG, Dentsply Maillefer) systems have been introduced that use the same reciprocating motion as WO. WOG files have a modified cross section, size, and geometry compared with those of WO files. WO files have a convex triangular cross-sectional design (13). In contrast, WOG files have an off-center, parallelogram design, which provides an 85° active cutting edge, with alternate 1-point contact. WO and WOG files have modified tapers. WOG files are also smaller than those of WO files. WOG files are made using advanced metallurgy, and they are manufactured using heat treatment technology (14, 15). Their unique gold color comes from a thermal cycling procedure (heated and cooled slowly many times). The manufacturer claims that the gold technology design improves the flexibility of the file.

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In the literature, numerous studies have evaluated the cyclic fatigue resistance of WO instruments (1, 16). However, there is limited information in the literature on the cyclic fatigue resistance of WOG instruments (14, 15). The aim of the present study was to compare the cyclic fatigue resistance of WO and WOG (small, primary, and large) files used in reciprocating motions. The null hypothesis was that there would be no difference in the cyclic fatigue resistance of the various groups.

Materials and Methods

One hundred twenty instruments were tested in this study. The WO and WOG files were evaluated in 2 curved artificial canals, with different angles and radii of curvatures. WO instrument systems with small (21/.06), primary (25/.08), and large (40/.08) files and WOG instrument systems with small (20/.07), primary (25/.07), and large (45/.05) files were selected for the cyclic fatigue resistance test (n = 10 in each test). Each instrument was inspected under a dental operating microscope to detect defects or deformities before the experiment. Whole defective instruments were discarded and changed with new ones.

Two simulated canals, one with a radius of 5 mm and a 90° angle of curvature and one with a radius of 3mm and a 60° angle of curvature, were prepared in a metal block as described previously by Larsen et al (10). The working length was adjusted to 19 mm. Synthetic oil (WD-40 Company, Milton Keynes, UK) was used for lubrication, and the stainless steel block was covered with a glass plate to prevent the instruments from slipping out and to observe the files during the experimental procedure. The instruments were allowed to rotate according to the manufacturers' instructions. The instruments were run using the motor (Silver Reciproc; VDW) in the "WAVEONE ALL" mode. For all instruments, the time until occurrence of fracture was recorded in seconds. The length of the fractured tip of the instruments was also recorded using a digital caliper (Digimatic; Mitutoyo Co, Kawasaki, Japan) (Fig. 1).

Statistical Analysis

The collected data were analyzed with SPSS version 18.0 (SPSS Inc, Chicago, IL). The normal distribution of the variables was tested using the Kolmogorov-Smirnov test. An independent Student't test was used to compare the means between the 2 groups. One-way analysis of variance and Tukey' post hoc tests were used for multiple comparisons. Data are given as the mean ± standard deviation. A P value less than .05 was considered statistically significant (Fig. 2).

Results

The results for the time to failure and length of the fractured part for each group are presented in Tables 1 and 2. There were statistically significant differences among the groups ($P < .001$). In both artificial canals, the WOG small, primary, and large files resulted in significantly higher cyclic fatigue resistance when compared with that of the corresponding WO small, primary, and large files ($P < .001$). The WOG small files and WOG primary files had the highest time to failure in the simulated canal with a 3-mm radius and a 60° angle of curvature. The WO

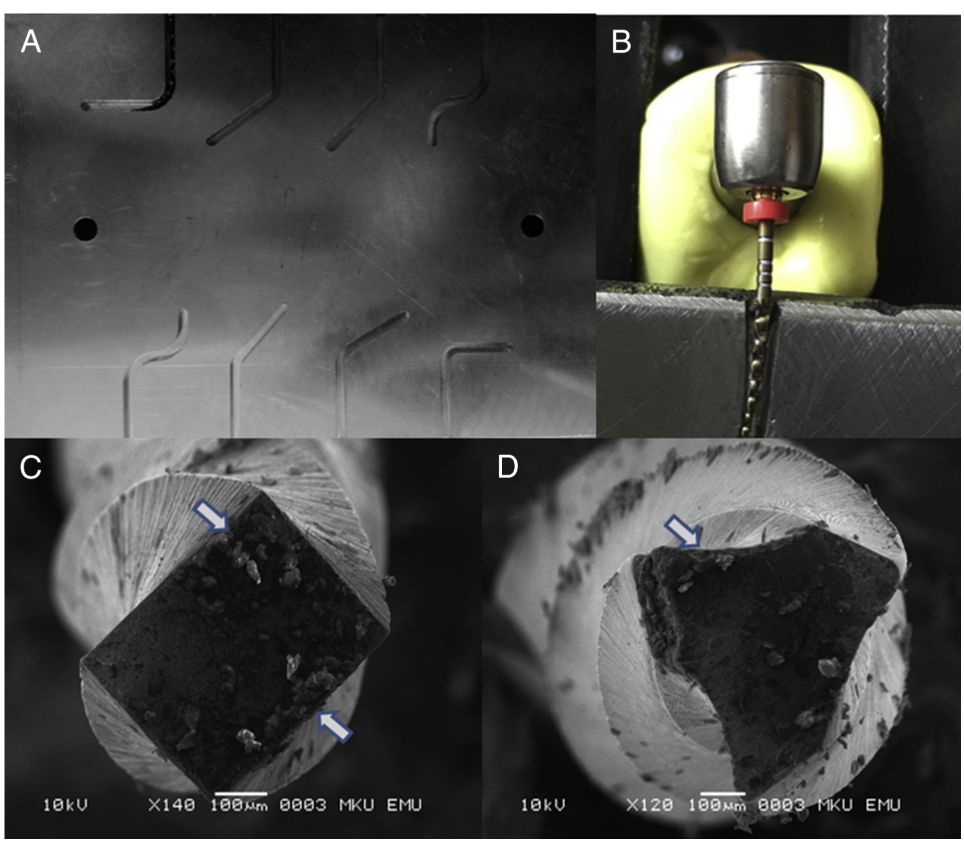

Figure 1. (*A*) A photographic image of the canal metal block. (*B*) A photographic image of the cycling testing device used for the fatigue test. (*C*) A representative scanning electron microscopic image of fractured WOG instruments. The *arrows* indicate the crack origin. The presence of fatigue striations and the absence of circular abrasion show the flexural fatigue failure (140×, original magnification). (*D*) A representative scanning electron microscopic image of fractured WaveOne instruments. The *arrows* indicate the crack origin. The presence of fatigue striations and the absence of circular abrasion show the flexural fatigue failure (120×, original magnification).