Assessment of Dentinal Damage during Canal Preparation Using Reciprocating and Rotary Files

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Abstract

Introduction: The role of motion kinematics in creating dentinal damage during instrumentation is not very clear. The purpose of this study was to compare the formation of dentinal cracks with instruments working in continuous rotation and reciprocating motion. **Methods:** One hundred twenty extracted human mandibular premolars were selected for the study. Thirty teeth served as controls, and the remaining 90 teeth were divided into 3 groups depending on the root canal preparation technique. Group 1 samples were treated with WaveOne primary files (Dentsply Maillefer, Ballaigues, Switzerland), group 2 samples with single F2 ProTaper (Dentsply Maillefer) working in reciprocating motion, and group 3 samples were prepared with sequential ProTaper (Dentsply Maillefer) until F2 working in continuous rotation motion. Roots were then sectioned at 3, 6, and 9 mm from the apex, and the cut surface was observed under a stereomicroscope for the presence of dentinal microcracks. **Results:** The control group and WaveOne, single F2 ProTaper in reciprocating motion, and continuous ProTaper groups caused cracks in 0%, 15%, 26%, and 53% of samples, respectively. A statistically significant difference was found between 2 reciprocating file groups (WaveOne and single F2 ProTaper in reciprocating motion) and the continuous rotation group (ProTaper) ($P < .05$). However, no significant difference was found among the 2 reciprocating file groups ($P > .05$). **Conclusions:** Dentinal cracks are produced irrespective of motion kinematics. Within the limits of this study and the current literature, such incidence is less with instruments working in reciprocating motion compared with those working in continuous rotation. *(J Endod 2014;40:1443–1446)*

Key Words

Dentinal defects, microcracks, nickel-titanium instruments, reciprocation, root canal preparations, root fracture

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Vertical root fracture (VRF) in endodontically treated teeth is one of the most frustrating complications of root canal therapy, which results in tooth or root extraction (1). Because its effects are catastrophic, identifying the etiologic factors of VRF in an endeavor to improve its prevention becomes important (2).

During biomechanical preparation, a canal is shaped by the contact between instruments and dentin walls. These contacts create many momentary stress concentrations in dentin. Such stress concentrations may induce dentinal defects and microcracks or craze lines (3, 4). These, in turn, were associated with increased VRF susceptibility because applied stresses caused by root canal obturation, retreatment, and repeated occlusal forces can be exponentially amplified at the tip of those defects and can initiate or propagate into cracks (4–6).

In the last decade, advances in nickel-titanium (NiTi) instruments have added a new dimension to root canal treatment. Recently, single-file systems in rotary and reciprocating motion were introduced (7, 8). Various file systems differing in their design features such as the NiTi core diameter, cross-sectional shape, rake angle, and flute depth may affect the behavior of the file and, therefore, may influence the generation of cracks (9, 10). ProTaper rotary files (Dentsply Maillefer, Ballaigues, Switzerland) are popular instruments that are characterized by an increasing taper design, convex triangular cross-section throughout their active portion, and a negative rake angle (11). Their design facilitates active cutting motion and removes relatively more dentin coronally compared with other systems (12). ProTaper rotary files were reported to create more dentin damage than other rotary instruments (7, 12, 13).

In 2008, a novel canal preparation technique with only the F2 ProTaper instrument used in a clockwise (CW) and counterclockwise (CCW) movement was described (14). The concept of using a single NiTi instrument to prepare the entire root canal is interesting because the learning curve is considerably reduced as a result of technique simplification. Moreover, the use of a single NiTi instrument is more cost-effective than the conventional multifile NiTi rotary systems. Added benefits include reduced cross-contamination and reduced instrument fatigue.

The WaveOne (Dentsply Maillefer) NiTi single-file system is relatively new and is designed to be used with a dedicated reciprocating motion motor (15). It consists of 3 single-use files: small (ISO 21 tip and 6% taper) for fine canals, primary (ISO 25 tip and 8% taper) for the majority of canals, and large (ISO 40 and 8% taper) for large canals. These instruments are manufactured with M-Wire (Dentsply Tulsa Dental Specialties, Tulsa, OK) NiTi alloy and are thus more flexible and resistant to cyclic fatigue.

Research on the different subjects related to a new treatment method is undoubtedly required. Single-file endodontics and reciprocating motion are the 2 major modifications in modern endodontics, but their bearing on the root canal wall is not fully elucidated. Thus, the purpose of this investigation was to know and compare the ability of the WaveOne Primary file, a single F2 ProTaper file in reciprocating motion, and the rotary ProTaper full-sequence system to induce dentinal damage.

Materials and Methods

Extracted human mandibular premolars with straight roots were selected for this study. Teeth with open apices or anatomic irregularities were excluded. All selected teeth were decoronated perpendicular to the long axis of the tooth by using a diamond-coated bur with water cooling, leaving roots approximately 12 mm in length to ensure straight-line access and provide a reference plane. All roots were observed in a stereomicroscope under 12× magnification (Stemi SV6; Zeiss, Jena, Germany) to exclude any external defects or cracks and were discarded if any of these characteristics were found. Mesiodistal and buccolingual radiographs were taken to verify the presence of a single canal. The width of the canal on both angles was measured at 7 mm from the apex. One hundred twenty roots with comparable canal widths were finally selected and stored in purified filtered water throughout the study (12). All roots were embedded in autopolymerizing acrylic resin, and periodontal ligament simulation was performed using hydrophilic vinyl polysiloxane impression material as described previously (7).

Tooth Preparation

Thirty teeth were left unprepared and served as the control group. The remaining 90 teeth were randomly divided into 3 experimental groups of 30 teeth each. Canal patency was established with a size 10 K-file (Dentsply Maillefer). All teeth in which canal patency could not be established were excluded from the study and replaced by similar teeth. Thereafter, root canal preparation was performed according to the relevant group (1–3) as described later.

Root Canal Preparation

Group 1. Thirty teeth were prepared with the ProTaper rotary system. Canals were prepared in a crown-down fashion with the aid of an X-SMART electric motor with torque control (Dentsply Maillefer) at 300 rpm. The ProTaper Shaping SX, S1, and S2 and finishing F1 and F2 files were sequentially used with a continuous in-and-out movement until the working length was reached. Torque and other parameters for each file were set as per the manufacturer's recommendation.

Group 2. The entire canal preparation was completed with a ProTaper F2 file used in a reciprocating motion. The reciprocating movement is a CW and CCW movement. The ATR Tecnika endomotor (Dentsply Tulsa Dental, Oklahoma City, OK) allows programming for reciprocating movement at four-tenths of a circle CW and two-tenths of a circle CCW. The F2 file was driven at 400 rpm with a 16:1 reduction ratio contra-angle handpiece. During preparation, the instrument was used with slow pecking motions and light apical pressure. If some resistance was felt that would have required more apical pressure, the instrument was removed, and the flutes were cleaned. This was repeated until the working length was reached.

Group 3. A primary reciprocating WaveOne file with a tip size of 25 and a taper of 0.08 was used in a reciprocating, slow in-and-out pecking motion until reaching the full working length according to the manufacturer's instructions. The dedicated reciprocating motor (Dentsply Maillefer) of the WaveOne file was used with the manufacturer's configuration setup.

In all experimental and control groups, each canal was irrigated with a freshly prepared 1% solution of sodium hypochlorite between each instrument during the preparation procedure using a syringe and a 27-G needle. Around 15 mm sodium hypochlorite solution was used for each root. After completion of the procedure, canals were rinsed with 2 mL distilled water. All roots were kept moist in distilled water throughout the experimental procedures. A single experienced operator performed all the procedures. In each of these 3 test groups, 1 set of instruments was used for the preparation of 4 root canals.

Sectioning and Microscopic Observations

All roots were cut horizontally at 3, 6, and 9 mm from the apex with a low-speed saw under water cooling (Leica SP1600; Leica Microsystems, Wetzlar, Germany). Slices were then viewed through a stereomicroscope, and digital images of each section were captured at 12× magnification using a digital camera attached to a stereomicroscope. Each specimen was checked by 2 operators for the presence of dentinal defects or no defects. Whenever there was a different score, a consensus had been reached. "No defect" was defined as root dentin devoid of any craze lines or microcracks either at the external surface of the root or at the internal surface of the root canal wall (1). "Defect" was defined if any lines were observed on the section that extended either from the outer root surface into the dentin or from the root canal lumen to the dentin. This also included teeth with a complete crack, which was defined as a line extending from the inner root canal space all the way to the outer surface of the root.

Statistical Analysis

Results were expressed as the number and percentage of defected roots in each group. A chi-square test was performed to compare the appearance of defected roots between the experimental groups by using the SPSS/PC version 15 (SPSS Inc, Chicago, IL). The level of significance was set at 0.05.

Results

No complete fracture was observed in any of the samples tested. Figure 1 shows the percentage of roots with defects. Unprepared canals (ie, the control group) showed no roots with defects. There was a statistically significant difference between NiTi file groups and the control group, which presented no defects ($P < .05$). Among the NiTi file groups, the least number of craze lines and partial cracks ("other defects") were observed in the WaveOne group, whereas the maximum number of such defects was observed in the rotary ProTaper group. No significant differences were noted between the WaveOne and single-file F2 ProTaper technique, whereas both were significantly different from the rotary ProTaper full-sequence technique.

Discussion

VRF of endodontically treated teeth is perhaps the most undesirable/frustrating clinical experience (2). Root canal–treated teeth present with greater probability of VRF (2, 16). Predisposing factors include the loss of healthy tooth substance as a result of caries or trauma, moisture loss in pulpless teeth, previous cracks in dentin, or loss of alveolar bone support (2). Moreover, previous studies have reported an insignificant difference in the moisture content and mechanical properties of vital and endodontically treated teeth (17, 18). Mostly, VRF is a result of the gradual

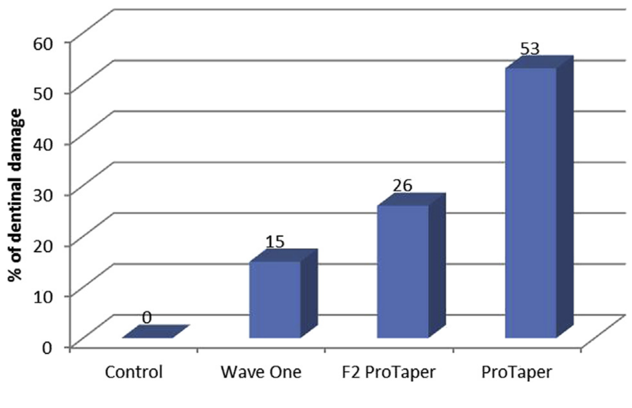

Figure 1. The total percentage of cracked teeth with their instrumentation technique.