Comparison of the Resistance of Teeth Instrumented with Different Nickel-Titanium Systems to Vertical Root Fracture: An *In Vitro* Study

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Abstract

Introduction: This study compared the fracture resistance of teeth instrumented with ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland), ProTaper Next (PTN, Dentsply Maillefer), WaveOne (Dentsply Maillefer), Twisted File (SybronEndo, Orange, CA), Mtwo (MT; VDW, München, Germany), and Revo-S (MicroMega, Besançon, France) nickel-titanium systems and obturated with compatible gutta-percha cones of finishing files using the single-cone technique and a resin sealer. **Methods:** The study included 72 mandibular premolar teeth. The roots were covered with additive silicone and placed in Eppendorf tubes, which were filled with a self-curing acrylic. The tubes were separated into 6 groups: prepared with the ProTaper Universal (F4 40/.06) (group 1), prepared with the PTN (X4 40/.06) (group 2), prepared with the WaveOne reciprocating file (40/.08) (group 3), prepared with the Twisted File (40/.04) (group 4), prepared with the MT (40/.06) (group 5), and prepared with the Revo-S (AS 40/.06) (group 6). After the preparations were completed, all the teeth were filled with the appropriate gutta-percha systems. The force (N) was applied at a 1-mm/min crosshead speed until the roots fractured. Differences among the groups were analyzed by Tukey and analysis of variance tests. **Results:** Group 2 was the most resistant to fracture, and group 5 was the least resistant. The difference in the fracture resistance between the 2 groups was statistically significant (P = .019). The resistance of group 3 and group 6 to vertical root fracture was similar, and the resistance of group 4 was slightly lower than that of the other groups (P = .058). **Conclusions:** The roots instrumented with the MT were the least resistant, and the roots instrumented with the PTN were the most resistant to VRF. *(J Endod 2015;41:1682–1685)*

Key Words

Fracture resistance, *in vitro* study, nickel-titanium systems, vertical root fracture

One of the main steps in root canal treatment is mechanical instrumentation to create sufficient space for irrigation agents and intracanal medicaments (1). Microcracks can occur during the mechanical instrumentation of root canal systems, especially at the apical area, as a result of thinned dentinal walls and increased strain (2–5). Bier et al (6) reported that root canal preparation with nickel-titanium (NiTi) systems caused more dentinal damage than hand files. It is inevitable that NiTi systems cause some force at the apex or the area around the apex. These forces may increase the strain on the dentinal walls, resulting in dentinal microcrack formation (3, 7). As the prevalence of microcracks increases, the risk of several fractures, especially vertical root fractures (VRFs) occurrence, may increase in teeth (8). Various predisposing factors, such as the loss or dehydration of dentin and the negative effect of irrigation solutions, may enhance the possibility of VRFs (9–11). Clinically, 10.9%–31% of root canal–treated teeth result in extraction because of VRFs that occur during or after root canal treatment procedures (12, 13). The design of the cutting blades, body taper, and tip configuration of NiTi systems differ from each other. Many studies have confirmed the association between NiTi systems and dentinal microcracks, which may result in VRFs (2, 3), but there is insufficient information in the literature on the resistance of teeth instrumented with NiTi systems to VRFs. There are many kinds of NiTi systems, with different production phases (M-wire, R, austenite, and martensite), alloys, cutting edges, and working motion available in the global market. These systems use specific single-cone gutta-percha cones and finishing files for root canal filling in a single-cone technique. The design features of NiTi systems have been described in detail in previous articles (1, 3, 4, 6, 7, 11). Gutta-percha has been used widely for root canal filling using a lateral compaction technique. However, studies have reported that this technique could increase the risk of VRFs because of potential propagation of microcracks in the apical area (3, 8, 14). Therefore, the aim of the present study was to compare the VRF resistance of teeth instrumented with ProTaper Universal (PTU; Dentsply Maillefer, Ballaigues, Switzerland), ProTaper Next (PTN, Dentsply Maillefer), WaveOne (WO, Dentsply Maillefer), Twisted File (TF; SybronEndo, Orange, CA), Mtwo (MT; VDW, München, Germany), and Revo-S (RS; MicroMega, Besançon, France) NiTi systems and obturated with compatible gutta-percha cones and the respective instruments' finishing files using the single-cone technique.

Materials and Methods

Seventy-two mandibular first premolar teeth orthodontically extracted from patients aged 17–24 years were collected and stored in distilled water for the study.

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A periapical radiograph verified that the teeth had 1 straight canal and a maturated apex. The coronal parts of the teeth were removed using a diamond-coated bur under water cooling, leaving the root 13 mm in length. The samples were examined under a stereomicroscope at ×10 magnification to detect any craze lines or microcracks. The samples with such features were replaced with similar and undamaged roots. The buccolingual and mesiodistal diameters of the roots as well as the weight of the roots were measured. Similar ones were selected for standardization of the samples using a method similar to that of Capar et al (11). The pulp tissue was eliminated using a #25 barbed broach. The roots were covered with a line of aluminum foil. Eppendorf tubes were separated from their stoppers. A hole was made in each stopper, and the roots were placed into the stopper up to the level of the cementoenamel junction. The roots were fixed to the stoppers with cyanoacrylate. They were then placed in Eppendorf tubes filled with self-curing acrylic. After the acrylic had polymerized, the roots were taken out, and the aluminum foil was removed from the roots. The roots were then covered with additional silicone impression material (Hydrorise Light, Zhermack, Italy) and returned to the tubes to create an artificial periodontal ligament (Fig. 1). The tubes were separated into 6 experimental groups:

Group 1: The root canals were prepared with the PTU system, which was used at 300 rpm and 2 Ncm, with a torque-controlled endodontic motor (X-Smart; Dentsply Maillefer). An SX file was used at one half of the working length (WL); S1 and S2 files were used at two thirds of the WL; and F1 (20/.07), F2 (25/.08), F3 (30/.06), and F4 (40/.06) files were used at the full WL. The SX, S1, and S2 files were used with a brushing motion. The other files were used with a gentle in-and-out motion. Irrigation was performed after every file using distilled water and an open-ended needle.

Group 2: The root canals were prepared with the PTN system using a gentle in-and-out motion at 300 rpm and 2-Ncm torque with a torque-controlled endodontic motor. The first SX file was used at one half of the WL, and the X1 (17/.04), X2 (25/.06), X3 (30/.06), and X4 files (40/.06) were used at the full WL.

Group 3: The root canals were prepared with the WO reciprocating file (40/.08) using a gentle in-and-out pecking motion and a WO reciprocating motor. Irrigation was performed after every 3 pecks to prevent plugging of the canal with debris.

Group 4: The root canals were prepared with the TF instruments using a torque-controlled endodontic motor. All the TF instruments were used to the WL according to the manufacturer's instructions using a gentle in-and-out motion. The instrumentation sequence was a size 24, .04 taper; size 25, .06 taper; and size 25, .08 taper. The enlargement of the root canal was completed using a size 30, .06 taper; size 35, .06 taper; and size 40, .04 taper.

Group 5: The root canals were prepared using the MT system with a torque-controlled endodontic motor. The following files were used: 10/.04, 15.05, 20/.06, 25/06, 30/.06, 35/.06, and 40/.06 files. Irrigation was performed between every file.

Group 6: The root canals were prepared with a torque-controlled endodontic motor using the RS NiTi instrument system, which includes three shaping instruments. The coronal two thirds of the root canal were shaped and cleaned with a number 1 instrument (SC1). An SC2 instrument and a universal shaper were used at the WL. AS30 (size 30, 0.06 taper), AS35 (size 35, 0.06 taper), and AS40 (size 40, 0.06 taper) were also used at the WL to provide apical enlargement to a size 40.

Twelve roots served as the control. The root canals were not shaped or filled in the control group.

After the preparations were completed, all the roots were filled with their respective gutta-percha systems using the single-cone technique and AH-26 (Dentsply DeTrey, Konstanz, Germany) as a canal sealer. The single cone was cut at the same level with the cementoenamel junction by using a gutta-percha cutter. The canals were then sealed with a temporary filling material, and the roots were kept in an environment of 100% moisture for 2 weeks. The roots were tested with a universal testing machine, and a force was applied with a 1-mm/min crosshead speed until the roots fractured (Fig. 2). The load necessary to fracture was recorded in newtons.

Statistical Analyses

Descriptive and comparative statistics were performed using IBM SPSS v21 (SPSS, Inc, Chicago, IL). Differences among the groups were analyzed by Tukey and analysis of variance tests. A P value <.05 was considered statistically significant for all tests. Variables were expressed as means ± standard deviation.

Results

The mean ± standard deviation and minimum and maximum values are shown in Table 1. In the experimental groups, group 2 was the most resistant to fracture, and group 5 was the least resistant.

Figure 1. A specimen prepared with the additive silicone to mimic the periodontal ligament.

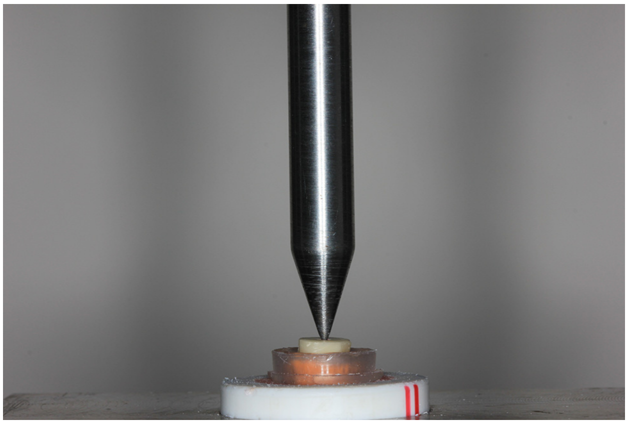

Figure 2. A specimen prepared with the additive silicone mounted on the Instron machine to test the fracture strength.