Comparison of Sealer Penetration Using the EndoVac Irrigation System and Conventional Needle Root Canal Irrigation

Aysun Kara Tuncer, DDS, PbD,* and Bayram Ünaı̇l, DDS, PbD†

Abstract

Introduction: The aim of this study was to compare the effect of the EndoVac irrigation system (SybronEndo, Orange, CA) and conventional endodontic needle irrigation on sealer penetration into dentinal tubules.

Methods: Forty single-rooted, recently extracted human maxillary central incisors were randomly divided into 2 groups according to the irrigation technique used: conventional endodontic needle irrigation and EndoVac irrigation. All teeth were instrumented using the ProFile rotary system (Dentsply Maillefer, Ballaigues, Switzerland) and obturated with gutta-percha and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) labeled with fluorescent dye. Transverse sections at 1, 3, and 5 mm from the root apex were examined using confocal laser scanning microscopy. The total percentage and maximum depth of sealer penetration were then measured.

Results: Mann-Whitney test results showed that EndoVac irrigation resulted in a significantly higher percentage of sealer penetration than conventional irrigation at both the 1- and 3-mm levels (P < .05). However, no difference was found at the 5-mm level. The 5-mm sections in each group showed a significantly higher percentage and maximum depth of sealer penetration than did the 1- and 3-mm sections (P < .05). Conclusions: The EndoVac irrigation system significantly improved the sealer penetration at the 1- to 3-mm level over that of conventional endodontic needle irrigation. (J Endod 2014;40:613–617)

Key Words

Confocal laser scanning microscopy, EndoVac, irrigation, sealer penetration

The main goal of endodontic treatment is to eliminate infection within the root canal system and prevent reinfection. Schilder (1) suggested that successful endodontic therapy can be achieved using mechanical instrumentation and chemical irrigation. Peters et al (2) found that regardless of the instrumentation technique used, 35% or more of the root canal surfaces remained uninstrumented. Because of the complex anatomic features of the root canal such as the lateral canals, isthmuses, and deltas, elimination of all debris and bacteria is impossible (3, 4), particularly in the apical third (5). Therefore, irrigation is an essential part of root canal debridement (6). Chemical irrigation agents such as sodium hypochlorite (NaOCl) and EDTA are able to penetrate these mechanically inaccessible areas (7), killing microorganisms, flushing debris, and removing the smear layer from the root canal system (8).

These irrigants must come in direct contact with the root canal wall for effective action (9). The degree of penetration of irrigants into the apical third of root canals is influenced by many factors, including the final apical preparation size (10), the maintainance of apical patency (4), the volume of irrigant used, the physical and chemical properties of the irrigant, and the presence of a vapor lock (11). Another important factor is the irrigant delivery method. Different irrigation delivery devices and techniques are available. Conventional needle irrigation does not allow the delivery of solutions beyond the tip of the irrigation needle (12). The EndoVac system (Sybronendo, Orange, CA), an apical negative pressure irrigation system, was developed to deliver irrigating solutions to the apical end of the canal system and suction out debris. This system has 3 components: the master delivery tip, which is designed for simultaneous irrigation and evacuation; the macrocannula, which removes coarse debris; and the microcannula, which allows for the removal of debris in the apical region (13). The EndoVac showed better removal of the smear layer in the apical third of the root canal than did needle irrigation (14).

In different studies, the effect of the EndoVac irrigation system on smear layer removal (15, 16), debridement efficacy (17, 18), bacterial elimination (19–21), and postoperative pain (22) have been evaluated. However, the effect of the EndoVac irrigation system on sealer penetration has not been studied. The aim of this study was to compare the effect of the EndoVac irrigation system and conventional endodontic needle irrigation on sealer penetration into dentinal tubules using confocal laser scanning microscopy. The null hypothesis tested was that there is no difference in the percentage and maximum depth of sealer penetration between the EndoVac irrigation system and conventional endodontic needle irrigation.

Materials and Methods

Forty recently extracted human maxillary central incisors with single canals, straight mature roots, and no caries or resorption were used in this study. The presence of a single canal was verified radiographically with 3 angulated radiographs. All experimental procedures were performed by a single operator.

After access cavity preparation with 4 surrounding walls, the working length was established by inserting a size 10 K-file (Mani Inc, Tochigi Ken, Japan) into each root canal up to the apical foramen and then subtracting 1 mm from this length. Root ends of all teeth were dried and sealed with glue to simulate in vivo conditions. Teeth were randomly divided into 2 experimental groups of 20 teeth each according to the irrigation
technique used: conventional needle irrigation using a 28-G needle (conventional endodontic needle irrigation group) and the EndoVac irrigation system (EndoVac group).

All teeth were instrumented using the ProFile rotary system (Dentsply Maillefer) with the crown-down technique to a size of 40/.04 at the working length. To ensure patency, recapitulation to the working length was accomplished after each rotary instrument series using a size 10 K-file.

In the conventional endodontic needle irrigation group, the root canals were irrigated using a 28-G side-vented needle (Max-i-Probe; Dentsply Rinn, Elgin, IL) and a syringe. The irrigation protocol for this study followed that used by Nielsen and Craig Baumgartner (14).

The canals were irrigated with 1 mL 5.25% NaOCl after each instrument, keeping the canal and the pulp chamber full of irrigant at all times. The irrigation needle was placed as deep as possible into the canal without binding to the canal wall but not closer than 2 mm from the working length. After instrumentation to the master apical file size, the canals were finally rinsed with 5.25% NaOCl for 30 seconds followed by rinsing with 17% EDTA and again with 5.25% NaOCl for 30 seconds.

In the EndoVac irrigation group, the master delivery tip of the EndoVac device was placed at the access opening to constantly deliver 5.25% NaOCl solution, filling up the root canal system. NaOCl (1 mL) was used to replenish the irrigant in the pulp chamber after each rotary nickel-titanium instrument, as in the conventional irrigation group. On completion of instrumentation to the size of the master apical file, macroirrigation was performed using 5.25% NaOCl with the microcan- nula constantly moving up and down in the canal from the point where it started to bind to a point just below the orifice. This step was accomplished in 30 seconds. NaOCl was then left untouched in the canal for 60 seconds. This rest period was followed by the 3 cycles of micro- irrigation. Each cycle of microcannular irrigation involved placing the tip at the full working length for 6 seconds, withdrawing 2 mm from the full working length for 6 seconds, and then returning back to the full working length for the next 6 seconds. This up-and-down motion continued until 30 seconds had elapsed. After 30 seconds of irrigation, the microcannula was withdrawn from the canal in the presence of sufficient irrigant in the pulp chamber to ensure that the canal remained totally filled with irrigant and that no air was drawn into the canal space, completing 1 microirrigation cycle. Irrigants were used as follows: first cycle, 5.25% NaOCl; second cycle, 17% EDTA; and the third cycle, 5.25% NaOCl. At the end of the third cycle, the microcannula was left at the working length to remove excess irrigant.

All the canals were dried with absorbent paper points (Dia- dent Group International Inc, Chongju, Korea) and obturated with AH 26 sealer (Dentsply DeTrey, Konstanz, Germany) and gutta-percha using the lateral compaction technique. For fluorescence under confocal laser scanning microscopy, AH 26 sealer was mixed with 0.1% fluorescent rhodamine B iso- thiocyanate (Be- reket Chemical Industry, Istanbul, Turkey). After the resin had completely set, each tooth was sectioned perpendicular to its long axis in 1-mm-thick sections using a slow-speed, water-cooled 0.3-mm microtome saw (Isomet Buehler) at points 1, 3, and 5 from the root apex. All sections were then polished with silicone carbide abrasive papers.

**Confocal Laser Scanning Microscopic Investigation**

All specimens were mounted onto glass slides and examined with a Leica TCS-SPE confocal laser scanning microscopy (Leica, Mannheim, Germany). The method used by Gharib et al (23) was applied to evaluate the images. First, each sample image was imported into Photoshop (Adobe Systems, Inc, San Jose, CA). In each sample image, the circumfer- ence of the root canal wall was outlined and measured with a Photoshop measuring tool. Next, areas along the canal walls in which the sealer penetrated into dentinal tubules were outlined and measured using the same method. The outlined lengths where sealer had penetrated were divided by the canal circumferences to calculate the percentage of sealer penetration into the canal wall.

**Results**

The percentage of sealer penetration and the maximum depth of penetration in the tested groups are reported in Figures 1 and 2. Representative pictures from each group are shown in Figure 3.
Mann-Whitney tests revealed that EndoVac irrigation resulted in a significantly higher percentage of sealer penetration than did conventional irrigation at both 1- and 3-mm levels \((P < \cdot 05)\). However, no difference was found at 5 mm. The Wilcoxon signed rank tests showed significantly different sealer penetration at 1, 3, and 5 mm within each experimental group.

Mann-Whitney tests revealed that EndoVac irrigation resulted in a significantly higher maximum depth of sealer penetration than did conventional irrigation at both the 1- and 3-mm levels \((P < \cdot 05)\). There was no significant statistical difference between the groups in the depth of penetration at 5 mm. The maximum depth of penetration within each experimental group was observed at 5 mm followed by 3 mm, with the least at 1 mm.

### Discussion

Apical preparation size and increased instrument taper might influence the efficacy of root canal debridement and irrigant flow. Although no consensus exists regarding the minimum apical preparation size or taper, in straight root canals (curvatures ranging from \(0^{\circ} - 10^{\circ}\)), an apical preparation ISO size of 40.04 is adequate to accommodate a sufficient irrigant volume in both positive- and negative-pressure systems \((24, 25)\). In addition, the microcannula of the EndoVac irrigation system can be used at the working length in a canal enlarged to ISO size 35 or larger \((14)\). Therefore, in the present study, apical size preparations were standardized to a size of 40/04. The 4-wall access cavity provided a strategic reservoir to hold a more effective volume of irrigant for exchange during irrigation \((26)\); thus, the volumes of irrigant used were standardized across the 2 irrigation groups as much as possible. An \textit{ex vitro} closed-end canal model was used to closely resemble clinical procedures because the root is enclosed within the bony socket.

In previous studies, the EndoVac irrigation system has been shown to be efficient at removing debris and the smear layer, especially in the apical area \((15–18)\). The EndoVac irrigation system is significantly more effective than the conventional irrigation needle in removing debris from root canals at 1 mm short of the working length but is not significantly better at 3 mm short of the working length \((14, 18)\). Saber and Hashem \((16)\) evaluated the effect of apical negative pressure, manual dynamic agitation, and passive ultrasonic irrigation on smear layer removal. Apical negative pressure and manual dynamic agitation resulted in better removal of the smear layer in the apical third, with no statistical difference between them. A possible explanation for this observation is that both techniques reach the full working length of the instrumented canals and hence allow adequate irrigant replacement, which is not possible or recommended with conventional needle irrigation or ultrasonic agitation devices. In contrast, Howard et al \((17)\) found no statistically significant differences in canal and isthmus cleanliness between EndoVac, PiezoFlow (Dentsply Tulsa Dental Specialties, Tulsa, OK), and Max-i-Probe groups at 2 and 4 mm from the working length. They reported that the depth and volume of irrigation were more important factors in removing debris and bacteria than was the type of method used.

In the present study, we did not directly observe the effect of the EndoVac irrigation system on the removal of the smear layer. Rather, confocal laser scanning microscopic analysis of sealer penetration into the dentinal tubule was used because removal of the smear layer from the root canal walls is considered to be essential for allowing sealer penetration into dentinal tubules. Therefore, sealer penetration into dentinal tubules can be used as an indicator for effective removal. In the present study, we evaluated the effect of the EndoVac irrigation system on the sealer penetration into dentinal tubules at 1, 3, and 5 mm from the working length compared with the conventional endodontic needle irrigation system. EndoVac irrigation resulted in a significantly higher percentage of sealer penetration than did conventional irrigation at both the 1- and 3-mm levels. The higher percentage of sealer penetration with EndoVac irrigation might be because of its effectiveness in removing debris from the
apical third of the root canal. EndoVac avoids air entrapment by using a continuous supply of fresh irrigant delivered by negative pressure to the working length. In addition, the orifices of the microcannula provide a portal of exit for canal debris in closed-end canal systems (15).

Previous studies have shown that conventional irrigation is effective for disinfecting the coronal and middle thirds of the root canals but are much less effective for the apical third (7, 14). The failure of conventional needle irrigation in the apical third might be attributed to several factors. The first factor is the vapor lock effect, which prevents the irrigant from effectively reaching the working length (11). The second factor is placement of the needle minimally 2 mm short of the working length to prevent extrusion of the irrigant, as in clinical use (14, 15).

The dilemma remains that an effective irrigation system is needed that can penetrate deeply into the apical endodontic system but at the same time does not cause extrusion of irrigants beyond the apex (28). To simulate the clinical situation in the present study, the conventional needle was placed no closer than 2 mm from the working length. Previous studies showed that if the needle was placed 2 mm short of the working length, the needle allowed the release of the irrigant solution 1–1.5 mm deeper into the canal (11, 12). However, results of the study by Munoz and Camacho-Quadra (29) showed that the irrigant only penetrated 0–1.1 mm deeper than the tip of the needle. The results of that study might explain why sealer penetration in the present study was lower using a conventional endodontic needle than EndoVac irrigation at both the 1- and 3-mm levels.

The results of the present study show that with both types of irrigation the percentage and maximum depth of the sealer penetration were greatest at the 5-mm level compared with the 3- and 1-mm levels (30, 31). This observation may be the result of the low numbers of dentinal tubules, lower tubule density, and the presence of more sclerotic dentin in the apical area than in the coronal dentin (32).

Within the limitations of the present study, we conclude that the percentage and maximum depth of sealer penetration using EndoVac irrigation were significantly better than conventional endodontic needle irrigation at 1 and 3 mm (but not 5 mm) short of the working length. Therefore, the null hypothesis was rejected. Further studies are needed to evaluate the effect of the EndoVac irrigation system on sealer penetration in complex, narrow, and curved root canals.

Acknowledgments

The authors deny any conflicts of interest related to this study.

References

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