Bacteria and Hard Tissue Debris Extrusion and Intracanal Bacterial Reduction Promoted by XP-endo Shaper and Reciproc Instruments

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Abstract

Introduction: This study used a multipurpose analytic approach to compare the levels of apically extruded bacterial and hard tissue debris as well as intracanal bacterial reduction after root canal preparation with either XP-endo Shaper (FKG Dentaire, La Chaux-de-Fonds, Switzerland) or Reciproc (VDW, Munich, Germany) instruments. **Methods:** Distobuccal canals from extracted maxillary molars were contaminated with *Enterococcus faecalis* and randomly distributed into 2 groups according to the instrumentation system: the XP-endo Shaper or Reciproc. Teeth were mounted in an apparatus that simulates the apical resistance offered by the periapical tissues and permitted to collect debris extruded during preparation. Saline was used as the irrigant during preparation, and all treatment procedures were performed inside a cabinet under a controlled temperature of 37°C. DNA extracts from samples taken from the canal before and after preparation were subjected to quantitative real-time polymerase chain reaction for *E. faecalis* counting. The volume of extruded debris was evaluated by micro–computed tomographic imaging. DNA was extracted from the extruded hard tissue debris and analyzed by quantitative real-time polymerase chain reaction. **Results:** Mechanical intracanal bacterial reduction was significantly more pronounced when using the XP-endo Shaper ($P < .001$). Although both instruments produced a similar volume of extruded debris ($P > .05$), extruded bacteria counts were significantly lower with Reciproc than the XP-endo Shaper ($P < .001$). No correlation was observed between the extruded bacterial counts and debris volume. **Conclusions:** Although bacterial extrusion was lower with Reciproc, the intracanal bacterial reduction was higher with the XP-endo Shaper. Both techniques produced a similar volume of hard tissue debris extrusion. *(J Endod 2018;■:1–6)*

Key Words

Bacterial extrusion, dentinal debris extrusion, infection control, microcomputed tomography, quantitative real-time polymerase chain reaction, root canal treatment

Significance

Although Reciproc caused less apical bacterial extrusion, the mechanical intracanal bacterial reduction was more pronounced with the XP-endo Shaper. Both single-file systems produced a similar volume of hard tissue debris extrusion.

Infection control and prevention of apical extrusion of bacteria and debris are important objectives of chemomechanical procedures during the treatment of teeth with apical periodontitis. Because this disease is caused by bacterial infection of the root canal, the maximum reduction in bacterial counts is paramount for an optimal treatment outcome (1). In addition, apical extrusion of bacteria and debris during preparation is conceivably the main cause of postoperative pain and flare-ups (2, 3). Apically extruded bacteria may also be a source of extraradicular infection and compromise the long-term outcome (4). Therefore, effective disinfection and control of apical extrusion of bacteria/debris can influence both postoperative comfort and periradicular tissue healing.

Clinically, it is not possible to determine the frequency and amount of apical extrusion of debris or bacteria during preparation. Consequently, numerous laboratory studies have been conducted to determine what intracanal procedures result in more or less extrusion of debris or bacteria through the apical foramen. There are studies evaluating the extrusion of hard tissue debris (5–9) and others focusing on bacterial extrusion (10–14), but no study thus far has evaluated both in the same teeth in an attempt to correlate findings. Moreover, the large majority of studies have not tried to simulate the resistance imposed by the periapical tissues to apical extrusion; consequently, extrusion is expected to occur more easily and frequently in laboratory studies, and the results may have limited relevance.

Single-file nickel-titanium instrumentation systems have become widely used for root canal preparation over the last years. Information regarding disinfection and apical extrusion is available for the most popular systems. For instance, laboratory (15–18) and clinical studies (19, 20) have shown that the reduction of intracanal bacterial populations promoted by Reciproc (VDW, Munich, Germany), a single-file system based on reciprocating motions, is similar to that obtained by multifile systems working

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in continuous rotation. As for extrusion studies, results are generally inconsistent regarding which single-file systems extrude less bacteria (5–9,14).

FKG Dentaire (La Chaux-de-Fonds, Switzerland) has recently introduced a new instrument named XP-endo Shaper, which has a size/taper 30/0.01 and is made from a MaxWire nickel-titanium alloy. When activated within the root canal at body temperature, the XP-endo Shaper instrument expands and contracts. The manufacturer claims that the XP-endo Shaper can reach a final 30/0.04 size canal preparation. Another interesting characteristic of this instrument is its tip design, which presents 6 cutting edges and a smooth transition from the base of the tip to the helical shaft known as a "booster tip"; it is considered a long tip compared with other file tips. So far, there is no available information regarding apical extrusion of dentinal debris and/or bacteria using this instrument as well as no study evaluating its intracanal antibacterial effects.

The purpose of this study was 2-fold:

(1) to compare the number of bacteria and hard tissue debris apically extruded after root canal preparation with the XP-endo Shaper and Reciproc systems and
(2) to compare intracanal bacterial reduction promoted by both instrument systems. A model that simulates the apical resistance imposed by the periapical tissues was used to collect the extruded material. Quantitative real-time polymerase chain reaction (qPCR) was used to evaluate the number of apically extruded bacteria and the bacterial reduction after instrumentation. Micro–computed tomographic (micro-CT) imaging was used to evaluate the volume of apically extruded hard tissue debris.

Materials and Methods

Specimen Selection

The Institutional Committee of Ethics in Research approved the study protocol. One hundred maxillary molars extracted for reasons not related to this study were initially selected. Coronal access preparations were made using diamond burs #1013 (KG Sorensen, Cotia, SP, Brazil) and the Endo-Z bur (Dentsply Sirona, Tulsa, OK). Only the distobuccal root canals were used in this study. Each tooth was sectioned in such a way that the distobuccal root and its respective crown portion were available for the experiment. Sectioning was needed to facilitate handling, sampling, and mounting the tooth in the extrusion apparatus. The tooth specimens were cleaned with pumice, rinsed with distilled water, and inspected under a stereomicroscope in order to inspect the root surfaces for the presence of cracks or resorption. Afterward, a size 10 instrument (C-Pilot, VDW) was introduced into the canal until its tip was visualized at the apical foramen under magnification, and a radiograph was taken. Only roots with fully formed apexes without evident cracks or resorption and displaying a single and patent canal were selected. Canals in which a size 10 file was loose and reached the apical region without any significant resistance were also discarded. Forty-three specimens met these criteria and were included in the experiment. The root curvature degree was evaluated in micro-CT scans and classified as moderate (mean, 12.8° ± 16.2°; range, 0°–70°) (21).

Initial Preparation

The coronal portion of the tooth specimens was reduced with the aid of a diamond disc (Brasseler, Savannah, GA) in order to standardize the root length to 15 mm and create a plateau for micro-CT scanning. The root canal length was obtained by placing a C-Pilot instrument in the canal until its tip was visible at the apical foramen under magnification. The total canal length was obtained using a digital caliper (Digimess, São Paulo, SP, Brazil) and regarded as the patency length. The working length (WL) was established 1 mm short of this measure. A rotary instrument (RaCe size 10/0.04, FKG Dentaire) was used 1 mm beyond the apical foramen to standardize the initial canal diameter before bacterial contamination.

Root Canal Contamination

Before contamination, the smear layer was removed by immersing the specimens in 17% EDTA for 1 minute under ultrasonic agitation. After washing in water, the root canals were filled with trypticase soy broth (TSB; Difco, Detroit, MI) using a NaviTip 30-G needle (Ultradent Products Inc, South Jordan, UT) until the culture medium flowed through the apical foramen. Next, all 43 specimens were centrifuged twice at 10,000 rpm for 2 minutes into microcentrifuge tubes filled with 1 mL TSB. Specimens were transferred to a flask containing 150 mL TSB, ultrasonicated for 1 minute, and sterilized in an autoclave. Afterward, the flask was incubated for 48 hours to confirm sterility.

Ten milliliters of a fresh pure culture of *Enterococcus faecalis* (ATCC 29212; American Type Culture Collection, Manassas, VA) grown overnight in TSB at 37°C was used to inoculate the broth with the specimens. The flask containing the specimens was incubated at 37°C for 30 days under gentle shaking, and TSB was completely replenished weekly. After this period, successful *E. faecalis* growth in pure culture was confirmed by Gram staining and plating onto Mitis-Salivarius agar (Difco). Specimens had the excess culture medium dripped off, and their root surfaces were wiped with sterile gauze. One specimen was fixed in 10% buffered formalin and processed for scanning electron microscopy as described elsewhere (22).

Specimens had their external root surfaces disinfected with 3% hydrogen peroxide for 1 minute followed by 2.5% sodium hypochlorite (NaOCl) for 1 minute. Sterile gazes soaked with these substances were vigorously rubbed in all external root surfaces. NaOCl was inactivated with 5% sodium thiosulfate, and sterility control samples were taken from the apical outer surface of each root using paper points dampened with Tris-EDTA buffer (10 mmol/L Tris-HCl and 1 mmol/L EDTA, pH = 7.6). Paper points were scrubbed onto all root faces. These control samples were subjected to the same qPCR assay used for bacterial counting (see later).

Apparatus for the Collection of Extruded Material

An apparatus previously described for the evaluation of apically extruded filling materials (23) was adapted and used in the present study to collect bacteria and hard tissue debris. Each tooth specimen was fixed on the lid of a microcentrifuge tube, passing through a previously custom-made hole in such a way that the apical 5-mm segment of the specimen was inside the tube and its coronal portion was outside. The space between the lid and the root was sealed with epoxy resin. A metallic cylinder (10-mm height, 8-mm outer diameter) was adapted to the lid, enclosing the root apex, and was filled with 1.5% sterile agarose gel (Difco) (Fig. 1*A*). This was done to simulate the resistance offered by the periapical tissues and provide a matrix to collect the apically extruded debris. The apical root surface was completely covered by the agarose gel. After gel solidification, the metallic cylinder was removed, and the setup was inserted into a microcentrifuge tube and maintained in this position during root canal preparation. All materials were sterile, and the procedures for mounting the extrusion setup were conducted inside an aseptic cabinet previously decontaminated with 70% alcohol and ultraviolet light.