

# Comparison of Apical Extrusion of NaOCl Using the EndoVac or Needle Irrigation of Root Canals

Ross Paton Mitchell, DMD, Sung-Eun Yang, DDS, PhD, and J. Craig Baumgartner, DDS, PhD

## Abstract

**Introduction:** The purpose of this study is to compare extrusion of irrigants delivered with a 27-G needle or the EndoVac system (Discus Dental, Culver City, CA) during instrumentation and final irrigation of teeth.

**Methods:** Matched paired single canal teeth were divided into four sample groups and controls. The experimental groups were needle irrigation International Standards Organization (ISO) size #40 (N40) and #60 (N60) and EndoVac ISO size #40 (E40) and #60 (E60). Teeth were secured and embedded in 0.2% agarose gel (pH = 7.3–7.4) containing 1 mL 0.1% m-cresol purple, which changes color at a pH of 9.0. Teeth received NaOCl and EDTA irrigation with the 27-G slot needle or the EndoVac system. The amount of irrigation was controlled for each sample. Standardized digital photographs were taken 20 minutes after the first irrigant was used. Photographs were analyzed by using Adobe Photoshop 7 (Adobe, San Jose, CA) to determine the amount of extrusion expressed as percent of total pixels. **Results:** Data from sample groups show the following: N40 with 50% extrusion (6/12), E40 with 8.33% extrusion (1/12), N60 with 58.33% (7/12), and E60 with 8.33% (1/12). The overall extrusion frequency, regardless of apical preparation size, was 54.17% (13/24) for needle and 8.33% (2/24) for EndoVac. Analysis of N40 and E40 revealed  $p < 0.03$ . Analysis of N60 and E60 revealed  $p < 0.01$ . Comparison of needle irrigation versus EndoVac showed a significant  $p$  value of 0.0007. **Conclusions:** This study showed significantly less extrusion risk using the EndoVac system compared with needle irrigation. (*J Endod* 2010; ■:1–4)

## Key Words

EndoVac, extrusion, irrigation

From the Catholic University of Korea, Seoul, Korea; and Oregon Health & Science University, Portland, OR, USA.

Address requests for reprints to Dr J. Craig Baumgartner, Department of Endodontology, 611 Campus Dr, Portland, OR 97239. E-mail address: baumgarc@ohsu.edu. 0099-2399/\$0 - see front matter

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Endodontic irrigants are used to remove pulp tissue, microorganisms, microbial byproducts, and debris from the root canal system (1, 2). Complex root canal systems include many irregularities that make complete debridement a clinical challenge. It has been shown that 35% or more of the canal system is untouched by endodontic instruments (3). This finding highlights the importance of root canal irrigation and the chemical debridement and disinfection of the root canal system (3). Practitioners enlarge the canal space to better deliver irrigants such as sodium hypochlorite (NaOCl) to the apical third of the root canal system (4, 5). Current techniques inadequately debride the entire root canal system (6–9). It is likely that irrigants do not predictably reach all aspects of the canal, especially the apical third.

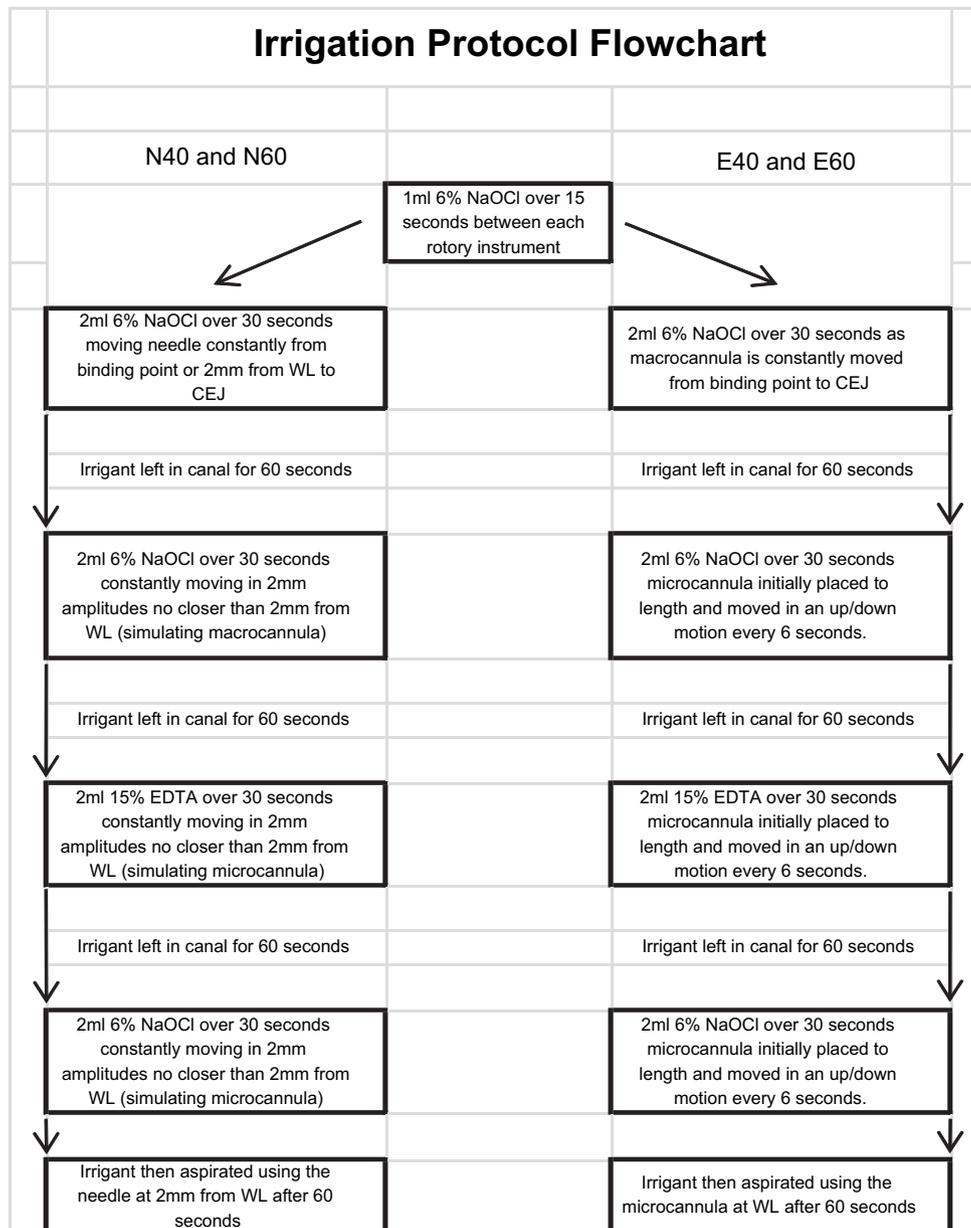
Irrigants are often delivered with either a 30- or 27-G endodontic slot tipped needle placed into the canal until just short of the binding point (10). The difficulty with this technique is that the depth of needle penetration is dependent on the size and morphology of each canal (ie, constriction and curvature). Predictable delivery of irrigants to the working length (WL) with needle irrigation is not often attained (11). If too little positive pressure is 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 commonly described as a NaOCl accident (12–16).

The EndoVac (Discus Dental, Culver City, CA) negative pressure irrigation system has been developed to address the procedural challenge of delivering irrigants safely to the WL. Nielson and Baumgartner (17) have shown that the EndoVac placed to the WL resulted in significantly better debridement at 1 mm from the WL compared with needle irrigation in teeth prepared to an ISO size #36 or larger. This showed that irrigants are delivered to the level of the microcannula. Desai and Himel (18) used water to compare the safety of available irrigation systems, with results showing no extrusion occurring in any of the EndoVac samples. The results of a study by Fukumoto et al (19) showed that an intracanal aspiration technique produced limited extrusion of irrigant versus conventional needle irrigation. The purpose of this investigation was to compare apical extrusion of NaOCl delivered with either a 27-G slot tipped endodontic irrigation needle or the EndoVac during both instrumentation and final irrigation of single canal teeth.

## Materials and Methods

Twenty-four pairs of single canal bilaterally matching human teeth were used as study groups, and four pairs were used as controls. Study pairs were as follows: maxillary: seven central incisors, one lateral incisor, and three canines and mandibular: four incisors, five canines, and four premolars. 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  $\times 20$  magnification. Simultaneously, the root end was inspected under the same magnification to verify closed apices and the absence of root resorption or visible cracks. Each tooth was then radiographed in a mesial/distal view to assess root curvature. Only roots with less than a  $20^\circ$  curvature were included in the study.

Each pair of bilaterally matching teeth was randomly assigned to either an apical size #40 or a size #60 group with 12 pairs in each group. Each tooth in a pair was then randomly assigned to either the needle group or the EndoVac group. The experimental groups were as follows: (1) group N40: needle irrigation prepared to size #40, (2)



**Figure 1.** An irrigation protocol flowchart outline for both needle and EndoVac groups.

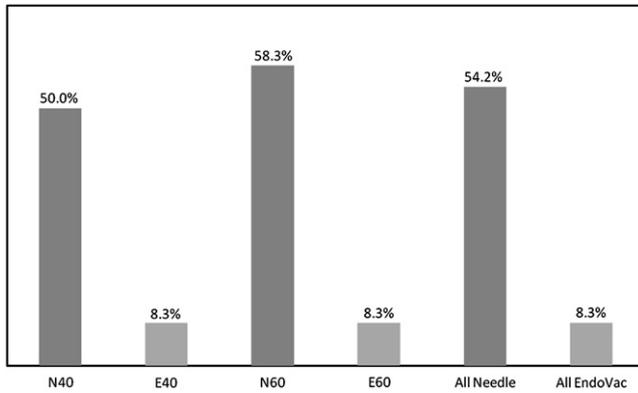
group E40: EndoVac prepared to size #40, (3) group N60: needle irrigation prepared to size #60, and (4) group E60: EndoVac prepared to size #60. Four other pairs of teeth were used as control teeth.

The teeth were rigidly fixed and secured to a modified flat-sided clear plastic container (SKS Industries, Watervliet, NY) with dimensions of 4.5 cm × 4 cm × 4 cm using self-curing resin (Lang Dental, Wheeling, IL) 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 a pH of 7.4 to purple at a pH of 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 N40

and E40 were instrumented to a size #40 master apical file by the crown-down continuous taper technique using Gates-Glidden drills (Dentsply Mailefer, Tulsa, OK), Orifice shapers (Dentsply, Tulsa, OK), and Profile .04 taper rotary instruments (Dentsply). Each of the teeth in N60 and E60 were instrumented to a #60 master apical file. Profile .04 tapered files were used to a size #40 followed by LightSpeed LSX (Discus Dental, Culver City, CA) files to apical size #60. Lightspeed was chosen for instrumentation to an ISO #60 because it only enlarges the apical area and does not affect the taper coronally. Apical patency was maintained by passing a #15 file to the WL after each rotary instrument in all groups.

Irrigation protocol for each group is outlined in Figure 1. Irrigation in the needle groups was performed with a 27-G slot tipped endodontic needle (27 × 1 1/4 slot, .4 mm × 31.7 mm; Monoject Tyco Healthcare, Mansfield, MA) and syringe. The needle was placed short of the binding point or 2 mm from the WL, and irrigants were



**Figure 2.** Percent extrusion of each study group. Analysis of N40 versus E40 ( $p = 0.03$ ). N60 versus E60 ( $p = 0.01$ ). Needle versus EndoVac ( $p = 0.0007$ ).

expressed over a defined time period. In the EndoVac groups, irrigant was delivered via the delivery/evacuation tip at the orifice level. All ISO #40 groups received a total irrigant volume of 20 mL NaOCl and 2 mL EDTA. All ISO#60 groups received a total irrigant volume of 24 mL NaOCl and 2 mL EDTA.

Four matched pairs were used as positive and negative controls to show color change within the gel. One tooth in each pair was the positive control, and the other was the negative control. Positive and negative control teeth were shaped at the WL to a size #40 at which point a file of corresponding size was placed to length and the gel was poured. After the gel was set, a 27-G endodontic slot tipped needle was inserted into the positive control canals to the WL, and 0.5 mL NaOCl was expressed over 30 seconds. Negative control teeth were prepared exactly the same as the positive controls except they were irrigated with 0.5 mL phosphate-buffered 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 exactly 20 minutes after the initial irrigation with NaOCl. The gel was positioned in front of a light box for transillumination and digitally photographed (Canon, Lake Success, NY) in a buccal/lingual direction by using a camera at a fixed distance (29.5 cm). The standardized photographs were analyzed by using Adobe Photoshop 7 (Adobe, San Jose, CA) to determine the area of the color change expressed in pixels. The total number of pixels in each photograph was 6,291,456. The threshold showing apical extrusion of NaOCl was determined to be the pixel number greater than two standard deviations above the mean of the negative control group (25,747 pixels or .4% of the total



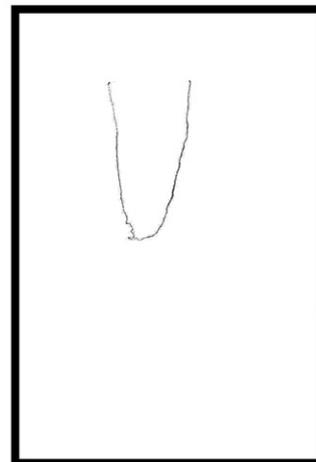
Picture 1050, Needle 40



Picture 1050 Analyzed: 167875 pixels demonstrating extrusion



Picture 1052, EndoVac 40



Picture 1052 Analyzed: 9649 pixels showing no extrusion

**Figure 3.** A representative matched pair sample.

area). The data was then analyzed by using the Fisher exact test with the one-tailed  $p$  value set at  $p < 0.05$ .

## Results

Positive controls had a mean affected area of 1,660,004 pixels or 26.39% of the total area. Negative controls had a mean affected area of 14,156 pixels or 0.23% of the total and represent the outline of the roots in the analyzed photos. Comparison of the two controls using the Mann-Whitney  $U$  test showed a significant difference ( $p = 0.0286$ ).

Data from sample groups are shown in Figure 2 and show the following extrusion frequency: N40 with 50.0% extrusion (6/12), E40 with 8.3% extrusion (1/12), N60 with 58.3% (7/12), and E60 with 8.3% (1/12). Therefore, the overall extrusion frequency, regardless of apical preparation size, was 54.2% (13/24) for needle irrigation and 8.3% (2/24) for the EndoVac. The analysis of N40 and E40 with the Fisher exact test revealed a one-tailed  $p$  value  $< 0.03$ , which was significant. The analysis of N60 and E60 revealed a significant result with  $p < 0.01$ . The comparison of N40 and N60 versus E40 and E60 showed a very significant  $p$  value  $< 0.0007$ . Figure 3 shows a representative matched pair from N40 and E40.

## Discussion

The results of this study are in agreement with Fukumoto (19), Desai and Himel (18), and Neilsen and Baumgartner (17), who concluded that negative pressure irrigation is a controlled effective method to deliver irrigants into the apical third of the canal system. Results also agree with Salzgerber and Brilliant (7) and Brown et al (20), who showed that positive pressure irrigation may extrude irrigants into the periapical tissues.

The amount of irrigant delivered between files and during final irrigation was controlled to allow for a direct comparison between the two delivery methods. A pilot study determined that the maximum amount of NaOCl evacuated by the microcannula when placed in a beaker was about .8 mL/30 seconds, and the maximum amount of NaOCl that the macrocannula could evacuate was about 9 mL/30 seconds. Irrigation of 2 mL/30 seconds was used in this study because this rate allowed for passive irrigation in the needle groups and provided adequate irrigation for the microcannula.

Recommendations for the use of needle irrigation include not binding the needle, not placing the needle to WL, and using a gentle expression of irrigant in order to avoid forcing irrigants into the periapex (10). In this study, the needle was not placed closer than 2 mm from the WL. In contrast, the EndoVac was used at the WL as recommended by the manufacturer. The results of this study reflect extrusion using the apical extent of “safe” endodontic needle placement and the manufacturer’s recommended location for the EndoVac at the WL.

Desai and Himel (18) compared extrusion using water as the irrigant in previously instrumented teeth open to atmospheric pressure. In this study, teeth were embedded in gel creating a closed system that more closely simulates the *in vivo* environment. The teeth were instrumented and irrigated similar to what is done in a clinical setting, and our results revealed that the frequency of extrusion past the apex is signif-

icantly increased when needle irrigation is used compared with the EndoVac. We also showed a trend that as you instrument to a larger apical diameter the likelihood that irrigants are extruded into the periradicular tissues increases if needle irrigation is used. In contrast, the risk remains constant if irrigation is performed using the EndoVac regardless of apical preparation size.

This study showed significantly less frequency of extrusion of NaOCl using the EndoVac compared with needle irrigation. Further research is needed to investigate the actual volume of irrigant reaching the apex with the EndoVac as well as the effect of the microcannula on the smear layer in the apical third.

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