Comparison of Apical Extrusion of Sodium Hypochlorite Using 4 Different Root Canal Irrigation Techniques

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Abstract

Introduction: We compared the apical extrusion of sodium hypochlorite delivered with a 27-G needle, self-adjusting file (SAF), passive ultrasonic irrigation, or the EndoVac system (SybronEndo, Orange, CA) during the instrumentation and final irrigation of root canals. **Methods:** Matched paired single-canal teeth were divided into 8 groups. The experimental groups were needle irrigation size #30 (NI30) and #50 (NI50), SAF size #30 (SAF30) and #50 (SAF50), passive ultrasonic irrigation size #30 (PUI30) and #50 (PUI50), and EndoVac size #30 (EV30) and #50 (EV50). Teeth were embedded in 0.2% agarose gel (pH = 7.4) containing 1 mL 0.1% m-Cresol purple (Sigma-Aldrich, St Louis, MO), which changes color at a pH level of 9.0. Root canals were irrigated with sodium hypochlorite and EDTA using 4 different techniques, and the amount of irrigant was controlled. Standardized digital photographs were taken 20 minutes after the first irrigant was used and were analyzed to determine the amount of extrusion (expressed as a percentage of total pixels). **Results:** The amounts of apical extrusion obtained in the NI30, NI50, SAF30, SAF50, PUI30, PUI50, EV30, and EV50 groups were 30% (3/10), 50% (5/10), 20% (2/10), 70% (7/10), 40% (4/10), 40% (4/10), 10% (1/10), and 10% (1/10), respectively. The overall extrusion frequency, regardless of the apical preparation size, was 40% (8/20) for needle, 45% (9/20) for SAF, 40% (8/20) for ultrasonic irrigation, and 10% (2/20) for EndoVac. Although the SAF group showed more extrusion, the percentage of pixels was significantly higher in the needle irrigation group ($P < .01$). The EndoVac group showed significantly lower extrusion values than the other techniques in terms of the number of teeth and pixels ($P < .05$ and $P < .01$, respectively). **Conclusions:** The risk of apical extrusion is significantly lower with the EndoVac in comparison with the 3 other techniques. *(J Endod 2015;41:380–384)*

Key Words

Apical extrusion, EndoVac, irrigation, passive ultrasonic irrigation, self-adjusting file

Careful removal of vital and necrotic remnants of pulp tissue, debris, microorganisms, and microbial toxins from a root canal system is essential in endodontic treatment (1). However, debris is difficult to remove effectively using mechanical instrumentation alone because the root canal system has a complex and irregular structure (2). Thus, root canal irrigation needs to be incorporated to enhance debridement (3, 4). The purpose of root canal irrigation is to remove pulp tissue and microorganisms from the root canal system and to remove debris and the smear layer formed after mechanical instrumentation of the root canal (5).

Clinicians enlarge the canal space to better deliver irrigants, such as sodium hypochlorite (NaOCl), to the apical third of the root canal system (6, 7). Current techniques inadequately debride the entire root canal system (8–10). Indeed, it is likely that irrigants do not predictably reach all aspects of the canal, especially the apical third (11).

Irrigation solutions are often delivered with a 30- or 27-G endodontic slot-tipped needle placed into the canal until just short of the apex (12). The difficulty with this technique is that the depth of needle penetration is dependent on the size and morphology of each canal. Predictable delivery of irrigants to the working length (WL) is often not achieved with needle irrigation (13). If adequate positive pressure is not used, irrigants may not reach close to the WL. If too much positive pressure is used, the practitioner risks forcing irrigants past the terminus of the root canal, which can produce tissue damage, pain, and swelling (14–17).

The self-adjusting file (SAF; ReDent Nova, Ra'anana, Israel) is hollow and designed as a thin cylindrical nickel-titanium lattice that adapts to the cross-section of the root canal. A single file is used throughout the procedure (18, 19). The resulting circumferential pressure allows the file's abrasive surface to gradually remove a thin, uniform hard tissue layer from the entire root canal surface, resulting in a canal with a similar cross-section but of larger dimensions (10, 20). This also holds true for canals with an oval or flat cross-section, which will be enlarged to a flat or oval cross-section of larger dimensions. The straightening of curved canals is also reduced, so the original shape of the root canal is respected, both longitudinally and in the cross-section (21).

Recently, with its gradually increasing popularity, passive ultrasonic activation of endodontic instruments has been suggested as a means to improve canal debridement (22), canal disinfection (23), and canal sealing (24). Passive ultrasonic irrigation (PUI) also has been recommended for removing $Ca(OH)_2$ from the root canal (25). However, whether PUI as an effective irrigation method causes extrusion of irrigant from the apical foramen remains unknown.

The EndoVac (SybronEndo, Orange, CA) negative pressure irrigation system was developed to address the procedural challenge of delivering irrigants safely to the WL. An EndoVac placed to the WL resulted in significantly better debridement at 1 mm from

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0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2014.11.003

the WL compared with needle irrigation in teeth prepared to an ISO size #36 or larger (26). Water was used to compare the safety of the available irrigation systems; the results showed no extrusion occurring in any of the EndoVac samples (27). It has also been shown that an intracanal aspiration technique produced limited extrusion of the irrigant compared with conventional needle irrigation (28). The purpose of this investigation was to compare apical extrusion of NaOCl delivered with a 27-G irrigation needle, the EndoVac, the SAF, or passive ultrasonic irrigation during both instrumentation and the final irrigation of single-canal teeth.

Materials and Methods

In total, 42 pairs of single-canal bilaterally matching human teeth were used as study groups, and 2 pairs were used as controls. After extraction, the teeth were stored at room temperature in phosphate-buffered saline. A flat occlusal surface was made as a reference for determining the WL, and the pulp chamber of each tooth was accessed with a #2 round bur. The WL was determined as the point in which a #15 file was just visible at the root end with ×20 magnification. The root end was also inspected at the same magnification to verify closed apices and the absence of root resorption or visible cracks. Teeth with an apical diameter more than #30 as measured by a K-file were excluded. Each pair of bilaterally matching teeth was randomly assigned to either an apical size #30 or a size #50 group with 20 pairs in each.

The experimental groups were as follows: needle irrigation size #30 (NI30) and #50 (NI50), SAF size #30 (SAF30) and #50 (SAF50), passive ultrasonic irrigation size #30 (PUI30) and #50 (PUI50), and EndoVac size #30 (EV30) and #50 (EV50). Two other pairs of teeth were used as controls.

The teeth were fixed rigidly and secured to a modified flat-sided clear plastic container (Deneysel Medical Devices, Istanbul, Turkey) with dimensions of 4 × 3 × 3 cm using self-curing resin (Imicryl, Konya, Turkey) and embedded in a gel. A #15 K-file was placed at the WL in each canal to prevent the 0.2% agarose gel (Difco Laboratories, Sparks, MD; pH = 7.3–7.4) containing 1 mL 0.1% m-Cresol purple (Sigma-Aldrich, St Louis, MO) from getting into the canals. m-Cresol purple has a pH-sensitive color change (from yellow at pH = 7.4 to purple at pH = 9). A color change to purple indicated the extrusion of NaOCl (pH = 11.4) into the gel. All experiments were completed within 2 hours of the gel setting. Before instrumentation, a dental dam was placed on each tooth to prevent observation of the gel by the operator.

Each of the teeth in the NI30, SAF30, PUI30, and EV30 groups were instrumented to a size #30 master apical file with ProTaper Universal rotary instruments (S1, S2, F1, F2, and F3; Dentsply, Ballaigues, Switzerland). Each of the teeth in the NI50, SAF50, PUI50, and EV50 groups were instrumented to a #50 master apical file with ProTaper Universal tapered files (S1, S2, F1, F2, F3, F4, and F5). Apical patency was maintained by passing a #15 file to the WL after each rotary instrument in all groups.

Root canals were irrigated using 2 mL 5.25% NaOCl between all instrument changes. The final irrigation was performed with 2 mL 5.25% NaOCl and then 2 mL 17% EDTA followed by 2 mL 5.25% NaOCl. Irrigation in the needle groups was performed with a 27-G slot-tipped endodontic needle (Monoject; Tyco Healthcare, Mettawa, IL) and syringe. The needle was placed short of the binding point or 2 mm from the WL, and irrigants were delivered over 30 seconds. In the SAF groups, irrigants were delivered through the SAF file according to the manufacturer's protocol. In the passive ultrasonic irrigation groups, irrigants were delivered as described in the manufacturer's directions (NSK Varios 970; NSK, Tokyo, Japan). In the EndoVac groups, the irrigant was delivered via the delivery/evacuation tip at the orifice level. Two matched pairs were used as positive and negative controls to show color changes in the gel. One tooth in each pair was the positive control; the other was the negative control. Positive and negative control teeth were shaped at the WL to a size #30, at which point a file of corresponding size was placed to length and the gel was poured. After the gel had set, a 27-G endodontic slot-tipped needle was inserted into the positive control canals to the WL, and 0.5 mL NaOCl was delivered over 30 seconds. Negative control teeth were prepared as described for the positive controls except that they were irrigated with 0.5 mL saline (pH = 7.2–7.4) over 30 seconds at the WL. To standardize the time for diffusion of the dye, the gel was photographed at precisely 20 minutes after the initial irrigation with NaOCl. The gel was photographed digitally using a camera at a fixed distance. The standardized photographs were analyzed using Adobe Photoshop 7 (Adobe, San Jose, CA) to determine the area of the color change (expressed in pixels) (Fig. 1). The total number of pixels in each photograph was 3,630,168. The threshold showing apical extrusion of NaOCl was determined to be the pixel number greater than 2 standard deviations above the mean of the negative control group (477 pixels or 0.01% of the total area). The data were then analyzed using the Kruskal-Wallis, Mann-Whitney *U*, chi-square, and Fisher exact tests with the *P* value set at <.05.

Results

Positive controls had a mean affected area of 213,454 pixels or 5.88% of the total area. Negative controls had a mean affected area of 177 pixels or 0.01% of the total; this represents the outline of the roots in the photographs analyzed. Comparison of the 2 controls using the Mann-Whitney *U* test showed a significant difference ($P < .05$). The amounts of apical extrusion in the NI30, NI50, SAF30, SAF50, PUI30, PUI50, EV30, and EV50 groups were 30% (3/10), 50% (5/10), 20% (2/10), 70% (7/10), 40% (4/10), 40% (4/10), 10% (1/10), and 10% (1/10), respectively. The overall extrusion frequency, regardless of the apical preparation size, was 40% (8/20) for needle, 45% (9/20) for SAF, 40% (8/20) for ultrasonic irrigation, and 10% (2/20) for the EndoVac (Table 1). Although the SAF group resulted in apical extrusion in more teeth, the percentage of pixels was significantly higher in the needle irrigation group ($P < .01$, Table 2). The EndoVac group showed significantly lower extrusion values than the other techniques in terms of the mean number of teeth and pixels ($P < .05$ and <.01, respectively; Table 3).

Discussion

A sufficient volume of irrigant should be supplied to a mechanically instrumented space. However, it is difficult to irrigate the apical portion of the root canal system sufficiently to achieve satisfactory root canal debridement (29, 30).

The results of this study are consistent with those of Fukumoto et al (28), Desai and Himel (27), and Neilsen and Baumgartner (26), who concluded that negative pressure irrigation was a controlled, effective method of delivering irrigants into the apical third of the canal system. The results are also consistent with Brown et al (31) and Mitchell et al (12), who showed that positive pressure irrigation may force irrigants into the periapical tissues.

The amount of irrigant delivered between files and during the final irrigation was controlled to allow for a direct comparison between the 4 delivery techniques. A pilot study determined that the maximum amount of NaOCl evacuated by the microcannula when placed in a beaker was ~0.8 mL per 30 seconds and the maximum amount of NaOCl that the macrocannula could evacuate was ~9 mL per 30 seconds. Irrigation of 2 mL per 30 seconds was used in this study because this allowed passive