Shaping Ability of the Conventional Nickel-Titanium and Reciprocating Nickel-Titanium File Systems: A Comparative Study Using Micro–Computed Tomography

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Abstract

Introduction: This study used micro–computed tomographic imaging to compare the shaping ability of Mtwo (VDW, Munich, Germany), a conventional nickel-titanium file system, and Reciproc (VDW), a reciprocating file system morphologically similar to Mtwo. **Methods:** Root canal shaping was performed on the mesiobuccal and distobuccal canals of extracted maxillary molars. In the RR group (n = 15), Reciproc was used in a reciprocating motion (150° counterclockwise/30° clockwise, 300 rpm); in the MR group, Mtwo was used in a reciprocating motion (150° clockwise/30° counterclockwise, 300 rpm); and in the MC group, Mtwo was used in a continuous rotating motion (300 rpm). Micro–computed tomographic images taken before and after canal shaping were used to analyze canal volume change and the degree of transportation at the cervical, middle, and apical levels. The time required for canal shaping was recorded. Afterward, each file was analyzed using scanning electron microscopy. **Results:** No statistically significant differences were found among the 3 groups in the time for canal shaping or canal volume change ($P > .05$). Transportation values of the RR and MR groups were not significantly different at any level. However, the transportation value of the MC group was significantly higher than both the RR and MR groups at the cervical and apical levels ($P < .05$). In the scanning electron microscopic analysis, file deformation was observed for 1 file in group RR (1/15), 3 files in group MR (3/15), and 5 files in group MC (5/15). **Conclusions:** In terms of shaping ability, Mtwo used in a reciprocating motion was not significantly different from the Reciproc system. *(J Endod 2014;40:1186–1189)*

Key Words

Micro–computed tomographic imaging, reciprocating motion, root canal transportation

For successful endodontic treatment, accurate canal shaping is essential (1). Procedural errors such as transportation can lead to inappropriate dentin removal or straightening of curved canals. Transportation above a certain level hinders complete sealing during the canal filling process (2, 3). Nickel-titanium (NiTi) instruments have excellent flexibility compared with stainless steel files (4). This allows for easy maintenance of the original canal shape and for quick preparation of the canal by the clinician with fewer errors (5). However, NiTi files are still at risk of fracture through flexural fatigue and torsional stresses (6).

A recently introduced canal shaping method using a reciprocating motion has been reported to significantly improve the cyclic fatigue life of the instrument compared with conventional continuous rotation (7–10). The use of new file systems designed for only reciprocating movements using a specific motor is on the rise. Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) are examples of such systems currently available on the market.

Reciproc is similar to Mtwo (VDW), which is a previously introduced NiTi file system made by the same manufacturer. Comparing the cross-sectional views of these 2 files, they form mirror images because of their identical symmetrical shapes but opposite helical directions. The reciprocating motion, which is installed in the motor specific for Reciproc, comprises counterclockwise (cutting direction) and clockwise motions (release of the instrument). The instrument proceeds toward the apex because the counterclockwise rotation angle is larger than the clockwise angle. According to a previous study, counterclockwise and clockwise rotation angles were revealed by the manufacturer to be 150° and 30°, respectively (11).

Several studies have reported satisfactory results using ProTaper F2 (Dentsply Maillefer, Ballaigues, Switzerland) in a reciprocating motion when cyclic fatigue resistance and shaping ability were measured (8, 11–13). Based on these results, it may be possible for canal shaping using a conventional rotary NiTi file system in a reciprocating motion to be applied clinically.

What is particularly interesting about ProTaper F2 is that, although it is not specifically designed for reciprocating motion, it could shape the canal to full length. ProTaper F2 cannot shape the canal to full length when it is used in a conventional continuous rotating motion. However, few studies have applied a reciprocating motion to conventional rotary NiTi files like ProTaper F2.

The aim of this study was to analyze and compare the root canal shaping ability of Reciproc, a reciprocating file system, and Mtwo, a conventional NiTi file system that is morphologically similar to Reciproc, using micro–computed tomographic (micro-CT)

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imaging. In addition, file deformation after canal shaping was examined by scanning electron microscopy.

Materials and Methods

Tooth Selection

Procedures for this study were approved by the Seoul National University Dental Hospital Institutional Review Board (CRI13009). Mesiobuccal and distobuccal canals of extracted maxillary molars with complete apices were selected for this study. Intact teeth without dental caries or fractures were collected and stored in 0.1% thymol solution. The teeth used in this study were extracted because of reasons irrelevant to this investigation such as periodontitis or pericoronitis. Soft tissue was removed using periodontal curettes. After the teeth were cleaned, radiographs were taken. Canal curvatures were measured according to the Schneider technique, and teeth belonging to the 20°–45° range were included in the experiment. Using #4 round and Endo Z burs (Dentsply Maillefer), access openings were created and straight-line access was achieved for each tooth. The working length was determined by inserting a #08 K-file until (Dentsply Maillefer) its tip could be seen through the apical foramen, after which 1 mm was deducted. The glide path was formed using #15 K-files.

Canal Preparation

The mesiobuccal and distobuccal canals of the selected maxillary molars were randomly divided into 3 groups of 15 canals each (RR group: Reciproc used in a reciprocating motion, MR group: Mtwo used in a reciprocating motion, and MC group: Mtwo used in a continuous motion). The curvature, volume, and surface area of the canals in each group were measured to evaluate differences between the 3 groups.

RR Group (n = 15). Using Reciproc, R25, canal shaping was performed with a reciprocating motion at 300 rpm to the working length. The rotation angle was set at 150° counterclockwise and 30° clockwise.

MR Group (n = 15). Using an Mtwo #25.07 file, canal shaping was performed with a reciprocating motion in a 150° clockwise and 30° counterclockwise direction at 300 rpm to the working length.

MC Group (n = 15). Using an Mtwo #25.07 file, canal shaping was performed with a 2.0 Ncm continuous rotating motion at 300 rpm to the working length. For each canal, only 1 new instrument was used, and transformation or defect of the instrument was checked beforehand. Canal shaping was performed using an electric motor (I-Endo dual; Acteon, Merignac, France) by 1 experienced clinician. The instrument was used in slow in-and-out pecking motions, and the amplitude of the in-and-out movements was set to be lower than 3 mm. After each pecking motion, debris was removed from the flute, and canal irrigation was performed. All canal shaping was performed using RC-prep (Premier Dental Product, Norristown, PA) as a lubricating agent. Then, 5.25% sodium hypochlorite irrigation was administered using a 30-G side-vented irrigating tip. The procedure time for each shaping was recorded. Only the time required for canal shaping using an instrument was included, and the times for exchanging the instrument, cleaning the canal, and removing debris from the instrument were excluded.

Micro-CT Analysis

Teeth were fixed using customized jigs to prevent a change in location, and micro-CT images were obtained before and after canal shaping. The Micro CT system (Skyscan 1172; Skyscan b.v.b.a., Aartselaar, Belgium) was used at settings of 100 kV, 100 Ma, and 16 μm with isotropic resolution.

Measurement of the Root Canal Volume. Using CTAn v 1.12 (Bruker micro-CT, Kontich, Belgium), an image analysis software package for micro-CT imaging, the canal volume from the canal orifice to the apical foramen was measured before and after canal shaping, and the change in volume was obtained.

Measurement of Root Canal Transportation. The entire canal from the apical foramen to the canal orifice was divided into coronal, middle, and apical thirds. Cross-sectional images at the middle point of each third were used to assess the degree of transportation according to the following equation suggested by Gambill et al (4): Transportation value = $(X1 - X2) - (Y1 - Y2)$, where X1 is the shortest distance from the outside of the curved root to the periphery of the uninstrumented canal, Y1 is the shortest distance from the inside of the curved root to the periphery of the uninstrumented canal, X2 is the shortest distance from the outside of the curved root to the periphery of the instrumented canal, and Y2 is the shortest distance from the inside of the curved root to the periphery of the instrumented canal.

A value of 0 from this equation indicates that no canal transportation occurred. A positive value indicates that transportation occurred outwardly from the canal, and a negative value indicates that transportation occurred inwardly.

Scanning Electron Microscopic Analysis

The surfaces of each file were observed under a scanning electron microscope (Hitachi S-4700, Tokyo, Japan) at 30× and 300× before and after canal shaping.

Statistical Analysis

Before canal shaping, 1-way analysis of variance was performed to compare root canal curvature, root canal volume, and root canal surface area between the 3 groups. After canal shaping, the preparation time, degree of transportation, and root canal volume change of the 3 groups were analyzed by 1-way analysis of variance. Post hoc analysis was performed by the Tukey post hoc test. The significance level was set at $P < .05$.

Results

Discrepancies in the time required for canal shaping and the volume before and after canal shaping are described in Table 1, and there were no statistical differences between the 2 groups. The transportation

TABLE 1. Preparation Time(s), Change in Root Canal Volume (mm^3), and Transportation Value (mm) of the Canals after Root Canal Preparation

Group	Preparation time (s), mean ± SD	Change in root canal volume (mm^3), mean ± SD	Transportation value (mm) of the cervical third, mean ± SD	Transportation value (mm) of the middle third, mean ± SD	Transportation value (mm) of the apical third, mean ± SD
RR	80.67 ± 0.88	0.79 ± 0.14	−0.11 ± 0.08[a]	−0.10 ± 0.03	0.07 ± 0.03[a]
MR	71.47 ± 4.07	1.37 ± 0.18	−0.07 ± 0.06[a]	−0.04 ± 0.03	0.02 ± 0.03[a]
MC	74.20 ± 4.30	1.13 ± 0.17	−0.35 ± 0.05[b]	−0.08 ± 0.04	0.20 ± 0.04[b]

MC group, Mtwo used in a continuous motion; MR group, Mtwo used in a reciprocating motion; RR group, Reciproc used in a reciprocating motion; SD, standard deviation.

Different subscript letters in the same column indicate a significant difference at $P < .05$.