An Evaluation of Apical Cracks in Teeth Undergoing Orthograde Root Canal Instrumentation

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Abstract

Introduction: Dentinal damage and cracks induced by orthograde preparation methods have been reported in studies using extracted teeth. The purpose of this *in situ* investigation was to evaluate dentinal cracks in non-extracted teeth after final instrumentation. The null hypothesis is that orthograde root canal instrumentation will have no effect on crack initiation in teeth retained in the natural periodontium. **Methods:** Mandibular first and second premolars of pig jaws were selected. Forty single-rooted canals were divided into 5 groups (n = 8): (1) WaveOne (Dentsply Tulsa Dental Specialties, Tulsa, OK) 25/08; (2) ProTaper rotary S1, S2, F2 (25/08) (Dentsply Tulsa Dental Specialties); (3) crown-down GT hand files 20/12, 20/10, 20/08 (Dentsply Tulsa Dental Specialties); (4) positive control (purposefully cracked); and (5) negative control (uninstrumented teeth). After instrumentation, superficial soft tissue was removed, and bone was carefully peeled away with surgical burs to the level of the root apices. Roots were resected 1 mm coronal to the working length, stained with caries indicator dye, and transilluminated; images were captured and viewed at 30× magnification to determine the presence or absence of dentinal cracks. **Results:** WaveOne, ProTaper rotary, and GT hand files produced no cracks. All positive controls had cracks; all negative controls had no cracks. **Conclusions:** Within the limits of this investigation, the presence of natural periodontal structures may prevent cracking or dentinal damage in teeth receiving orthograde root canal instrumentation. *(J Endod 2015;41:2021–2024)*

Key Words

Crack, instrumentation, root canal

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Complete removal of tissue, debris, and microorganisms is a goal in endodontic treatment. These goals are met by biomechanical instrumentation of the root canal and by developing a continuously tapering canal form while keeping the apical opening as small as practical (1). During instrumentation to achieve these goals, dentin within the canal system is in contact with instruments of varying taper and cross-sectional shape. The removal of dentin chips during the time that the instrument is contacting dentin produces the canal shape. In studies using extracted teeth, dentinal damage and defects may be induced by some instrumentation methods (2). Although rotary instrumentation takes less time than instrumentation with hand files (3), hand filing has been reported to produce no dentinal cracks (4), crack initiation, or propagation (5). Wilcox et al (6) reported that the more tooth structure removed, the more likely a root is to fracture, with no cracks evident until 40%–50% of dentin has been removed.

Some extracted tooth studies (7, 8) have found cracks after rotary instrumentation and no cracks in noninstrumented control teeth. Other extracted tooth studies (9–11) found cracks in both instrumented experimental teeth and noninstrumented control teeth. Recent extracted tooth studies using micro–computed tomographic analysis found the presence of dentinal microcracks in 27.64% and 34.62% of preoperative images (10, 11). These studies (7–12) and others have examined cracks after the tooth has been extracted from the donor. Adorno et al (12) mounted extracted teeth with a simulated periodontal ligament to cushion the teeth during instrumentation. However, the apical 3 mm were left exposed for visualization and analysis. They acknowledged that the absence of coverage of the apex during instrumentation was 1 of the limitations of their study.

No previous studies were found showing results of orthograde root canal instrumentation of teeth while teeth remained in the natural unpreserved periodontium. The purpose of this *in situ* investigation is to evaluate apical cracks in instrumented non-extracted teeth. The null hypothesis was that orthograde root canal instrumentation will have no effect on crack initiation in teeth retained in the natural periodontium.

Materials and Methods

Eight lower hemisected jaws from 12-month-old pigs were obtained from Carlton Farms, OR. Animals were slaughtered for reasons not related to this study. Jaws were hemisectioned into blocks containing canine, first premolar, second premolar, first molar, and second molar. First and second premolars were selected for this study because of their similarity in canal anatomy and size to human premolars. Digital radiographs to confirm similar canal development and anatomy were taken at 7 inches from the source at 70 kVp and 7 mA. A power analysis was performed using the calculator.net website in consultation with a biostatistician. The statistical tool used was the 1-sample z test. A sample size of 8 jaws was determined to give 80% power and 5% significance.

Instrumentation

Forty single-rooted first premolars and second premolars from 8 right and 8 left jaw sections were used in the study. All instrumentation was performed with an 8:1 contra-angle per manufacturer's instructions powered by a torque-limited electric motor using its dedicated program library for each file (Promark; Dentsply Tulsa Dental Specialties, Tulsa, OK). Preparations were as follows: all cusps were flattened to create a reproducible measuring surface, and pulp chambers were accessed with round carbide

#4 FG bur H1.314.023 (Komet USA, Schaumburg, IL) under water cooling. Canals were negotiated with a #10 K-file, teeth were radiographed, and the working length (WL) was determined. The WL was defined as 1 mm coronal to the radiographic apex. Teeth (n = 8 per group) were allocated by randomly drawing a piece of paper with a group name out of a box as follows:

Group 1: The WaveOne 25/08 (Dentsply Tulsa Dental Specialties) primary file was used in gentle pecking motions to the WL. Flutes were cleaned with alcohol gauze after 3 pecks.
Group 2: ProTaper Universal rotary (Dentsply Tulsa Dental Specialties) preparation with S1, S2, F1 (20/07), and finally F2 (25/08) files were used according to the manufacturer's instructions using a gentle in-and-out motion. Instruments were removed from the canal and cleaned with alcohol gauze after 3 pecks. F1 and F2 instruments were taken to the WL.
Group 3: Profile GT hand file (Dentsply Tulsa Dental Specialties) shaping was performed in the following crown-down sequence: 20/12, 20/10, and 20/08. Instruments were removed from the canal and cleaned with alcohol gauze when flutes were filled with debris.
Group 4: Positive control was used (a #80 K-file placed beyond the apex; crack audible upon clockwise turn of the file).
Group 5: Negative control was used (no instrumentation).

During instrumentation, approximately 2 mL 6.15% sodium hypochlorite (Clorox Professional Products Co, Oakland, CA) was used to irrigate canals after each instrument. A final rinse was performed with 0.9% sodium chloride isotonic irrigation solution (Baxter Healthcare Corp, Cherry Hill, NJ). Each file was discarded after 2 uses.

Evaluation and Analysis

After instrumentation, soft tissue was removed with a scalpel and periosteal elevator. Bone was then removed with a surgical bur and copious water cooling. This revealed the root apices. Roots were resected horizontally with a #57 stainless steel bur (Meisinger USA, Centennial, CO) 1 mm coronal to the determined WL with continuous water spray. This bur showed the smoothest resection cut, comparing favorably with a Buehler Isomet diamond saw (Buehler, Chicago, IL) (13). Specimens were kept moist with isotonic saline during the experimental, evaluation, and storage periods.

After root resection, caries indicator dye (To-Dye-For; Roydent, Johnson City, TN) was applied and rinsed with 0.9% sodium chloride solution. Transillumination was performed with a light-emitting diode microlux transilluminator with a 3-mm glass light guide (AdDent, Danbury, CT). According to Wright et al (14), caries indicator dye has a higher specificity, sensitivity, and accuracy than methylene blue when used with transillumination.

Specimens were examined with a surgical operating dental microscope at 30× magnification, and digital images were captured. A crack was defined as a defect extending from the canal space to the external root surface in which stain would remain (15, 16). No crack was defined as root dentin without a stained crack line to the external surface of the root. Images were viewed at least 2 times with at least 2 weeks between viewing. The incidence of apical cracks was statistically analyzed with the Pearson chi-square test. The level of significance was set at $P < .05$.

Results

During preparation, no instrument fractured, and no deformation of an instrument was noted. All positive controls had a crack extending from the canal lumen to the external root surface (Fig. 1*A*). All negative controls had no cracks (Fig. 1*B*). Because there were no cracks in the experimental groups (Fig. 1*C*), a statistical analysis was not performed. Post hoc power analysis with n = 8 gave a power of 94% at the 5% level of significance. The null hypothesis was accepted.

Discussion

This study revealed that the attachment apparatus might be able to prevent cracks in root dentin because of the cleaning and shaping of the canal system. Some studies using a layer of silicone to simulate the periodontal ligament leave the apex exposed to allow visualization of cracks produced during instrumentation (12, 17). Adorno et al (11) stated the clinical situation is more complex because the presence of the periodontal ligament influences the distribution of forces. Elastomeric material used as a replacement for the periodontal ligament may collapse and permit direct tooth to acrylic contact (18). In root end cavity preparations in human cadavers, Calzonetti et al (19) found that microfractures were not observed after instrumentation and resection when periradicular tissues supported the roots, suggesting that supporting tissues may have absorbed the instrumentation impact and prevented microfractures. Another cadaver study found microcracks in untreated control teeth and no significant differences between the incidences of microcracks when comparing GT hand files, WaveOne files, and uninstrumented controls (20). In contrast, Liu et al (21) in their extracted tooth study found cracks during instrumentation with single-file reciprocating and multiple-file rotary systems. Although these investigators did not find cracks during instrumentation when using Gates Glidden instruments for coronal flaring, another group observed cracks after coronal flaring with Gates Glidden instruments in extracted mandibular molars (22). Taking these reports into consideration, the present findings support the premise that the incidence of cracks obtained from extracted teeth studies may be overstated.

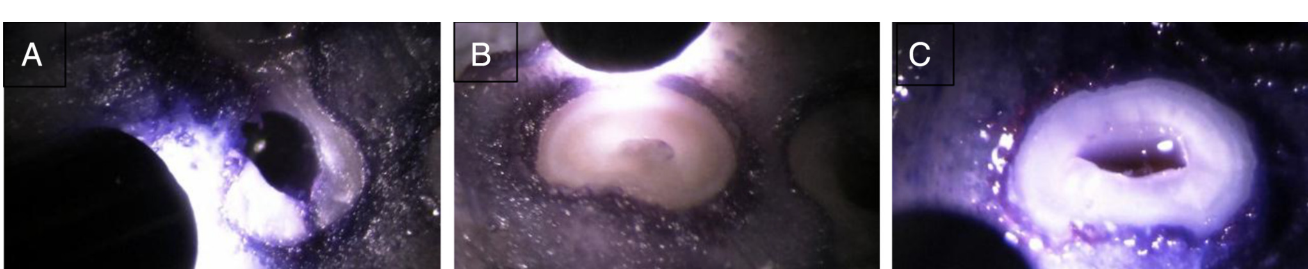

Figure 1. All lighting with a light-emitting diode microlux illuminator. (*A*) Positive control with crack (stained line extending from the canal to the periodontal ligament in the 6 o'clock position). (*B*) Negative control, no crack. (*C*) Instrumented with no crack (30×).