Spectrophotometric Determination of Irrigant Extrusion Using Passive Ultrasonic Irrigation, EndoActivator, or Syringe Irrigation

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Abstract

Introduction: Sodium hypochlorite (NaOCl) irrigation is critical to endodontic success, and several new methods have been developed to improve irrigation efficacy (eg, passive ultrasonic irrigation [PUI] and EndoActivator [EA]). Using a novel spectrophotometric method, this study evaluated NaOCl irrigant extrusion during canal irrigation. **Methods:** One hundred fourteen single-rooted extracted teeth were decoronated to leave 15 mm of the root length for each tooth. Cleaning and shaping of the teeth were completed using standardized hand and rotary instrumentation to an apical file size #40/0.04 taper. Roots were sealed (not apex), and 54 straight roots (n = 18/group) and 60 curved roots (>20° curvature, n = 20/group) were included. Teeth were irrigated with 5.25% NaOCl by 1 of 3 methods: passive irrigation with needle, PUI, or EA irrigation. Extrusion of NaOCl was evaluated using a pH indicator and a spectrophotometer. Standard curves were prepared with known amounts of irrigant to quantify amounts in unknown samples. **Results:** Irrigant extrusion was minimal with all methods, with most teeth showing no NaOCl extrusion in straight or curved roots. Minor NaOCl extrusion (1–3 μL) in straight roots or curved roots occurred in 10%–11% of teeth in all 3 irrigant methods. Two teeth in both the syringe irrigation and the EA group extruded 3–10 μL of NaOCl. **Conclusions:** The spectrophotometric method used in this study proved to be very sensitive while providing quantification of the irrigant levels extruded. Using the PUI or EA tip to within 1 mm of the working length appears to be fairly safe, but apical anatomy can vary in teeth to allow extrusion of irrigant. *(J Endod 2014;40:1622–1626)*

Key Words

Creosol purple, endodontic irrigation, sodium hypochlorite, spectrophotometer

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Endodontic treatment uses chemomechanical preparation to remove microorganisms, pulp tissue, and dentin debris from the root canal system. Sodium hypochlorite (NaOCl) is the irrigant most often used because of its antimicrobial activity and tissue dissolution ability (1). However, all areas of the canal system may not be completely accessible by hand or rotary instruments (2). Debris accumulation may also interfere with root canal treatment. Complete removal of debris is essential for allowing direct contact of the irrigant solution into the dentin tubules to assist with disinfection (3).

Root canal irrigation using NaOCl via passive irrigation with a needle (PIN) is limited and primarily depends on the depth of the irrigation cannula (4, 5). The efficiency of irrigation is thought to be increased by activating the solution with an ultrasonic or sonic device in some (6–9) but not all studies (10). Irrigation of the root canal system includes a risk of extrusion of the irrigant into the periapical region, which is often associated with pain, swelling, and tissue damage (11–13).

There are several reports about the complications of irrigation with NaOCl during root canal therapy (11, 14). One study showed increased debris extrusion with higher hypochlorite concentration (15). Most of the complications are the result of accidental extrusion of the solution from the apical foramen, accessory canals, or perforations into the periapical area (14). Most NaOCl accidents occur because of inaccurate working length determination, iatrogenic widening of the apical foramen, lateral perforation, or wedging of the irrigating needle. If a perforation or an open apex does exist, special attention is needed to provide irrigation (16).

Bone lesions may also contribute to irrigant extrusion by reducing the periapical tissue resistance to extrusion. Long-standing periapical lesions have also been associated with an increased possibility of external apical root resorption, resulting in an effect similar to overinstrumentation (17). A pathway with reduced tissue resistance toward soft tissues, the oral cavity, or the maxillary sinus (ie, cortical bone fenestration or perforation, sinus tract, direct communication with the maxillary sinus, or root perforation) could be additional factors leading to extrusion accidents (18).

Diverse study models have been used to detect irrigant extrusion. For instance, a radiopaque solution was used to observe apical extrusion of irrigant in patients with necrotic pulps (19). Another method measured the volume of the extruded liquid collected during irrigation (20). In 2010, Mitchell et al (21) presented a model using image analysis to evaluate apical irrigant extrusion from extracted teeth with a simulated periapical environment. More recently, an *ex vivo* method of quantifying the volume of extruded irrigant during root canal irrigation was examined using a point conductivity probe by determining electrolyte concentration (22). Mitchell et al (23) concluded that the frequency of NaOCl extrusion was dependent on the type of root canal irrigation system and apical preparation size, with syringe and slotted-needle irrigation resulting in the greatest extent of extrusion.

Passive ultrasonic irrigation (PUI) and subsonic irrigation (EndoActivator [EA]; Dentsply, York, PA) methods have recently been proposed to improve irrigation efficacy. However, the safety of these new methods has yet to be evaluated. The aim of this *in vitro* study was to examine the safety of different irrigation methods during canal irrigation using a novel spectrophotometric method to quantify irrigant extrusion.

Materials and Methods

The research protocol used in this study was exempted by the University of Minnesota's Institutional Review Board. One hundred fourteen extracted single-rooted teeth were selected after extraction at local dental clinics with teeth stored in normal saline containing 0.2% sodium azide.

Teeth Selection and Preparation

Fifty-four straight roots (n = 18/group) and 60 curved roots (n = 20/group) were selected for the study groups (PIN, PUI, or EA). Teeth were placed into either straight (0°–20°) or curved root groups (>20°) after measuring root canal curvatures (Schneider method) (24). Teeth were decoronated to leave 15 mm of root length to standardize the length of each sample. A #10 FlexoFile (Dentsply Maillefer, Johnson City, TN) was placed in all teeth until just visible at the apex to determine patency, and 1 mm was subtracted to establish the working length.

For root canal preparation, rotary instrumentation was performed using the ProTaper system (Dentsply Maillefer) in a crown-down fashion to the working length with apical enlargement up to a file size #40/0.04 taper while irrigating with 1 mL 5.25% NaOCl between files using syringe irrigation. The apical foramen was kept patent during cleaning and shaping using a #10 FlexoFile to improve delivery of irrigant to the apical 2 mm of the canal (25).

Irrigation Methods and Extrusion Detection

After cleaning and shaping, teeth from both the straight and curved groups were randomized for final irrigation into 3 treatment groups: PIN, PUI, or EA. The apical foramen position was noted on every tooth, and a 1-mm area around the apical foramen was left uncoated by nail polish. Roots were sealed in a microcentrifuge tube using silicone impression material to collect any extruded NaOCl. Roots were then irrigated via PIN (3 mL irrigant delivered in 60 seconds), PUI (canal filled with irrigant and activated for 60 seconds), or EA (canal filled with irrigant and activated for 60 seconds) according to treatment randomization. For the PIN group, Max-i-Probe irrigation needles (side port opening, rounded tip, 30 gauge; Dentsply Rinn, Elgin, IL) were used. For the PUI group, the ultrasonic used was the MTS Ultrasonic Obtura Spartan system (Obtura Spartan Endodontics, Algonquin, IL) with a power of 40 kHz, which was used at the half power (5/10 bar) setting. The ultrasonic tip used was a size #15 Zipperer (VDW, Munchen, Germany). For the EA, the large size tip (blue 35/04) was used. This battery-operated handpiece activated from 2,000–10,000 cycles/min, which translates to 0.166–0.3 kHz. All groups were irrigated 2 mm short from the working length. A standardized solution of m-creosol purple (3–4 fold dilution, 170 μL, pH = 7) (Sigma-Aldrich, St Louis, MO) was then added to each unknown sample of extruded irrigant. Samples were vortexed, and 170 μL from each sample was pipetted onto a 96-well plate. To prepare the standard curves, an equal amount of indicator with known amounts of added NaOCl (0–30 μL) was used, and the 96-well plate with both the unknown samples and the standard curve samples were read by a spectrophotometer (Synergy HT; BioTek, Winooski, VT) (Fig. 1).

Micromolar concentrations were determined for the quantification of NaOCl used for standards. Log (μmol/L) was calculated and plotted to the respective absorbance values to produce the standard

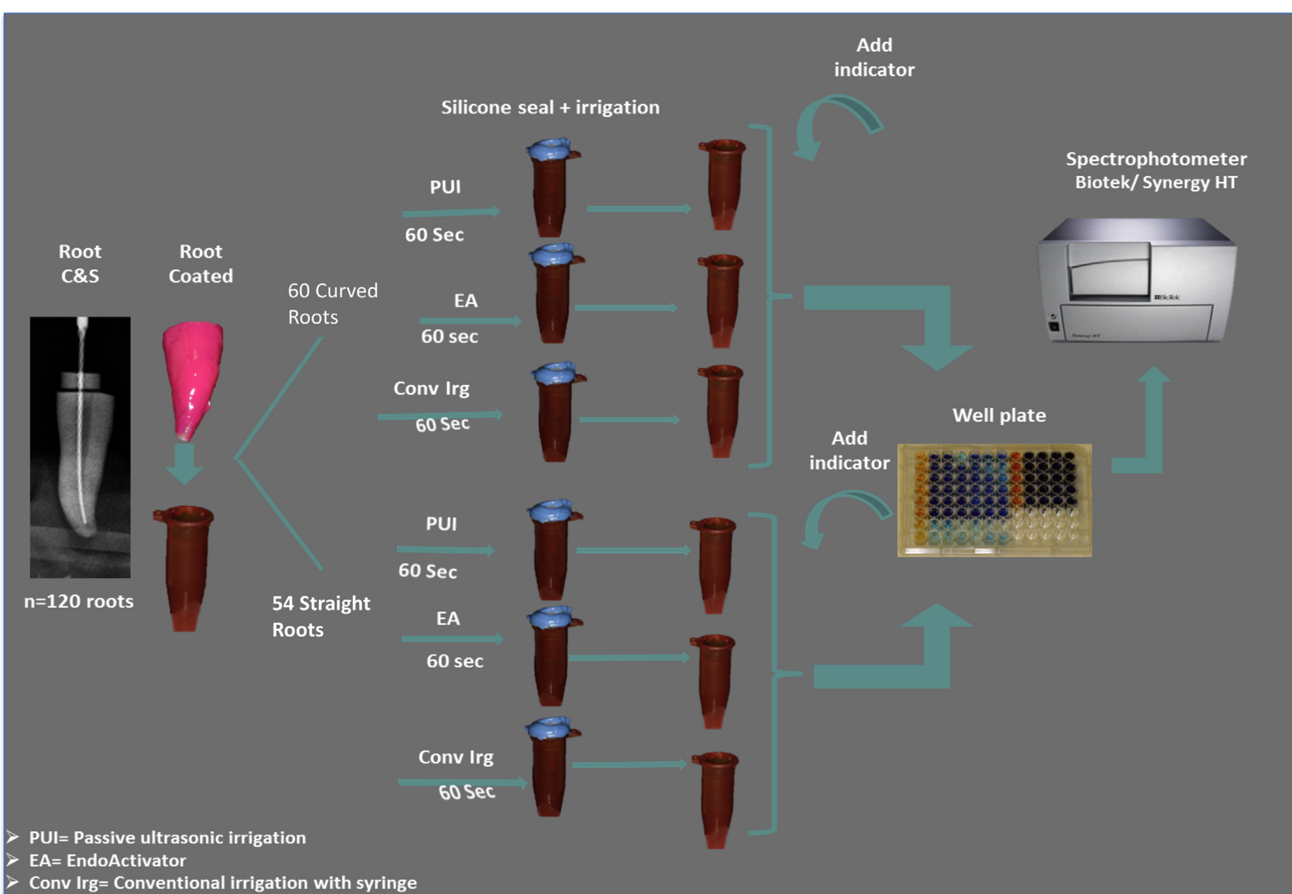

Figure 1. Experimental design and methods for irrigant extrusion measurement.