Comparison of the Debridement Efficacy of the EndoVac Irrigation System and Conventional Needle Root Canal Irrigation *In Vivo*

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Abstract

Introduction: The purpose of this study was to compare the debridement efficacy of EndoVac irrigation versus conventional needle irrigation *in vivo*. **Methods:** Seven adult patients with a total of 22 matched pairs of single-canaled vital teeth with fully formed apices were recruited. Canals were instrumented to a master apical file size #40/.04 taper. One tooth from each matched pair was irrigated by using the EndoVac system. The other tooth was irrigated by conventional needle irrigation. Five additional teeth were used as positive controls. A #10 K-file was inserted into the control canals to determine working length (WL), with no other instrumentation or irrigation performed to confirm the presence of debris. The teeth were extracted, fixed, and decalcified. Six histologic slides each 6 μm thick were made from sections at 1 and 3 mm from WL and stained. The slide with the most debris was photographed at each level for each tooth. A Wilcoxon signed rank test was used to compare the percentage of debris remaining in the canals between the 2 irrigation techniques. **Results:** The median amount of debris remaining at 1 mm was 0.05% for the EndoVac group and 0.12% for the conventional irrigation group ($P < .05$). The median amount of debris remaining at 3 mm was 0.09% for the EndoVac group and 0.07% for the conventional needle irrigation group ($P > .05$). **Conclusions:** EndoVac irrigation resulted in significantly less debris at 1 mm from WL compared with conventional needle irrigation. There was no significant difference at the 3-mm level. *(J Endod 2010;36:1782–1785)*

Key Words

Conventional needle, debridement, debris, EndoVac, irrigation, root canal

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Irrigation of the root canal system is important in endodontic therapy (1). Peters et al (2) compared micro–computed tomography scans before and after mechanical instrumentation and found that regardless of the instrumentation technique, 35% or more of the root canal surfaces remained uninstrumented. Lateral canals, fins, and other irregularities might also remain uninstrumented and provide an environment for microbes to colonize and cause disease (3, 4). During root canal therapy, endodontic irrigants are delivered to the apical areas to help remove loose debris, dissolve organic tissues, kill microbes, and remove smear layer (5, 6).

In conventional needle irrigation, replenishment and exchange of irrigant in the apical third and the effectiveness of chemical debridement are dependent on the depth of penetration. Boutsioukis et al (7) showed in a computational fluid dynamic model that the exchange of irrigant only occurs 1–1.5 mm past a side-vented needle, and the irrigant beyond that point remains stagnant. Chow (8) also found that the exchange of irrigant does not extend much beyond the tip of the irrigating needle. Vapor lock that results in trapped air in the apical third of root canals might also hinder the exchange of irrigants and affect the debridement efficacy of irrigants (9). Studies have shown that conventional needle irrigation is less effective in cleaning the apical areas compared with the coronal areas of root canal systems (10–14).

An irrigation system called EndoVac (Discus Dental, Culver City, CA) might better deliver the irrigant to apical areas of canals and into root canal irregularities (15). The EndoVac system uses a suction needle placed at working length (WL). With negative pressure, the irrigant flows down from the pulp chamber into the canal to the apical areas. A study by Nielsen and Baumgartner (15) showed significantly better debridement at 1 mm from WL on extracted teeth by using the EndoVac compared with conventional needle irrigation. Shin et al (16) also showed that the EndoVac left significantly less debris behind than conventional needle irrigation.

To our knowledge, the extent of research on the debridement efficacy of the EndoVac is limited to *in vitro* studies. The aim of this *in vivo* study was to compare the debridement efficacy of EndoVac irrigation with conventional needle irrigation by using a 30-gauge ProRinse side-vented needle (Dentsply Tulsa Dental, Tulsa, OK).

Materials and Methods

Teeth Selection and Preparation

Seven adult patients with ages ranging from 36–70 years, with teeth treatment planned for extraction at Oregon Health & Science University (OHSU), participated in this study. The inclusion criteria included patients with American Society of Anesthesiologists status I or II and patients with single-canaled matched pairs of maxillary and mandibular incisors, canines, and premolars with vital pulps and completely formed apices treatment planned for extraction. Vital teeth were chosen to help reduce the variability of debris present in the matched pairs of teeth. Periapical radiographs of the teeth were reviewed to help confirm the presence of a single canal and formed apices. Teeth with severe periodontitis or gross caries were excluded from the study. Informed consent was obtained from each patient in accordance with approval by the OHSU Institutional Review Board. All clinical procedures were performed by the primary author (C.S.). The experimental procedures were based on those of Nielsen and Baumgartner (15). A flow chart of the protocol for the experimental and control groups is shown in Fig. 1.

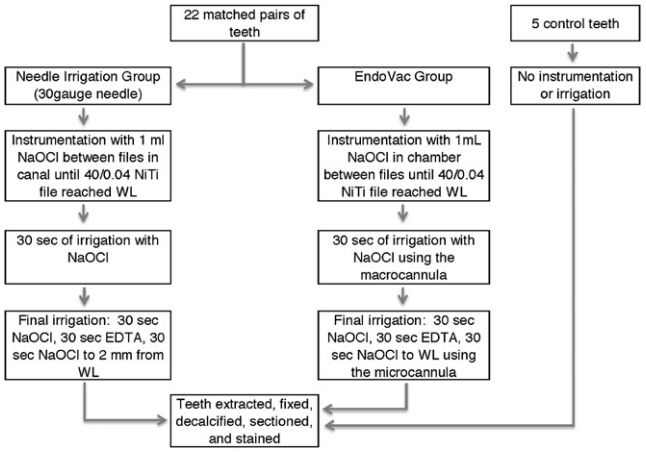

Figure 1. Flow chart of the methodology.

Experimental Procedures

Twenty-two matched pairs (44 teeth) were used. One tooth from each matched pair (22 teeth) received irrigation by using the EndoVac irrigation system (EndoVac group). The other tooth from each matched pair (22 teeth) received conventional needle irrigation by using a 30-gauge needle (conventional needle irrigation group). The method of irrigation with 5.25% NaOCl and 15% tetrasodium ethylenediaminetetraacetic acid (EDTA) (17, 18) was determined randomly by a flip of a coin. Each tooth in each pair received an equal amount of time for irrigation. Five additional teeth were used for the positive control group to confirm the presence of debris.

For all teeth, vitality was confirmed with cold tests and/or the electric pulp tester. After anesthesia was attained, a dental dam was placed. Access to the pulp chamber and the canal was made by using #4 carbide bur (Brasseler USA, Savannah, GA). All teeth in the experimental and control groups contained vital tissue and had a single canal on access.

For both the EndoVac and conventional needle irrigation groups, a #10 K-file was inserted to WL determined by an electronic apex locator, Apex NRG XFR (Medic NRG Ltd, Tel Aviv, Israel), to provide a glide path for the rotary files. The cervical bulge of dentin was removed by using sizes #2–#4 Gates-Glidden drills in a low-speed handpiece, followed by sizes #50–#30 nickel-titanium Orifice Shapers (Dentsply Tulsa Dental) in an electric rotary handpiece set at 300 rpm. The canals were instrumented to final size #40/.04 taper nickel-titanium rotary ProFiles (Dentsply Tulsa Dental) in a crown-down manner (14, 19, 20).

For the EndoVac group, irrigation began during the use of the Gates-Glidden drills. The irrigant was delivered into the pulp chamber by using a syringe tip placed above the access opening. Suction tubing attached to the syringe tip removed any excess irrigant. This allowed the canal and pulp chamber to be full of irrigant at all times. During instrumentation, 1 mL of 5.25% NaOCl was replenished after each rotary instrument. Once instrumentation was complete, when the master apical file reached WL, the canal was macroirrigated and microirrigated following manufacturer's instructions. Thirty seconds of macroirrigation with 5.25% NaOCl were accomplished by using a macrocannula inserted into the canal and moved up and down from a point where it bound to just below the orifice. The NaOCl was suctioned through the tip of the macrocannula while the NaOCl was constantly being replenished via the syringe tip. The irrigant was then left undisturbed for 60 seconds. Three cycles of microirrigation followed. Microirrigation was accomplished by using a microcannula placed at WL for 6 seconds, then 2 mm short of WL for 6 seconds, then at WL for 6 seconds, and then alternating between these positions for a total of 30 seconds. During microirrigation, the irrigant was constantly replenished. The microcannula was removed, and the irrigant was left undisturbed for 60 seconds. This completed 1 cycle of microirrigation. NaOCl was used in the first cycle. EDTA was used in the second cycle. NaOCl was used in the third cycle. After the final cycle of microirrigation, the microcannula was left at WL without replenishment to suction the remaining fluid. Paper points were inserted to WL to dry the canal.

For the conventional needle irrigation group, the pulp chamber and canal were irrigated by using a conventional syringe and 30-gauge ProRinse side-vented needle at a rate of 3 mL/min. A 1-mL flush of 5.25% NaOCl was used after each instrument, leaving the canal filled with irrigant between each instrument. During irrigation, the needle was placed short of the binding point in the canal and no closer than 2 mm to the WL. The needle was also moved up and down with 2-mm amplitude during irrigation. Once the master apical file reached WL, the canal received irrigation with 5.25% NaOCl for 30 seconds. The irrigant was then left undisturbed for 60 seconds. Three additional cycles of irrigation followed. Each cycle involved irrigation with the needle moving from 2 mm from WL to 4 mm from WL in constant motion for 30 seconds, followed by 60 seconds where the irrigant was left undisturbed. NaOCl was used in the first cycle. EDTA was used in the second cycle. NaOCl was used in the third cycle. The irrigant was aspirated from the canal by using a 30-gauge needle that was placed at WL. Paper points were inserted to WL to dry the canal.

For the positive control group, the pulp chamber was accessed, and #10 K-file was inserted into the canal to determine WL by using an electronic apex locator. No other instrumentation or irrigation was performed.

A piece of sponge was placed into the pulp chamber of each tooth, and the teeth were extracted. The sponge was removed, and the canal was gently irrigated with 0.5 mL of phosphate-buffered saline followed by 0.5 mL of formalin by using a 30-gauge needle at a rate of 0.5 mL/min at WL to remove red blood cells that might have entered the canal during tooth extraction and to allow fixation of any remaining debris and pulpal tissue. The teeth were then submerged in formalin for a minimum of 24 hours.

Teeth were marked at 1 and 3 mm from the WL on the external surface by using a 1/8 round bur (Brasseler USA) and decalcified in Kristenson's solution (102 g sodium formate, 1.5 L of hot water, 515 mL formic acid, and 925 mL of cold water) for at least 1 month. Root segments were cut at the 1- and 3-mm marks from WL with a scalpel. Six histologic slides that were 6 μm thick were made from each section at the 1- and 3-mm levels and stained with hematoxylin-eosin. The identification of each slide was masked and coded. The slides were randomized before viewing to facilitate blinded evaluation by the primary author. A light microscope at 100$\times$ magnification was used for viewing and comparing the slides. The slide with the greatest amount of debris from each section was digitally photographed. These images were evaluated by using the NIH Image J software program to quantify the percentage of debris left in the canals (14, 15, 19).

Statistical Analysis

Because the data were not normally distributed, Wilcoxon signed rank test was used to compare the remaining debris between the 2 irrigation techniques at each of the 2 depths, and medians were reported instead of means.

Results

One specimen was lost during processing at each level, leaving 21 matched pairs at the 1-mm level and 21 matched pairs at the 3-mm level. Table 1 shows the median, minimum, and maximum range of the debris remaining for each group. At the 1-mm level, there was

significantly less percentage of debris in the EndoVac group compared with the conventional irrigation group ($P < .05$). The median amount of debris remaining at 1 mm was 0.05% for the EndoVac group and 0.12% for the conventional irrigation group. At the 3-mm level, there was no significant difference between the 2 methods of irrigation. The median amount of debris remaining at 3 mm was 0.09% for the EndoVac group and 0.07% for the conventional irrigation group. The control teeth that were not instrumented and not irrigated had a median amount of debris of 29.25% and 23.27% at the 1-mm and 3-mm levels, respectively.

Discussion

In this study, we evaluated the amount of debris remaining in the canal for 2 different irrigation techniques. The EndoVac group resulted in significantly less debris at 1 mm from WL level compared with the conventional needle irrigation group. At the 3-mm level, no significant difference was found. Our results are in agreement with Nielsen and Baumgartner (15). Their study had similar findings, with significantly less debris remaining at the 1-mm level for the EndoVac group compared with conventional needle irrigation group and no difference at the 3-mm level. Although not directly comparable, it is interesting to note that the debris scores from this study at the 1-mm level are lower than those from Nielsen and Baumgartner: 0.05% versus 1.57%, respectively, for the EndoVac irrigation group and 0.12% versus 5.73%, respectively, for the conventional irrigation group. However, it is not a fair comparison because this study reported debris scores as median, whereas their study reported debris scores as mean. Shin et al (16) also reported similar results. They found that at both 1.5 mm and 3.5 mm from WL, EndoVac left significantly less debris behind compared with conventional irrigation with 24-gauge and 30-gauge needles.

The EndoVac group had less median amount of debris at 1 mm than at 3 mm. Other studies have shown the opposite where the amount of debris remaining is greater at the apical sections of the canal compared with the coronal sections (14–16, 19). When comparing the mean amount of debris remaining instead of the median, the percentage of debris remaining was indeed greater at the 1-mm level compared with the 3-mm level for both experimental groups.

There are a number of studies that have compared the microbial reduction efficacy of the EndoVac system with other irrigation techniques with conflicting results. Brito et al (21) compared the effectiveness of 3 irrigation techniques on the reduction of intracanal *Enterococcus faecalis* and found that there were no significant differences among conventional irrigation, conventional irrigation with activation by EndoActivator, and EndoVac irrigation. When Miller and Baumgartner (22) exposed the dentinal tubules in the apical 5 mm by crushing the root end, there was no statistically significant difference in the bacterial reduction between the EndoVac and conventional needle irrigation. When Hockett et al (23) used paper points to sample canal contents, they concluded that irrigation with the EndoVac resulted in significant microbial reduction compared with using a traditional irrigation delivery system. Townsend and Maki (24) found that ultrasonic irrigation was significantly more effective in removing intracanal bacteria than both needle irrigation and EndoVac irrigation.

In the convention needle irrigation group, we limited the depth of needle penetration to 2 mm from WL, similar to clinical use of needle irrigation (15). For the EndoVac group, the macrocannula was inserted short of binding, and the microcannula was inserted to WL as recommended by the manufacturer. Increased conventional needle penetration depth closer to WL has been correlated to increased bacterial reduction (25); however, increased needle penetration also increases the risk of irrigant extrusion past the apical foramen into the periapical tissues. NaOCl forced out the apex will cause severe inflammation, cellular destruction, hemolysis, and tissue necrosis (26–28). Mitchell et al (29) compared the extrusion of NaOCl by using EndoVac irrigation with conventional needle irrigation and showed that EndoVac irrigation resulted in significantly less extrusion than needle irrigation. Desai and Himel (30) compared the extrusion of EndoVac irrigation with manual irrigation with Max-I-Probe needle, EndoActivator irrigation, ultrasonic needle irrigation, and Rinsendo irrigation. They found that the EndoVac did not extrude irrigant, whereas the EndoActivator had minimal extrusion out the apex, and the Manual, Ultrasonic, and Rinsendo groups had a significantly greater amount of extrusion. In our study, no NaOCl accidents occurred in any of the experimental groups.

In our study, the rate of irrigant delivery into the canal was 3 mL/min for the conventional needle irrigation group. We did not measure the rate of irrigant delivery for the EndoVac group because the volume of irrigant reaching into the canal is independent of the amount of irrigant delivered from the syringe. Rather, it is dependent on the suction of the irrigant from the chamber into the tip of the microcannula and macrocannula. Brunson et al (31) showed that an increase in apical preparation size from #35 to #45 and an increase in preparation taper from 0.02 to 0.08 resulted in an increase of the volume of irrigant being delivered to the apical areas of the canal by using the microcannula. Their maximum average flow rates of 1.49 mL per 30 seconds and 1.48 mL per 30 seconds were achieved with apical preparation sizes #45/0.06 and #40/0.08, respectively. Their size #40/.04 taper resulted in a flow rate of 1.37 mL per 30 seconds.

Teeth with positive vitality tests were used in this study. Vital teeth were chosen to help reduce the variability of debris present in the matched pairs of teeth. The use of necrotic teeth might potentially contain less tissue debris or contain variable amounts of bacterial biofilm and debris. Further research is needed to compare the debridement efficacy of microbial biofilm and debris of these different irrigation systems.

In conclusion, the EndoVac group resulted in significantly less debris at 1 mm from WL level compared with the conventional needle irrigation group. No significant difference was found at the 3-mm level. The median amount of debris remaining at 1 mm was 0.05% for the EndoVac group and 0.12% for the conventional needle irrigation group. The clinical significance of the difference in median is unknown. Further research is needed to determine whether this difference in remaining canal debris affects clinical success.

TABLE 1. Amount of Debris at 1 mm and 3 mm WL

Group	Median (%)	*P* value	Minimum	Maximum
EndoVac 1 mm	0.05	.044*	0.01	4.39
Conventional needle 1 mm	0.12		0	9.73
EndoVac 3 mm	0.09	.266	0	7.58
Conventional needle 3 mm	0.07		0	7.62
Control 1 mm	29.25		21.69	74.58
Control 3 mm	23.27		6.06	88.83

WL, working length.

*Significant $P < .05$.

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The authors deny any conflicts of interest.

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