Effects of Root Canal Preparation on Apical Geometry Assessed by Micro–Computed Tomography.

Frank Paque´, Dr med dent, Daniel Ganahl, med dent, and Ove A. Peters, DMD, MS, PhD

ABSTRACT
Previous micro–computed tomography analyses of root canal preparation provided data that were usually averaged over canal length. The aim of this study was to compare preparation effects on apical root canal geometry.

METHODS
Sixty extracted maxillary molars (180 canals) used in prior studies were reevaluated for analyses of the apical 4 mm. Teeth were scanned by using micro–computed tomography before and after canal shaping with Flexmaster® (VDW GmbH), GT-Rotary (Dentsply), LightSpeed™ (Kerr Endodontics), ProFile™ (Dentsply), ProTaper™ (Dentsply), instruments or nickel-titanium K-files for hand instrumentation. Data for canal volume changes, the structure model index (quantifying canal cross sections), and untreated surface area were contrasted by using analysis of variance and Scheffe’ tests.

RESULTS
Mean mesiobuccal, distobuccal, and palatal canal volumes increased after preparation (P < .05), but differences were noted for preparation techniques. All canals were slightly rounder in the apical 4 mm after preparation indicated by nonsignificant increases in structure model index. Untreated areas ranged from 4%–100% and were larger in mesiobuccal and palatal canals than in distobuccal ones.

CONCLUSIONS
Apical canal geometry was affected differently by 6 preparation techniques; preparations with GT instruments to an apical size #20 left more canal surface untouched, which might affect the ability to disinfect root canals in maxillary molars.

Figure 1. Bar charts (means + STDEVs) of untreated canal areas for the apical 4 mm and overall canals. There were significant differences among techniques in the apical section, with GT leaving significantly more untreated area compared with all other techniques (P < .05). There were no significant differences when comparing the techniques for the full canal length.
Preparation of Oval-shaped Root Canals in Mandibular Molars Using Nickel-Titanium Rotary Instruments: A Micro-computed Tomography Study

Frank Paque`, Prof. Dr. med dent, Marc Balmer, med dent, Thomas Attin, Prof. Dr. med dent, and Ove A. Peters, MD, MS, PhD

ABSTRACT
This study evaluated the prepared surface areas of oval-shaped canals in distal roots of mandibular molars using four different instrumentation techniques.

METHODS
Teeth were prescanned and reconstructed using micro–computed tomography (MCT) scans at low resolution (68 μ). Forty-eight molars with ribbon shaped/oval distal root canals were selected and randomly assigned to four groups. Distal canals (n = 12 ea.) were prepared by circumferential filing using Hedstrom files to apical size #40 (group H/CF); with ProTaper nickel-titanium rotaries to finishing file 4 (F4) considering the distal canal as 1 canal (group PT/1); ProTaper to F4 considering buccal and oral aspects of the distal canal as 2 individual canals (group PT/2); ProTaper to F4 in a circumferential filing motion (PT/CF). Before and after shaping, teeth were evaluated using MCT at 34 μ resolution. The percentage of prepared surface was assessed for the full canal length and the apical 4 mm. Statistical analysis was performed using analysis of variance and Bonferroni/Dunn multiple comparisons.

RESULTS
Preoperatively, canal anatomy was statistically similar among the groups (p=0.56). Mean ± (STDEV) untreated areas ranged from 59.6% (±14.9, group PT/2) to 79.9% (±10.3, PT/1) for the total canal length and 65.2% to 74.7% for the apical canal portion, respectively. Canals in group PT/1 had greater untreated surface areas (p < 0.01) than groups PT/2 and PT/CF. Among all groups, amounts of treated surface areas were statistically similar in the apical 4 mm.

CONCLUSIONS
Preparations of oval shaped root canals in mandibular molars left a variable portion of surface area unprepared regardless of the instrumentation technique used. However, considering oval canals as two separate entities during preparation appeared to be beneficial in increasing overall prepared surface.

Figure 1. Panel with reconstructed models of distal roots of mandibular molars, representative for groups H/CF, PT/1, PT/2 and PT/CF. Green color indicates preoperative surfaces (top row), red color indicated postoperative surfaces (middle row). Superimposition (bottom row) illustrates amount and localization of uninstrumented areas. Roots are shown from the proximal aspect. Note that all techniques leave some root canal surface area uninstrumented.
ABSTRACT
The aim of this in vitro study was to determine whether irrigation with apical negative pressure was more effective than traditional positive-pressure irrigation in eradicating Enterococcus faecalis from preshaped root canals.

METHODS
Fifty-four extracted mandibular molars were instrumented to produce either a non-tapered or tapered preparation, sterilized, inoculated with E. faecalis for 30 days, and then randomly assigned into the following groups:

1. Non-tapered preparation and negative-pressure irrigation,
2. Non-tapered preparation and positive-pressure irrigation,
3. Tapered preparation and positive-pressure irrigation, and
4. Tapered preparation and negative-pressure irrigation.

Mesial canals were sampled before and after final irrigation and samples incubated aerobically for 48 hours at 37°C. Scanning electron microscopic analysis confirmed dense bacterial colonies in the positive control, consistent with biofilm formation.

RESULTS
A statistically significant difference was evident when comparing apical negative-pressure irrigation to positive-pressure irrigation (p = 0.004). There was no statistically significant difference in colony-forming units (CFUs) between sizes #35 and #45, nor between tapered and non-tapered preparation.

CONCLUSIONS
The results of this in vitro study showed that apical negative-pressure irrigation has the potential to achieve better microbial control than traditional irrigation delivery systems.

Figure 1. Positive control. SEM analysis. (A) At x 100, the presence of bacteria over the root canal surface is shown. (B–D) At x 1,000, x2,000, and x 4,000 respectively, the bacterial arrangement as biofilms is observed. (E) At x 4,500, note the cell aggregations of bacteria covering the dentinal tubules. (F) E. faecalis colonization of the root canal and dentinal tubules is confirmed at x 20,000.
Figure 2. Eight specimens of the positive pressure irrigation groups rendered a positive culture at the end of the incubation period. A significant statistical difference was evident when comparing the apical negative pressure irrigation versus positive pressure irrigation ($p = 0.004$).
Effect of Vapor Lock on Root Canal Debridement by Using a Side-vented Needle for Positive-pressure Irrigant Delivery

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ABSTRACT
This study examined the effect of vapor lock on canal debridement efficacy by testing the null hypothesis that there is no difference between a “closed” and an “open” system design in smear layer and debris removal by using a side-vented needle for irrigant delivery.

METHODS
Roots in the closed system were sealed with hot glue and embedded in polyvinylsiloxane to restrict fluid flow through the apical foramen during cleaning and shaping. For the open system, the apical foramen was enlarged and connected to the external environment via a channel within the polyvinylsiloxane to permit unrestricted fluid flow. Smear and debris scores were evaluated by using scanning electron microscopy and analyzed by using Cochran-Mantel-Haenszel statistic.

RESULTS
No difference in smear scores was detected between the 2 systems at all canal levels. Significant differences in debris scores between the 2 systems were found at each canal level: coronal (P < .001), middle (P < .001), and apical (P < .001).

CONCLUSIONS
The null hypothesis was rejected; presence of an apical vapor lock effect adversely affects debridement efficacy. Thus, studies with unspecified or questionable mechanisms to restrict fluid flow through the apical foramen have to be interpreted with caution.

Figure 1. A micro-CT snapshot of a shaped canal from the closed system group after delivery of CsCl. Radiopaque carbon paint was applied over the solidified glue surface to enhance the contrast (pointer). A vapor lock with an air bubble on top was produced along the apical end of the canal space (open arrowheads).
Figure 2. Representative scanning electron micrographs (MG) taken from different parts of the cleaned and shaped canal walls. MGs arranged on the left (A, C, and E) and right (B, D, and F) sides of the plate were derived from the closed system and open system groups, respectively. (A) Along the apical 2 mm zone, the canal wall was sclerotic with minimal tubules (asterisk). For the closed system, this zone was heavily covered with loose debris and some smear layer remnants. (B) For the open system, the apical 2 mm zone was sclerotic but devoid of the smear layer and had minimal debris. (C) A high magnification view of the region marked by the asterisk in (A). Particulate smear layer remnants (open arrowhead) were attached to the surface of the demineralized collagen matrix. (D) A high magnification view of (B) showing a clean, smear layer–free and debris-free fibrous collagen matrix. No sign of dentinal tubules could be seen in this image. (E) A high magnification image representative of the middle and coronal thirds of the canal wall in the closed system. The dentinal tubules were mostly patent and devoid of smear plugs. However, smear layer remnants and articulate debris conglomerates (open arrowhead) could be seen adhering to the fibrous collagen matrix. (F) A high magnification image in the middle and coronal thirds of the canal wall in the control group. Tufted collagen fibrils could be identified from the surface of the smear layer–depleted, BioPure MTAD–demineralized intertubular dentin. Minimal debris was present.
Comparison of the EndoVac System to Needle Irrigation of Root Canals

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ABSTRACT

Past studies have shown that current irrigation methods are effective at cleaning root canals coronally but less effective apically. To be effective, endodontic irrigants should ideally be delivered near working length. The purpose of this study was to compare the efficacy of the EndoVac irrigation system and needle irrigation to debride root canals at 1 and 3 mm from working length.

METHODS

One tooth of each matched pair was instrumented and irrigated by using the EndoVac, which uses negative pressure to deliver irrigating solutions to working length. The other tooth of the matched pair was instrumented and irrigated with a 30-gauge ProRinse™ (Dentsply) irrigating needle. All teeth were irrigated with NaOCl and EDTA for a predetermined amount of time, and total volume of irrigant used was recorded. After instrumentation and irrigation, the teeth were fixed, decalcified, and sectioned at 1 mm and 3 mm from working length. Serial sections were made and digitally photographed. The amount of remaining debris was determined as a percentage of the area of the canal lumen. Remaining debris and total irrigant were analyzed by using the Wilcoxon signed rank test at the 5% confidence level.

RESULTS

At the 1 mm level, significantly less debris was found in the EndoVac group (p = 0.0347). At the 3 mm level, there was no significant difference between groups (Table 2). Significantly more irrigant was delivered with the EndoVac (p < .0001, Table 1).

CONCLUSIONS

The volume of irrigant delivered with the EndoVac system was significantly more than the volume delivered with needle irrigation over the same amount of time. With the EndoVac system, more irrigant can be delivered through the delivery/evacuation tip. While the cannulas are in the canal, a constant flow of fresh irrigant is being delivered by negative pressure to working length. This study showed significantly better debridement at 1 mm from working length by using the EndoVac compared with needle irrigation (Figure 2).

Figure 1. Pictures taken of representative slides at 1 mm from working length with 100x magnification. (A) No debris, (B) moderate debris, and (C) control sample showing moderate to severe debris with no instrumentation of the lumen.

Reference: J Endod 2007; 33: N/A “Study Summery”
### Table 1. Volume of Irrigant Used

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<th>Mean (mL)</th>
<th>STDEV</th>
<th>p Value</th>
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<td>EndoVac Irrigation</td>
<td>42.214</td>
<td>7.55</td>
<td>&lt;0.0001*</td>
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<tr>
<td>Needle Irrigation</td>
<td>15.714</td>
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*Significant p < 0.05.

### Table 2. The amount of debris at 1 mm and 3 mm from working length

<table>
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<th></th>
<th>Mean (%)</th>
<th>STDEV</th>
<th>p Value</th>
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<tr>
<td>EndoVac 1 mm</td>
<td>1.565</td>
<td>3.99</td>
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<td>Needle 1 mm</td>
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<td>EndoVac 3 mm</td>
<td>0.421</td>
<td>0.86</td>
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<tr>
<td>Needle 3 mm</td>
<td>2.825</td>
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*Significant p < 0.05.

Reference: J Endod 2007; 33: N/A “Study Summery”
Comparative Safety of Various Intracanal Irrigation Systems

Pranav Desai, BDS, DDS and Van Himel, DDS

ABSTRACT
The objective of this project was to evaluate the safety of various intracanal irrigation systems by measuring the apical extrusion of irrigant. The irrigation systems used were EndoVac, EndoActivator, manual irrigation with Mac-I-Probe needle, Ultrasonic Needle Irrigation, and Risendo.

METHODS
Twenty-two single canal, extracted mature teeth were instrumented and secured through the lid of a scintillation vial to collect apically extruded irrigant. A precision syringe pump delivered controlled amounts of irrigant at constant flow.

RESULTS
Results were analyzed by using one-way analysis of variance with Scheffé test (P < .05). The EndoVac Micro and Macro cannulae groups did not extrude irrigant, and there was no statistically significant difference between these two groups and the EndoActivator group. Within the groups that produced extrusion, EndoActivator extruded statistically significant less irrigant than Manual, Ultrasonic, and Rinsendo groups. There was no statistically significant difference among Manual, Ultrasonic, and Rinsendo groups.

CONCLUSIONS
This study concluded that the EndoVac did not extrude irrigant after deep intracanal delivery and suctioning the irrigant from the chamber to full working length. EndoActivator had a minimal, although statistically insignificant, amount of irrigant extruded out of the apex when delivering irrigant into the pulp chamber, placing the tip into the canal, and initiating the sonic energy of the EndoActivator. Manual, Ultrasonic and Rinsendo groups had significantly greater amounts of extrusion compared with EndoVac and EndoActivator groups.

Figure 1. Percent apical irrigant extrusion by group.