Comparison of Endovac irrigation system with conventional irrigation for removal of intracanal smear layer: an in vitro study

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Aim. This study comparatively evaluated the efficacy of Endovac irrigation system with conventional needle irrigation in removing smear layer from the root canal.

Study design. Thirty permanent maxillary central incisors were divided into 3 groups of 10 teeth each. In group I, the teeth were instrumented and irrigated by conventional irrigation using 27-gauge irrigation needle. In group II, irrigation was done using Endovac irrigation system. In group III (negative control) chemomechanical preparation was performed using saline solution. Scanning electron microscope evaluation was done for assessment of smear layer removal in the coronal, middle, and apical thirds.

Results. Data were analyzed using post hoc test and Kruskal-Wallis test for significance at $P < .05$. Statistically significant difference was seen between the 2 test groups in smear layer removal from the apical third (3 mm) of the root canal, although no significant difference was seen in the coronal and middle thirds. The most efficient smear layer removal was seen in group II (Endovac) compared with other groups ($P < .05$).

Conclusions. The study showed significantly better removal of smear layer from the apical third of root canal using Endovac compared with conventional needle irrigation. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011; 112:407-411)

Thorough debridement is crucial for long-term success in root canal treatment. Hand and rotary instrumentation techniques produce an irregular, granular, and amorphous layer covering the root canal dentin, referred to as smear layer. Cobankara et al. showed that the presence of smear layer could negatively influence the coronal and apical seal of root canal–treated teeth. Removal of the smear layer is recommended, because it results in a more thorough disinfection of the root canals and would ensure better adaptation between the obturating materials and the canal walls.

Hand and/or rotary instrumentation along with needle irrigation does not effectively debride the entire root canal. Also, the intricacies within the apical third of the root canal make complete debridement a clinical challenge. Irrigation forms an essential part of root canal debridement, because it allows for cleaning beyond what might be achieved by root canal instrumentation alone. The mechanical and chemical effectiveness of the irrigant delivery system depends on its ability to deliver irrigants to the apical third and non-instrumented regions of the canal space. It should also have the ability to create a strong current to carry the debris away from the canal walls.

The Endovac system (Discus Dental, Culver City, CA, USA) was introduced in 2007 and was designed to safely deliver irrigants to the apical terminus of root canals. The device consists of a delivery/evacuation tip that is attached to a syringe containing the irrigant and high-speed suction of the dental chair. Using a combination of a macro- or a microcannula attached to the suction device, the irrigant is introduced into the pulp chamber that is then pulled by negative pressure down the canal into the tip of the cannula and removed through a coronally positioned suction hose. Measuring 0.32 mm in diameter, the microcannula can be placed to the working length provided the canal is prepared to a minimum size of ISO 35. Recent studies have shown promising results of the Endovac system compared with conventional syringe irrigation regarding debris removal, irrigant extrusion, and antimicrobial efficacy. However, no study has compared the smear layer...
removal efficacy of Endovac with the syringe needle irrigation technique. Therefore, the purpose of the present study was to compare the smear layer removal efficacy of Endovac with syringe irrigation at different levels in the radicular dentin.

MATERIAL AND METHODS

Thirty freshly extracted human permanent maxillary central incisors with intact mature apices were used for evaluation. All teeth were single rooted with a single canal, which was confirmed with multiple angulated radiographs. All teeth were devoid of caries, cracks, endodontic treatments, and restorations. The teeth were stored in 2% thymol solution at room temperature until used. Endodontic access was achieved and the canals were negotiated with an ISO size 15 K-file (Mani, Tochigi, Japan) until its tip just appeared through the apical foramen. The working length was established 1 mm short of the length when the tip of the file appeared beyond the apex. The samples were randomly divided into 3 groups of 10 teeth each based on the irrigant and irrigant delivery system used.

In group I, the coronal portion of the canal was flared using Gates-Glidden drills 1 to 3. The root canals were instrumented in a stepback sequence using K-files up to a master apical file size #60. To ensure patency, recapitulation was done to the estimated working length. One milliliter of 2.5% sodium hypochlorite was used to irrigate the canal after each instrument. With a 27-gauge needle placed 1 mm from working length during irrigation, the needle tip was constantly moved (1-2 mm) in a coronal-apical direction. After instrumentation to the master apical file size #60 with stepback up to size ISO 100, final irrigation was performed using 9.0 mL 2.5% sodium hypochlorite followed by 9.0 mL 17% EDTA and a final rinse with 9.0 mL saline solution.

In group II, irrigation with Endovac began after the use of Gates-Glidden drills. While the Gates-Glidden drills were being used, the Endovac delivery evacuation tip was placed above the access opening to constantly deliver and evacuate 2.5% sodium hypochlorite (used as a working solution). One milliliter of sodium hypochlorite was used to replenish the irrigant in the pulp chamber after each instrument. After reaching the working length with master apical file, macrorotation of the canal with 1 mL sodium hypochlorite was accomplished. This was done by using the Endovac delivery evacuation tip while the macrocannula was constantly moved up and down in the canal from a point where it starts to bind to a point just below the orifice. This was followed by irrigation using the microcannula placed 1 mm from the working length using 9.0 mL 2.5% sodium hypochlorite, 9.0 mL EDTA, and a final flush with 9.0 mL saline solution.

In group III, the same protocol for instrumentation was followed as in group I, but only saline solution was used as an irrigant.

After amputation of the crown at the cementoenamel junction, longitudinal grooves were cut on the mesial and distal surfaces of the roots by using a diamond disk under continuous water irrigation without penetrating through the canal. The roots were then split longitudinally with cutting pliers. One side of each canal was chosen randomly for scanning electron microscope (SEM) evaluation. After being air dried, the specimens were mounted with conductive adhesive onto metal bases, sputter-coated with gold, and viewed in an SEM (5800 LV; Jeol, Tokyo, Japan) under normal vacuum mode. Initially, the specimens were viewed under SEM at lower magnification to identify the representative areas (coronal, middle, and apical) of the root canal, following which each area was viewed under higher magnification for evaluation of smear layer removal. Each representative area was obtained from 3 different random points, and a mean score was obtained. Evaluation was done by 2 blinded evaluators. Intraexaminer and interexaminer reliability for SEM assessment was verified by kappa test. SEM photomicrographs of the 3 random representative areas were obtained at a magnification of ×5000 (Fig. 1). The efficacy of smear layer removal was assessed in accordance with the criteria proposed by Sadr-Lahijani et al. Intragroup analysis (Table II) showed no significant difference between the coronal and apical foramen. The working length was established 1 mm short of the length when the tip of the file appeared beyond the apex. The samples were randomly divided into 3 groups of 10 teeth each based on the irrigant and irrigant delivery system used.

RESULTS

Kappa test results, with a significance of 0.5, showed good interexaminer and intrarexaminer agreement, with values ≥0.9 for the different groups. Table I shows scores obtained for smear layer removal using the different irrigation systems. Group I (conventional syringe irrigation) and group II (Endovac) performed better than group III (negative control) at all levels of the radicular dentin. There was statistically significant difference between group I (conventional syringe irrigation) and group II (Endovac) in the apical 3 mm of root canal (P < .05), although coronal and middle third showed no significant difference (P > .05). Group II (Endovac) gave the best result in removing smear layer from the apical third of the root canal, whereas group III (negative control) showed the worst results at all levels of radicular dentin.

Intragroup analysis (Table II) showed no significant difference in smear layer removal between the coronal
and middle thirds in both test groups (group I and group II; \(P > .05\)). However, significant difference was seen between the coronal and apical thirds and between the middle and apical thirds, with none of the irrigation systems showing complete removal of smear layer (\(P < .05\)). Representative SEM images in the coronal, middle, and apical thirds of the 3 groups are shown in Fig. 1.

**DISCUSSION**

Syringe irrigation is still a widely accepted method of irrigant delivery by clinicians. It may be effective in cleaning the coronal third of the root canals but may not clean the apical third, because predictable delivery of irrigant to the working length with needle irrigation may not be obtained.\(^1,12\) This is because irrigant can progress only 1 mm farther from the tip of the needle.\(^4\) Lower positive pressure to deliver the irrigating solution does not allow the irrigant to reach close to the working length.

| Table I. Intergroup analysis for smear layer removal in the coronal, middle, and apical thirds |
|---------------------------------|---|---|---|
| Coronal third                   | n  | Mean \pm SD | Significant differences |
| Group I                         | 10 | 1.00 \pm 0.000 | I and III |
| Group II                        | 10 | 1.00 \pm 0.000 | II and III |
| Group III                       | 10 | 3.30 \pm 0.483 | III and I |
| Middle third                    | n  | Mean \pm SD | Significant differences |
| Group I                         | 10 | 1.80 \pm 0.422 | I and III |
| Group II                        | 10 | 1.50 \pm 0.527 | II and III |
| Group III                       | 10 | 3.70 \pm 0.483 | III and I |
| Apical third                    | n  | Mean \pm SD | Significant differences |
| Group I                         | 10 | 2.80 \pm 0.632 | I and II |
| Group II                        | 10 | 1.20 \pm 0.422 | II and III |
| Group III                       | 10 | 3.90 \pm 0.316 | III and I |

Fig. 1. Scanning electron microscopy (SEM) images in the (A) coronal, (B) middle, and (C) apical thirds of (I) group I (conventional syringe irrigation), (II) group II (Endovac), and (III) group II (negative control).
However, greater positive pressure and placement of the needle closer to the working length could increase the likelihood of periapical irrigant extrusion. Moreover, in the clinical scenario, because the root is enclosed within the bony socket, the root canal behaves as a closed-end channel. This results in gas entrapment at its closed end, producing the vapor lock effect, which prevents the irrigant to effectively reach the working length. This phenomenon can be overcome by the use of dynamic irrigation systems, because they avoid air entrapment due to continuous supply of fresh irrigant delivered by negative pressure to the working length.

Compared with syringe needle irrigation, hydrodynamic activation of the irrigant using pressure-alternating systems such as Rinsendo and Endovac has proved to be more effective for thorough debridement of root canal. This method allows the delivery of the irrigant to the working length, causing irrigant to reflux and displacing the debris coronally without inadvertent expression of the irrigant into periapical tissues. Endovac has been shown to be a controlled effective method to deliver irrigant to the apical third of the canal system. Heilborn et al. has shown Endovac to achieve better root canal cleaning at the apical third with less exposure time (150 s) than that required with traditional positive-pressure irrigation. Parente et al. showed that apical negative pressure irrigation (Endovac) was an effective method to overcome the fluid dynamics challenges inherent in closed canal systems. Rinsendo has shown greater penetration depth of the irrigant in the circumpulpal dentin of root section compared with conventional syringe irrigation; it also showed greater extrusion of irrigant periapically. Other agitation systems have been developed for more effective irrigant delivery, including machine-assisted agitation (sonics, ultrasonics, rotary brushes, and Quantec E irrigation system) and manual agitation using a well fitting gutta-percha point. Recently, Bronnec et al. in an ex vivo study showed 100% penetration of irrigant using active manual irrigation with a well fitting gutta percha point. But Desai and Himel in an in vitro study comparing the safety of various irrigation systems, such as manual, sonic, ultrasonic, Rinsendo, and Endovac reported no extrusion of irrigant in using Endovac irrigation system. Therefore, keeping in mind the efficacy of the irrigation systems in producing clean canals and at the same time avoiding periapical extrusion of irrigant, Endovac seems to be a promising delivery system.

In the present study, equal volumes (9.0 mL) of 2.5% sodium hypochlorite and 17% EDTA was used to the working length. This combination is standard accepted irrigating regimen for debriding and disinfecting the root canal as proposed by Zehnder et al.

Central incisors were enlarged to MAF 60 using step-back technique with sodium hypochlorite as a working solution between the instruments. Earlier studies have shown that the efficacy of canal debridement and irrigant flow improved as apical size preparation and instrument taper increased. Brunson et al. have also shown a 44% increase in the irrigant volume in the apical third of root canal when the canals were enlarged from ISO #35 (as recommended by manufacturers) to ISO #40 using Endovac. Therefore, in the present study, apical size preparation was standardized to ISO size 60 to improve the irrigant flow in the apical third of root canal. The results, however, cannot be generalized to teeth with smaller root diameters and/or curved canals.

The results of the present study showed better efficacy of Endovac compared with needle irrigation in the apical 3 mm of the root canal. Although the same volume of EDTA was used in both the groups, more efficient smear layer removal in the Endovac group may be due to the turbulence created with the help of the negative pressure with the Endovac system. Also, the direction of the fluid flow is from the coronal to apical in the case of Endovac, whereas it is from the apical to coronal in conventional needle irrigation.

Additionally, Endovac has the ability to deliver the irrigating solution to the working length with minimal chances of periapical extrusion. Better mechanical flushing action of the irrigant is achieved with Endovac as the irrigant can be introduced in the root canal with pressure. Endovac avoids air entrapment by continuous supply of fresh irrigant delivered by negative pressure to the working length. Additionally, as the apical size increases, there is a decreased chance of the holes in the microcannula to contact the root canal wall and becoming blocked. The larger area surrounding the microcannula allows for increased volume of irrigant reaching the microcannula tip, resulting in effective smear layer removal. Nielsen and Craig-Baumgartner also showed superior performance of Endovac compared with syringe irrigation in removing

### Table II. Intragroup analysis for smear layer removal in the coronal, middle, and apical thirds

<table>
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<tr>
<th>Group</th>
<th>n</th>
<th>Mean ± SD</th>
<th>P value</th>
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<tr>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronal</td>
<td>10</td>
<td>1.00 ± 0.000</td>
<td>.000</td>
</tr>
<tr>
<td>Middle</td>
<td>10</td>
<td>1.80 ± 0.422</td>
<td>.026</td>
</tr>
<tr>
<td>Apical</td>
<td>10</td>
<td>2.80 ± 0.632</td>
<td>.015</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronal</td>
<td>10</td>
<td>1.00 ± 0.000</td>
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<td>Apical</td>
<td>10</td>
<td>3.90 ± 0.316</td>
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 Due to the nature of dentinal tubules which are irregular and less in number, SEM is probably the best tool to identify organic and inorganic debris on the canal walls after endodontic preparation, allowing visualization of the dentinal tubules at a higher magnification and giving a detailed picture of the presence of smear layer surrounding peritubular dentin or occluding dentinal tubules. In the present study, even with the use of Endovac, complete removal of smear layer was not possible in the apical third of the root canal. This could possibly be due to the nature of dentinal tubules which are irregular and less in number. Whittaker and Kneale suggested relatively fewer dentinal tubules per unit area being present in the apical third of the root canal wall. But Carrigan et al. were of the opinion that it is difficult to evaluate the apical third of the root canal for smear layer removal, possibly owing to the smaller size of the dentinal tubules, which are often sclerosed compared with those in the coronal and middle thirds.

**CONCLUSIONS**

Within the limitations of the present study, we showed that both Endovac and conventional irrigation were equally effective in removing smear layer from the coronal and middle thirds of the root canal. However, in the apical third of the root canal, Endovac showed significantly better performance in removing smear layer compared with conventional syringe irrigation. However, both systems were ineffective in complete removal of smear layer from the apical third of root canal.

**REFERENCES**


**Reprint requests:**

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