Cyclic Fatigue Resistance of RaCe and Mtwo Rotary Files in Continuous Rotation and Reciprocating Motion

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Abstract

Introduction: The purpose of this study was to evaluate and compare the cyclic fatigue resistance of RaCe (FKG Dentaire, La Chaux-de-Fonds, Switzerland) and Mtwo (VDW, Munich, Germany) rotary files in continuous rotation and reciprocating motion. **Methods:** A total of 60 new rotary Mtwo and RaCe files (ISO size = 25, taper = 0.06, length = 25 mm) were selected and randomly divided into 4 groups (n = 15 each): Mt_c (Mtwo NiTi files in continuous rotation), R_c (RaCe NiTi files in continuous rotation), Mt_r (Mtwo NiTi files in reciprocating motion), and R_r (RaCe NiTi files in reciprocating motion). A cyclic fatigue testing device was fabricated with a 60° angle of curvature and a 5-mm radius. All instruments were rotated or reciprocated until fracture occurred. The time taken for each instrument to fracture and the length of the broken fragments were recorded. All the fractured files were analyzed under a scanning electron microscope to detect the mode of fracture. The Kolmogorov-Smirnov test was used to assess the normality of samples distribution, and statistical analysis was performed using the independent sample t test. **Results:** The time taken for the instruments of the Mt_r and R_r groups to fail under cyclic loading was significantly longer compared with the Mt_c and R_c groups ($P < .001$). Scanning electron microscopic observations showed that the instruments of all groups had undergone a ductile mode of fracture. The length of the fractured segments was between 5 and 6 mm, which was not statistically significant among the experimental groups. **Conclusions:** Mtwo and RaCe rotary instruments showed a significantly higher cyclic fatigue resistance in reciprocating motion compared with continuous rotation motion. *(J Endod 2014;40:995–999)*

Key Words

Cyclic fatigue, nickel-titanium files, reciprocation, rotation

Nickel-titanium files (NiTi) are commonly used in current endodontic practice. NiTi files offer many advantages over stainless steel files such as flexibility and elasticity (1, 2). Despite these advantages, NiTi instruments appear to have a high risk of separation (3). One of the reasons for the fracture of NiTi instruments is torsional or cyclic fatigue (4, 5). Torsional fatigue occurs when the tip of the instrument binds in the canal while the shank continues to rotate (3, 5). Cyclic fatigue occurs when the instrument continues to rotate freely in a curvature, and at the point of maximum flexure, tension/compression cycles are generated until fracture occurs (5). Increasing the resistance to file separation has been the main goal for ensuring safety during endodontic instrumentation.

Conventional NiTi rotary endodontic files are manufactured by machining starting wire blanks that are in the superelastic austenitic phase (6). Under stress, it changes to the martensitic phase. One of the unique properties of the martensitic phase is that it has excellent resistance to fatigue (7). The stress-induced transformation to the martensitic phase is reversible (8). The temperature at which the martensitic phase gets transformed to the austenitic phase is called the austenitic finish temperature. The higher the austenitic finish temperature, the longer the file remains in the martensitic phase. This phase transformational behavior and microstructure of NiTi can be optimized using thermomechanical processing. This ultimately increases the mechanical and fatigue properties of the file (9). Another method of improving cyclic fatigue resistance is by electropolishing the files. This surface treatment improves the surface smoothness, thereby delaying the initiation of surface cracks (10).

An alternative method of increasing cyclic fatigue resistance is the use of rotary NiTi instruments in reciprocating motion (11). Two reciprocating systems are currently available: Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland). Reciprocating NiTi files have a better cyclic fatigue resistance when compared with that of continuous rotary NiTi files (12). Studies have been conducted to evaluate the use of various rotary NiTi files including Mtwo (VDW), K3, ProTaper (Dentsply Maillefer, Ballaigues, Switzerland), and Twisted Files (Sybron Endo, Orange, CA) in reciprocating motion, and it has been proved that these files possess better cyclic fatigue resistance (12–14). Mtwo files, which have a cross-section similar to that of Reciproc files (15), have improved cyclic fatigue resistance in both continuous and reciprocating motion (12). RaCe files (FKG Dentaire, La Chaux-de-Fonds, Switzerland) have a triangular cross-section with distinct positive cutting angles (16). RaCe files have improved cyclic fatigue resistance in continuous rotation when compared with that of ProTaper and Helix rotary files (17). However, to date, the effect of reciprocating motion on RaCe files has not been studied. The null hypothesis is that there is no difference in the cyclic fatigue resistance of RaCe and Mtwo rotary files using continuous rotation and reciprocating motion.

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Materials and Methods

A total of 30 new rotary Mtwo (VDW, Munich, Germany) and 30 RaCe instruments (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) (ISO tip size = 25, taper = 0.06, length = 25 mm) were selected. All the instruments were previously inspected under an optical stereo microscope (Zoom Stereo Binocular Microscope [ZSM-111], Hicksville, NY); with 20× magnification for any visible signs of deformation. None of the instruments were discarded. All the files were then subjected to cyclic fatigue testing.

Cyclic Fatigue Testing Device

A static cyclic fatigue testing device was custom fabricated for this study (Fig. 1*A* and *B*). It consisted of a main metal frame made of iron to which an artificial canal system and a support for the handpiece were being attached. The canal system, which simulated a root canal, consisted of 2 adjustable metal frames made of brass that can accommodate any instrument to its exact size and taper. It was constructed with a 60° angle of curvature. The curvature started at 5 mm from the tip of the canal. The WaveOne handpiece was mounted over the support, which also ensured the correct positioning and placement of files to the same appropriate depth for all the samples.

Cyclic Fatigue Test

Sixty samples were randomly divided into 4 groups (n = 15) according to the type of rotary files and rotary motions used.

Group Mt_c

Fifteen Mtwo instruments were allowed to rotate in continuous rotation (CW) motion using a WaveOne motor set at continuous rotation mode with recommended torque control settings and at a constant speed of 300 rpm.

Group Mt_r

Fifteen Mtwo instruments were allowed to rotate in reciprocating motion (counterclockwise [CCW] = 170 and CW = 50) using a WaveOne motor set on the WaveAll mode with recommended torque control settings and at a constant speed of 350 rpm (11).

Group R_c

Fifteen RaCe instruments were allowed to rotate in continuous rotation motion using a WaveOne motor set on the continuous rotation mode with recommended torque control settings and at a constant speed of 600 rpm.

Group R_r

Fifteen RaCe instruments were allowed to rotate in reciprocating motion (CCW = 170 and CW = 50) using a WaveOne motor set on the WaveAll mode with recommended torque control settings and at a constant speed of 350 rpm (11). Glycerin (Glycerin Pure; AB Enterprises, Mumbai, India) was used as a lubricant after the use of each file during instrumentation in this study. Instruments were rotated or reciprocated until fracture occurred. To obviate human errors, cyclic fatigue

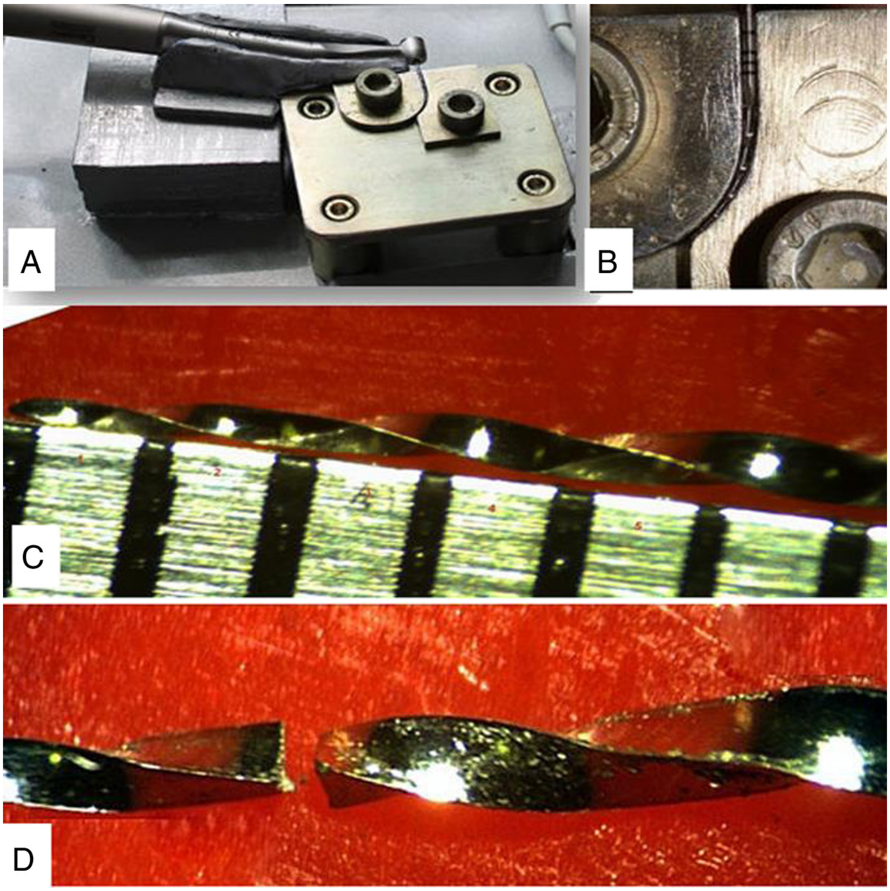

Figure 1. (*A* and *B*) The custom fabricated static cyclic fatigue testing device. (*C*) Stereomicroscopic image of a new RaCe file. (*D*) Stereomicroscopic image of a fractured RaCe file depicting the fracture at the D5–D6 regions.