Comparison of 2 Canal Preparation Techniques in the Induction of Microcracks: A Pilot Study with Cadaver Mandibles

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Abstract

Introduction: The purpose of this pilot study in a cadaver model was to compare 2 different shaping techniques regarding the induction of dentinal microcracks. **Methods:** Three lower incisors from each of 6 adult human cadaver skulls were randomly distributed into 3 groups: the control group (CG, no instrumentation), the GT group (GT Profile hand files; Dentsply Tulsa Dental, Tulsa, OK), and the WO group (WaveOne; Dentsply Tulsa Dental). In the GT group, manual shaping in a crown-down sequence with GT Profile hand files was performed. In the WO group, Primary WaveOne files were used to the working length. Teeth were separated from the mandibles by careful removal of soft tissue and bone under magnification. Roots were sectioned horizontally at 3, 6, and 9 mm from the apex using a low-speed saw. Color photographs at 2 magnifications (25× and 40×) were obtained. Three blinded examiners registered the presence of microcracks (yes/no), extension (incomplete/complete), direction (buccolingual/mesiodistal), and location. Data were analyzed with chi-square tests at $P < .05$. **Results:** Microcracks were found in 50% (CG and GT) and 66% (WO) of teeth at 3 mm, 16.6% (CG) and 33.3% (GT and WO) at 6 mm, and 16.6% in all 3 groups at 9 mm from the apex. There were no significant differences in the incidence of microcracks between all groups at 3 ($P = .8$), 6 ($P = .8$), or 9 mm ($P = 1$). All microcracks were incomplete, started at the pulpal wall, and had a buccolingual direction. **Conclusions:** Within the limitations of this pilot study, a relationship between the shaping techniques (GT hand and WaveOne) and the incidence of microcracks could not be shown compared with uninstrumented controls. *(J Endod 2014;40:982–985)*

Key Words

Cadaver mandible, GT hand, microcracks, WaveOne

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A frequent reason for tooth loss after root canal treatment is vertical root fracture (VRF) (1, 2). VRFs have been described in nonendodontically treated as well as in teeth after root canal preparation (3, 4). However, there seems to be disagreement about the causes of root fracture. Historically, pulpless teeth were considered to be more brittle (5), whereas more recent studies reported no significant differences in moisture content (6), strength and stiffness of dentin (7, 8), nanomechanical changes to radicular intertubular dentin (9), or brittleness of endodontically treated teeth (10).

There is an increasing awareness among clinicians and patients about VRF that calls for the identification of the factors responsible for fractures of endodontically treated teeth in order to maximize tooth survival time (11). Some studies have suggested that factors directly related to cleaning (12), shaping (13), and filling (14) procedures, per se, could debilitate root canal–treated teeth.

The instrumentation of root canals alone significantly reduced the resistance of teeth to fracture in *in vitro* studies (13, 15). Moreover, different preparation techniques and file designs have been identified as being responsible for different degrees of dentinal damage and the induction of microcracks (16–20). More recent data suggested a relationship between the presence of dentinal defects and different shaping motions. Although hand instrumentation techniques produced significantly less dentinal defects (20, 21), reciprocating files that operate under the concept of single-file preparation were shown to create significantly more incomplete dentinal cracks than full-sequence rotary systems (22).

It could be speculated that the use of a single instrument, rather than a series of files, to perform the entire canal preparation will generate more stress (22). However, these experiments used extracted teeth (15, 17–20, 22, 23) that lacked bone and periodontal ligament (PDL) support around the teeth, thus possibly altering the generated forces (24).

In some studies, extracted teeth were mounted in resin blocks with simulated PDL in order to mimic bony sockets that in turn may influence the forces applied during endodontic procedures (18, 19, 21, 25). However, no artificial material was found to completely reproduce viscoelastic properties of the PDL, whereas the PDL acts to absorb much of the forces introduced into teeth clinically (24).

A major shortcoming of studies in extracted teeth is that specimens can be subjected to undue forces during the extraction procedure and may display microfractures before being used as samples in crack studies. In addition, time since extraction and the lack of knowledge of the previous circumstances of the patient's dentition such as occlusal dysfunctions or trauma could also influence the results (23). Therefore, the aim of this study was to compare the ability of 2 different shaping techniques in the induction of dentinal microcracks in an *in situ* cadaver model.

Materials and Methods

Six adult human cadaver skulls with at least 3 lower incisors were obtained; the final sample number in each of the 3 groups was $n = 6$. The time of demise was less than 9 months previous to the completion of the study. The mean age of the tissue donors was 82.8 (±14.6) years. Two digital radiographs with different angulations were taken for each anterior hemimandible in order to assess the similar anatomy, diameter, and length of the 3 incisors in the same mandible.

The 3 lower incisors in each mandible were randomly distributed to 1 of the 3 following groups: the control group (CG, no root canal preparation), the GT group (manual shaping with Profile GT hand files; Dentsply Tulsa Dental, Tulsa, OK), and the WO group (WaveOne, Dentsply Tulsa Dental). All teeth in the GT and WO groups were accessed with a round carbide FG bur E0123 010 (Cavity Access Kit; Dentsply Maillefer, Ballaigues, Switzerland) under water cooling. Canals were negotiated with a 10 K-file (Dentsply Tulsa) using ProLube (Dentsply Tulsa Dental) in the access cavity. Apical patency was achieved, and working lengths were established radiographically 0.5 mm short of the radiographic canal lengths. All canals were manually enlarged to a 15 K-Flexofile (Dentsply Tulsa) to achieve a glide path.

In the GT group, manual shaping with ProFile GT hand files was performed with the following crown-down sequence: 0.12/20, 0.10/20, 0.08/20, 0.06/20, and 0.04/25. Both 0.06/20 and 0.04/25 instruments reached the working length.

In the WO group, Primary WaveOne files were used to the working length following the directions of the manufacturer. All root canals were irrigated with 6% sodium hypochlorite applied with a 30-G needle after each instrument during the shaping procedure.

Soft tissue was first removed from the mandibles using a scalpel; bone was then carefully peeled away with surgical burs under water cooling until the teeth were separated. Radiographs were taken when needed to assess the distance for the apex to be exposed. Bone around the lateral surface of individual teeth remained when it was not easily eroded.

The procedure was performed under magnification with an operating microscope. Special care was taken not to touch the teeth with burs or instruments during this procedure. Mandibles and teeth were stored in containers providing moisture at all times.

Roots were sectioned horizontally at 3, 6, and 9 mm from the apex by using a low-speed saw (Techcut 4; Allied High Tech Products Inc, Compton, CA) under constant water cooling. The resulting slices were viewed through a measurement microscope (Carl Zeiss, Oberkochen, Germany); pictures were taken with a camera (Axiocam, Carl Zeiss) at 2 magnifications (25× and 40× the original magnification).

Digital images of the slices (Fig. 1) were then collected, and the canal cross-sections were masked with a black circle slightly larger than the canal in order to prevent examiners from identifying which slice belonged to a shaped canal or a control tooth. The sequence of images (at 25× magnification) received random numbers. The high-magnification image of the same slice was placed in the slide immediately after the corresponding 25× image to facilitate the assessment by the observers after viewing images with lower-power magnification. An automatic time frame of 30 seconds separated each slide.

Three blinded examiners, who had been previously calibrated by the individual analysis of all the slices, evaluated the pictures together. The presence of microcracks (yes/no), extension (incomplete/complete), direction (buccolingual/mesiodistal), and location at the pulpal wall or elsewhere was registered. Whenever there was a disagreement in a slice, it was stained with 1% aqueous toluidine blue solution; new images were taken with the same 2 magnifications, mounted in a new document following the same parameters, and re-evaluated. Comparisons between groups were analyzed with chi-square tests at $P < .05$.

Results

A total of 18 microcracks were found in the 54 sections. Two teeth in CG, 3 in the GT group, and 2 in the WO group did not exhibit any crack. The distribution of microcracks per group and section level is summarized in Table 1.

There were no significant differences in the incidence of microcracks among the CG, GT, and WO groups at 3 (P = .8), 6 (P = .8), or 9 (P = 1) mm from the apex. The typical pattern of microcracks detected in the 3 groups is shown in Figure 1. All microcracks were incomplete, started at the pulpal wall, and followed a buccolingual direction. No craze lines in the external surface of the slices were detected.

Discussion

This *in situ* study compared microcrack formation after hand and reciprocating root canal instrumentation using cadaver mandibles. The study was developed with 1 main concern in mind: the need to search for a reproducible method to identify if shaping procedures induce microcracks. Similarly, when ultrasonic retrograde preparation was introduced in endodontics, it was associated with increased crack formation until further study in cadavers did not support such a notion (26).

Recently, several researchers have described a sizable percentage of microcracks or dentinal defects in extracted teeth during shaping procedures with different approaches (15–19, 21, 22, 25, 27, 28). The results found in these studies could raise concern about the longevity of root canal–treated teeth.

These studies have been conducted in previously extracted teeth (15, 17–20, 22, 23) in which a lack of bone and PDL around the teeth could alter the internal forces received both during access cavity preparations and during negotiating and shaping procedures (24). In addition to these drawbacks, other circumstances related to extracted teeth could influence the results, such as unknown forces that teeth were subjected to when being extracted and the lack of awareness of the presence of pre-existing occlusal dysfunctions, trauma, or similar situations in the mouth of the patient (23). Likewise, technical aspects of any procedure (access cavity, negotiation, shaping, or filling) could create microcracks and defects in intact extracted teeth with other lost properties because of the preservation conditions since the time of extraction. In fact, propagation of microcracks induced by shaping and filling procedures in extracted teeth continued during 4 weeks in which the sample was passively stored with no additional function or stress applied (15).

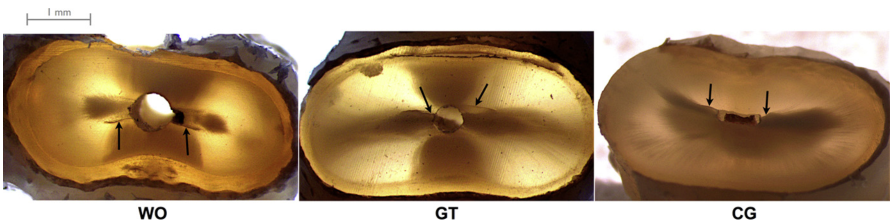

Figure 1. Canal cross-sections showing the pattern of microcrack formation in each group. Note the incomplete buccolingual microcracks starting at the pulpal wall in all 3 specimens.