A study to compare the cleaning efficiency of three different irrigation devices at different root canal levels (An in vitro study)

Ali H. Alani B.D.S M.Sc. (1)
Walid N. Al-Hashimi B.D.S. M.Sc. (USA) (2)

ABSTRACT
Background: Irrigation of the canal system permits removal of residual tissue in the canal anatomy that cannot be reached by instrumentation of the main canals so the aim of this study was to compare and evaluate the efficiency of conventional irrigation system, Vibringe sonic irrigation system and Endovac irrigation system in removing of dentin debris at three levels of root canals and to compare the percentage of dentin debris among the three levels for each irrigation system.

Materials and methods: Forty-five extracted premolars with approximately straight single root canals were randomly distributed into 3 test groups of 15 teeth each. All canals were prepared with Protaper Universal hand files to size #F4, and irrigated with 2.5% NaOCl 1ml between files and 5ml for 60 seconds as a final irrigant by different irrigation devices; group one, by using conventional system; group two, by using Vibringe sonic irrigation system and group three, by using the Endovac system. After the final irrigation, the roots were split longitudinally and photographed with a digital camera. The roots were magnified to 100X; a percentage of debris was calculated for the apical 0-3, 3-6 and 6-9 mm. The debris score was calculated as a percentage of the total area of the canal that contained debris as determined by pixels in Adobe PhotoshopCS2. Data were analyzed statistically by ANOVA and LSD at 5% significant level.

Results: when comparing the debris remaining, both the Endovac and Vibringe groups showed significantly less debris than the conventional group at all three levels (p < 0.01). The Endovac group showed significantly less debris than the Vibringe group at 3-9 mm levels while no significant difference found between the Endovac system and Vibringe system at a apical 0-3mm. The apical 0-3 mm showed significantly more debris than both the 3-6 and 6-9 mm for all groups.

Conclusion: the EndoVac system showed a higher cleaning capacity of the canal at all levels, followed by the protocols that used Vibringe sonic irrigation system. The conventional irrigation system with maxi-i-probe needles showed inferior results. The apical three millimeters showed a greater amount of debris than the 3-9 millimetres from the working length, regardless of the irrigation device used.

Key words: dentin debris, Vibringe, Endovac.

INTRODUCTION
Irrigation is an important phase of endodontic treatment. In addition to antimicrobial effects and tissue dissolution, microbiorganisms and debris are flushed out of the root canal by the washing action of the irrigant. Irrigants must be brought into direct contact with the entire canal area and especially with the apical portions of narrow root canals for optimal effectiveness. The penetration and flushing action of the irrigant depend not only on the anatomy of the root canal system but also on the system of delivery, the volume and fluid properties of the irrigant, and the size, type, and insertion depth of the irrigation needle (1). It has been demonstrated that debris accumulation is a potential side effect of root canal instrumentation, and that accumulated debris certainly has a negative impact on the sealing ability of root canal fillings, but it also may impede disinfection in cases with apical periodontitis (2, 3).

The effectiveness and safety of irrigation depends on the means of delivery. Traditionally, irrigation has been performed with a plastic syringe and an open-ended needle into the canal space. An increasing number of novel needle-tip designs and equipment are emerging in an effort to better address the challenges of irrigation. Throughout the history of endodontic, endeavors have continuously been made to develop more effective irrigant delivery and agitation systems for root canal irrigation (4).

The Vibringe (Vibringe BV, Amsterdam, the Netherlands) (figure 1) is the first endodontic irrigation device to combine manual delivery of the solution with the patented micro-processor controlled sonic technology, which called the...
sonic flow technology. This enables delivery and activation of the irrigation solution in one step.

Endovac system (Discus Dental, Culver City, CA, USA) (figure 2) is depending on the apical negative pressure for cleaning of the root canal with safely deliver irrigant to working length.

The purposes of this study are to Compare and evaluate the efficiency of maxi-i-probe (conventional irrigation system), Vibriinge (sonic irrigation system) and EndoVac (apical negative pressure irrigation system) in removing of dentin debris at three levels of root canal and to compare the percentage of dentin debris among the three levels for each irrigation system.

MATERIALS AND METHODS

A total of 45 extracted permanent single canal premolars teeth were used. Immediately after extraction, the teeth cleaned with cumine scaler to remove calculus and soft tissue debris then washed under tap water and kept in distilled water solution (5). Access preparations were made and patency established by passing a #10 K-file beyond the apex of all canals. Working lengths were determined by subtracting 0.5 mm from the length at which the #10 file first appeared at the apical foramen. The teeth were mounted in the surgical tube filled with silicon material within 1 mm apical to cemento-enamel junction (6). The teeth prepared with protaper hand system (Dentsply, Maillefer, Switzerland), the method of use was based on the balanced force technique. Shaping files SX were used to enlarge the coronal two third of the canal then the shaping continue with S1 and S2 files to the WL. The apical third prepared with finishing files F1 followed by F2, F3, and F4 in sequence to the full WL (7). The teeth were divided into three groups 15 teeth for each.

Group 1 served as conventional group, a 28-gauge Max-I-Probe needle (Maxp28i, Dentisply, rinn, USA.) attached to 5 ml luer lock syringe was used to deliver 1ml of 2.5% sodium hypochlorite to the canals between each files and 1 ml before SX protaper file. During irrigation, the needle was placed short of the binding point in the canal and no closer than 2 mm to the WL. The canals were irrigated with a final flush of 5 ml of 2.5% NaOCl. The Vibriinge system was used to activate the 2.5% NaOCl for 60 seconds. The needle was also moved up and down with 2-mm amplitude during irrigation.

Group 3 received apical negative pressure irrigation by the EndoVac system. Irrigation with the EndoVac began before the use of SX file. Before the SX file was being used, the EndoVac delivery/evacuation tip was placed above the access opening to constantly deliver and evacuate 1 ml of 2.5% sodium hypochlorite (NaOCl), keeping the canal and pulp chamber full of irrigant at all times. One millilitre of NaOCl was used to replenish the irrigant in the pulp chamber after each protaper file. After reaching working length with F4 file, macroirrigation of each canal with 2ml of 2.5% NaOCl was accomplished over a 30 second period. 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 started to bind to a point just below the orifice. Three cycles of microirrigation followed. During a cycle of microirrigation, the pulp chamber was maintained full of irrigant while the microcannula was placed at working length for 6 seconds. The microcannula was then positioned 2 mm from working length for 6 seconds and then moved back to working length for 6 seconds. This up-down motion continued until 30 seconds had elapsed, thus ensuring 18 seconds of active irrigation directly at working length. Three ml of 2.5% of NaOCl was used during the microcannula irrigation. After the final cycle of microirrigation, the microcannula was left at WL without replenishment to suction the remaining fluid (6, 9). The canals were dried by protaper paper point and the access cavities were closed by cotton pellet and temporary filling (10).

Guiding lines were made horizontally and longitudinally by blue marker before sectioning. The horizontal groove was made at cemento-enamel junction and the roots were longitudinally grooved with a diamond disk.

The crowns and roots were split by placing chisel in the groove and striking the chisel with a small mallet. The buccolingual longitudinal section of each root with≤180° of the canal circumference was selected for study. The sections with >180° of canal circumference...
would possibly interfere with total canal visualization during photography (11).

Images of the split roots were made using a Nikon D40 digital camera (Nikon Corp., Tokyo, Japan) at a 1:1 setting. The images were transferred to a computer with Adobe Photoshop cs2 software (Adobe Systems Inc., San Jose, CA) and enlarged to 100 x the original size. Lines were superimposed over the canals at 0, 3, 6 and 9 mm from the apical constriction. The debris in each canal was traced and the total number of pixels occupied by the debris was reported by using the histogram function in the software program. The outline of the canal up to 9mm was then traced and the same feature of the software reported the total pixels occupied by the canal. Percentage of debris was calculated by dividing the pixels of debris at each level by the total pixels representing the entire area of the canal. Percentage of debris was calculated for 3 levels (11-13).

The data were collected and analyzed using SPSS (version 15) for statistical analysis. One-Way Analysis of Variance (ANOVA) and least significant difference test (LSD) was used to determine whether there is a statistical difference among the groups and within group at different levels with a significance level of p ≤ 0.05.

RESULTS

The mean percentage of debris remaining in experimental groups is shown in Table 1 and Figure 3.

The comparison between the three irrigation systems in removing of dentin debris at each level

One way ANOVA showed that there was a highly significant difference among all groups at all levels (p < 0.01). By performing the least significant difference test (LSD), at (0-3mm) level high significant differences (p<0.01) were found between Maxi-I-probe and both Vibringe and Endovac. While no significant difference was found between Vibringe and Endovac. At (3-6mm) level high significant differences (p<0.01) were found between Maxi-I-probe and both Vibringe and Endovac, also highly significant difference was found between Vibringe and Endovac. At (6-9mm) level high significant differences (p<0.01) were found between maxi-I-probe and both Vibringe and endovac, a high significant difference between Vibringe and Endovac.

The percentage of dentin debris remaining at three difference levels for each irrigation system

The percentages of dentin debris remaining at 3- 6mm and 6-9 mm levels were significantly less than found at apical 0-3mm level for all groups, while the 3-6mm level showed no significant difference with 6-9mm level in percentage of dentin debris for all groups.

Table 1: Descriptive statistical analysis for the percentage of debris remaining at three levels for three irrigation systems

<table>
<thead>
<tr>
<th>levels</th>
<th>Tested groups</th>
<th>n</th>
<th>Mean %</th>
<th>±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3 mm</td>
<td>Maxi-I-probe</td>
<td>15</td>
<td>2.9737</td>
<td>0.42568</td>
</tr>
<tr>
<td></td>
<td>Vibringe</td>
<td>15</td>
<td>0.8271</td>
<td>0.15933</td>
</tr>
<tr>
<td></td>
<td>Endovac</td>
<td>15</td>
<td>0.6750</td>
<td>0.05227</td>
</tr>
<tr>
<td>3-6 mm</td>
<td>Maxi-I-probe</td>
<td>15</td>
<td>1.2659</td>
<td>0.26103</td>
</tr>
<tr>
<td></td>
<td>Vibringe</td>
<td>15</td>
<td>0.5290</td>
<td>0.06858</td>
</tr>
<tr>
<td></td>
<td>Endovac</td>
<td>15</td>
<td>0.3264</td>
<td>0.04438</td>
</tr>
<tr>
<td>6-9 mm</td>
<td>Maxi-I-Probe</td>
<td>15</td>
<td>1.0668</td>
<td>0.17952</td>
</tr>
<tr>
<td></td>
<td>Vibringe</td>
<td>15</td>
<td>0.5395</td>
<td>0.07618</td>
</tr>
<tr>
<td></td>
<td>Endovac</td>
<td>15</td>
<td>0.3402</td>
<td>0.06622</td>
</tr>
</tbody>
</table>
DISCUSSION

The mechanical flushing action created by conventional hand-held syringe needle irrigation is relatively weak. After conventional syringe needle irrigation, inaccessible canal extensions and irregularities are likely to harbor debris and bacteria, thereby making thorough canal debridement difficult. For these reason many devices and techniques were developed to overcome this weakness in cleaning of root canal. In our study three different irrigation systems were compared for their efficiency in removing of dentin debris; the conventional irrigation, the Vibringe system and the Endovac system.

The Percentage of debris was calculated for the 0- to 3-mm, 3- to 6-mm and 6-to 9 mm from WL levels for each canal. Reports on the efficacy of irrigation at different coronal-apical levels have been contradictory; therefore, 6-9 mm level was added to this method to evaluate debris removal not only from 0-6 mm but also from 6-9mm of the root canal.

The efficiency of the three irrigation systems at apical 0-3 mm level:

At the 0-3 mm level, both the Endovac and Vibringe systems resulted in less dentin debris remaining compared with the conventional needle irrigation system; the Endovac system showed least amount of dentin debris remaining among all groups but statically, no significant difference found between the Endovac system and Vibringe system. The results of comparison of Endovac group with conventional group at apical 0-3 mm are in agreement with previous study by, Siu and Baumgartnerin (9); and Shin et al (15). The explanations for these results might be related to 1. The depth of the irrigation needles; in the conventional needle irrigation group, we limited the depth of needle penetration to 2 mm from WL, similar to clinical use of needle irrigation. With the Endovac, irrigant is pulled into the canal and removed by negative pressure at working length; the microcannula was inserted to WL (6).

Increased conventional needle penetration depth closer to WL has been correlated to increased debris reduction (16); 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 (17).

Desai and Himel (18) found that the Endovac was able to be used to the working length very safely, without extrusion of irrigating solution beyond the apical constriction of the canal.

2. The volume of irrigant delivered to the canal apically by the Endovac system was significantly higher than the volume delivered by conventional syringe needle irrigation during the same time period (6).

The superior efficiency of the Vibringe group in removing dentin debris at 0-3mm level is in agreement with Rödig et al. (19). They found that the Vibringe System performed significantly better than conventional syringe irrigation in the apical part of the root canal. In spite of the Vibringe and conventional groups used the same type and gauge needles (maxi-I-probe gauge 28 which equivalent to ISO size 40) and the Vibringe system only activated at the final irrigation. However, the Vibringe show superior removal of dentin debris at apical 0-3mm level because of the oscillation amplitude of the sonically activated irrigation needle, resulting in an increased fluid velocity and increasing the capacity of sodium hypochlorite to dissolve organic tissue and removing of debris (20,21).

While the limitations of positive-pressure irrigation (conventional irrigation) alone, particularly at the apical third, might be related to the presence of gasses in the apical region forming a vapor lock into which further fluid penetration is difficult (22).

The efficiency of the three irrigation systems at 3-6 mm and 6-9 mm from WL levels:

At the 3-6 mm and 6-9mm levels, The Endovac system resulted in less dentin debris remaining compared with the Vibringe or conventional needle irrigation. Also the Vibringe
system resulted in less dentin debris remaining compared with conventional needle irrigation. The high efficiency of the Endovac systems at 3–9 mm level were coincide with Shin et al (15), Shin et al found that at 3.5 mm from WL, Endovac left significantly less debris behind compared with conventional irrigation with 24-gauge and 30-gauge needles. The efficiency of the Endovac at these levels could be due to the macrocannula design; the macrocannula is a plastic cannula with an open end that measures (ISO) size 55 with a 0.02 taper. This design made the macrocannula act like Manual-Dynamic irrigant system and negative pressure system at the same time; the open end acted to sucking of irrigation solution with debris. The push-pull motion of a plastic macrocannula in the canal might generate higher intracanal pressure changes during pushing movements, leading to more effective delivery of irrigant to the "untouched" canal surfaces (23).

The amount of dentin debris among three levels

The percentages of dentin debris remaining at 3–6 mm and 6–9 mm levels were less than found at apical 0–3 mm level for all groups, while the 3–6 mm level showed no significant difference with 6–9 mm level in percentage of dentin debris for all groups. Because of these result found among all groups so the possible reason may be related to the type of instrumentation and internal canal morphology. The apical instrumented space was narrowest than the middle and coronal region so less amount of irrigation delivered to these area and also the complexity and irregularity of these area (23). Furthermore, once the file reaches the working length, subsequent files contact mainly the apical area, and in turn, more debris can be packed into the dentinal tubules in this narrow space.

The method of determining the percentage of debris used in this study removes the subjectivity of some previous studies where evaluators gave canals a score of no, light, moderate, or heavy for the amount of remaining debris. This method gives the amount of remaining debris as a percentage of the total area of the canal, thus making a better comparison of the different techniques used. Also this method of determining the percentage of debris gave more precise result of dentin debris remained over the entire canal while in histological evaluation method only parts of the canal evaluated after transverse cross section, only 15 slices from 765 were examined (26,19).

REFERENCE


