Innovations in Endodontic Irrigation

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Scientific Studies
- Safety
- Efficacy
- Antimicrobial

Mechanical Delivery

chemistry

DEBRIDEMENT
INFECTION
OBTURATION

Infected Tubules
Infected Tubules

There is no evidence, however, that special measures should be taken to kill the bacteria in the dental tubules. Should time permit, a sound obturation technique immediately following the cleaning, shaping and disinfection phases allows the remaining bacteria in the tubules to be either inactivated or prevented from repopulating the (former) canal space.

Peters, Westermink, Moor.
EDJ 1995 pg 95

Lasers

Chemistry

Irritants

Preparation Irrigants
- NaOCl (0.5 > 6%)
- Hydrogen Peroxide
- Citric Acid
- Ozonated Water
- EDTA
- BioPure
- Smear Clear
- QMix

Intracanal Medicaments
- Calcium Hydroxide
- CHX
- Formocresol
- Alcohol
- CMCP
- Iodoform Paste
- Beechwood Creosote

Which one or combo?
**Sodium Hypochlorite**
- Current irritant of choice
- Effective antimicrobial agent (Kanavel & Kanavel 1988, Leonardo et al. 1990)
- Excellent organic tissue solvent (O'Hara et al. 1993)
- Lubricates
- Effective fairly quickly

**Gross Canal Cleaning**

\[18\text{ClO}^- + \text{C}_6\text{H}_14\text{N}_2\text{O}_2 \rightarrow \text{18Cl}^- + 8\text{H}_2\text{O} + 2\text{NH}_3 + 6\text{CO}_2\]

**EDTA**

**17% Aqueous EDTA**
Cetrimide

Is it effective?

The following photography courtesy of:
Jantarat J., Yanpiset K., Harmirattisai C.

EDTA (17%)

REDTA (17%)

Smear Clear

Water
**Biofilm Formation of Endodontic Enterococcus Faecalis**

- Sessile microbial communities composed of cells irreversibly attached to a substratum and interface or to each other
- Slow metabolic rate of microorganisms deep in the biofilm impede the effectiveness of many antimicrobials

Duggan J, Sedgley Christine, JOE, July 2007

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**Chemistry of Endodontic Irrigation - Organic Debris**

<table>
<thead>
<tr>
<th>Solution</th>
<th>Presence of Bacteria</th>
<th>Biofilm Status</th>
<th>Culture Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>6% NaOCl</td>
<td>-</td>
<td>Absent</td>
<td>0%</td>
</tr>
<tr>
<td>5% NaOCl</td>
<td>+</td>
<td>Disrupted</td>
<td>100%</td>
</tr>
<tr>
<td>1% NaOCl</td>
<td>+</td>
<td>Disrupted</td>
<td>100%</td>
</tr>
<tr>
<td>1% NaOCl2/3M</td>
<td>+</td>
<td>Inert</td>
<td>0%</td>
</tr>
<tr>
<td>2% CHX</td>
<td>+</td>
<td>Inert</td>
<td>0%</td>
</tr>
<tr>
<td>Positive control</td>
<td></td>
<td>Absent</td>
<td>0%</td>
</tr>
<tr>
<td>Negative control</td>
<td></td>
<td>Inert</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Note: 17% EDTA used in all test groups prior to biofilm growth.*

Clegg, et. al. JOE 5/06 pg. 434-7

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**Interaction between Sodium Hypochlorite and Chlorhexidine Gluconate**

Precipitate observed when the medications interacted (Zehnder M, JOE, 2006, Vivacqua-Gomes et al, Int End J, 2002.)

Formation of Para-chloraniline may be toxic and carcinogenic therefore formation should be avoided by removing the NaOCL before placing CHX into the canal (Basran B et al, JOE, Aug 2007.)

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**Chemistry of Endodontic Irrigation - Organic Debris**

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**STOP**

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**CHLORHEXIDINE**

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Chemistry of Endodontic Irrigation - Organic Debris

<table>
<thead>
<tr>
<th>Test Agent</th>
<th>N</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% NaOCl</td>
<td>32</td>
<td>99.78 ± 0.306%</td>
</tr>
<tr>
<td>6% NaOCl</td>
<td>32</td>
<td>99.99 ± 0.000%</td>
</tr>
<tr>
<td>SwimClear™</td>
<td>32</td>
<td>70.05 ± 53.232%</td>
</tr>
<tr>
<td>2% CHX</td>
<td>32</td>
<td>40.49 ± 44.596%</td>
</tr>
<tr>
<td>EDTA</td>
<td>32</td>
<td>26.99 ± 29.992%</td>
</tr>
<tr>
<td>BioPuls™</td>
<td>32</td>
<td>16.88 ± 21.764%</td>
</tr>
</tbody>
</table>

Test: %

Different letters in the same row indicate statistically significant homogenous groups (p < 0.05)

Clegg, et. al. JOE 5/06 pg. 434-7

The Physics of Endodontic Irrigation

6% NaOCl + 17% EDTA

How Much?

How Long?

18Cl⁻ + C6H14N2O2

18Cl⁻ + 8H2O + 2NH3 + 6CO2

The Physics of Endodontic Irrigation

Rate = k(T) * [ClO⁻] * [C6H14N2O2]

% Weight Loss

Concentration NaOCl

Hand et. al. JOE 2/78 pg. 60-4

Sonic & Ultrasonic Agitation

Passive sonic after hand instrumentation produces a cleaner canal than hand instrumentation alone and is comparable with that of passive ultrasonics.

Jensen et. al. JOE 11/89 pg. 736-8

20 Grams Shrimp
75 ml 6% NaOCl
without Agitation

""
Sonic & Ultrasonic Agitation

“Although passive activation of sonic and ultrasonic after hand instrumentation produced cleaner canals than hand instrumentation alone, no technique was able to debride the canal system completely.”

Jensen et al. JOE 11/09 pg 735-8

“Debris was observed at all levels of the canal system, but tended to be concentrated in the apical 1 to 3 mm.”

Jensen et al. JOE 11/09 pg 735-8

“Why?”

Debris was observed at all levels of the canal system, but tended to be concentrated in the apical 1 to 3 mm.

Jensen et al. JOE 11/09 pg 735-8

Sonic & Ultrasonic Agitation

“The needle was placed as far as possible into the canal without bending, but never closer than 5 mm from the established working length.”

Jensen et al. JOE 11/09 pg 735-8

“But if you squirt...!!!”

Jensen et al. JOE 11/09 pg 735-8
Salzgeber & Brilliant, 1977

**Safety**

A. Ahonem & T. Jakobovics. JOE 10/2011 pg 1460-64

Upper Right Canine Systemic diffusion into periapical veins

**Mechanism of Action?**

**Anatomy of sodium hypochlorite accidents involving facial ecchymosis—A review**

A novel hypothesis that involves intravenous infusion of extruded NaOCl into the facial vein via non-collapsible venous sinusoids within the cancellous bone is presented.


**Anatomy of sodium hypochlorite accidents involving facial ecchymosis—A review**

Thus, NaOCl extruded though a patent tooth root foramen, an immature apex or a root canal perforation may easily and rapidly infuse into the facial vein, should there be an anatomic variation in the facial venous vasculature (Drake) and when the apically-directed fluid pressure gradient exceeds 30 mm Hg.

The Perfect Storm

Pressure > 30mm Hg

Available Vein

Patient Apex

"Inferior alveolar veins from the lower teeth and superior alveolar veins from the upper teeth drain mainly into the pterygoid plexus of veins in the infratemporal fossa, although some drainage from the anterior teeth may be via tributaries of the facial vein."


1) continuing severe pain for two to five minutes
2) immediate swelling (ballooning) of the area
3) spread of the tissue reaction to the surrounding areas
4) profuse hemorrhage, either internally and/or
5) intraorally through the tooth.
Final Irrigation Protocol

Efficacy

Case by Dr. Marga Ree

Instrumentation
MB1 & MB2 = #35/08
DI = 4001/10
P = 800/10

Irrigation
5% NaOCl
17% EDTA

Ultrasonic Activation

One (1) Month Recall

Diagnostic Flap
Chow's Paradigm

- Reach the apex
- Create a current (wall shear stress)
- Remove Debris

Wall Shear Stress

Wall shear stress effects of NINE different endodontic irrigation techniques and systems:

- Navitip™
- Maxi Probe™
- MDA- non and well fitting gp cones
- Endoactivator™ with medium and large points
- VPro EndoSafe
- VPro Steam Clean Continuous US irrigation
- EndoVac™ Apical Negative Pressure

Perhaps the most important factor is the delivery system and not the irrigating solution per se. Furthermore, it was found that the volume of the irrigant is more important than the concentration or type of irrigant.

**Wall Shear Stress**

**Results:**

EndoVac was the only technique that removed more than 99% calcium hydroxide debris from the canal fin at the predefined flow rate. This group was significantly different (p < 0.05) from the other groups that exhibited incomplete Ca(OH)2 removal.


**Conclusion:**

The ability of the EndoVac system to significantly clean more debris from a mechanically inaccessible recess of the model curved root canal may be caused by robust bubble formation during irrigant delivery, creating higher wall shear stresses by a two-phase air-liquid flow phenomenon that is well known in other industrial debridement systems.


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**ANP - EndoVac**

- Passive Ultrasonics
- \( \approx 1.8 \text{ ml/canal} \)
- \( \approx 0.0058 \text{ ml/canal} \)
- \( \approx 1.8/0.0058 = 310x \)

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**Rate = k(T) * [ClO\text{-}] * [C6H14N2O2]**

**% Weight Loss**

<table>
<thead>
<tr>
<th>Concentration NaOCl</th>
<th>1.25%</th>
<th>2.5%</th>
<th>1.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>60</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>60</td>
<td>40</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>40</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Hand et al., JOE 2:78 pg 69-4

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**Irrigant Delivery Systems**
Safety

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.


Periapical Pressures Generated

Periapical Pressures Developed by Nonbinding Irrigation Needles at Various Irrigation Delivery Rates

- Maxi Probe™
- Navitip™
- VPro EndoSafe
- VPro Steam Clean Continuous US irrigation
- EndoVac™ Microcannula


Periapical Pressures Generated

Conclusion:

EndoVac Microcannula was the only device that was capable of delivering negative apical fluid pressures, in the range of -35 mm Hg, at all fluid flow rates. All other devices generated positive apical pressures that increased non-linearly with increasing fluid flow rates.


Less Post Op Pain

The outcome of this investigation indicates that the use of a negative apical pressure irrigation device can result in a significant reduction of postoperative pain levels in comparison to conventional needle irrigation.


Emergency

-Courtesy Dr. Filippo Santacangelo
Efficacy
**Canal Debris**

**Nielsen & Baumgartner, JOE 5/2007 pg. 1040-43**

**TABLE 1. The amount of debris at 1 mm and 3 mm from working length**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean (%)</th>
<th>Standard Deviation</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EndoVac 1 mm</td>
<td>1.565</td>
<td>3.60</td>
<td>0.0347*</td>
</tr>
<tr>
<td>Needle 1 mm</td>
<td>5.730</td>
<td>10.05</td>
<td></td>
</tr>
<tr>
<td>EndoVac 3 mm</td>
<td>0.421</td>
<td>0.066</td>
<td></td>
</tr>
<tr>
<td>Needle 3 mm</td>
<td>2.825</td>
<td>0.26</td>
<td>0.1119</td>
</tr>
</tbody>
</table>

*Significant p < 0.05.

**Why?**

**Canal Debris**

**Paninta & Tay et al., IJE 2010 Nov 43(1):1001-12**

**Results:** The ability of manual dynamic agitation to remove smear layer and debris in a closed canal system was significantly less effective...than the EndoVac (P < 0.001).

**Canal Debris**

**Antimicrobial - Clinical**

**Bacteria in tubules after ANP**

**Comparison of the Antimicrobial Efficacy of Irrigation Using the EndoVac to Endodontic Needle Delivery**

**Miller & Baumgartner JOE 3/2010 pg. 309-11**

**Comparison of the Effectiveness of Three Irrigation Techniques in Reducing Intracanal Enterococcus faecalis Populations: An In Vitro Study**

**Brito et al. JOE 9/2009 pg. 1422-27**

**Antimicrobial - Clinical**

**Bacteria in tubules after ANP**

**Pulverized Teeth**

**Instrumented deep into wall**
Infected Tubules

There is no evidence, however, that special measures should be taken to kill the bacteria in the dentinal tubules. Should time permit, a sound obturation technique immediately following the cleaning, shaping, and disinfection phases allows the remaining bacteria in the tubules to be either inactivated or prevented from re-populating the (former) canal space.

Potter, Westoll, Moor
EJ 1995 pg 95

Lasers?

Isthmus Cleaning

“F” File
EndoActivator
Pressure Ultrasonic Needle
Passive Ultrasonic Irrigation
Side Vent Needle
EndoVac

Isthmus Cleaning Studies
@ WL - 1mm

Failure to Clean

22%

Failure to Clean

EndoActivator

Klym JOE 2010, pg. 1367-71
Antimicrobial

Antimicrobial efficacy of two irrigation techniques in tapered versus non-tapered canal preparation

In vitro study. 100% Negative Cultures in EndoVac Group and 67% Negative Cultures in Traditional Positive Pressure Group

Hockett J, Dormirsch J, Johnson JD, Cohens N. JDE Nov 2008

Antimicrobial in vitro

Traditional vs. EndoVac

p < .004

Hockett et al. JDE 11/2008 pg. 1374-7

Antimicrobial - Clinical

University of Washington

Antimicrobial - Clinical

University of Washington

Antimicrobial - Clinical

University of Washington

% Negative Cultures

100%

75%

50%

25%

0%

+ Pres

EndoVac
Case History

Clinician: Dr. F. Santarcangelo

14 year old boy

Clinical Considerations

Let Gravity Work!

System Synergy
Apical Shape

Pretreatment
User Friendly?

Cost?

$7-$10 per case

You can’t afford NOT to use Apical Negative Pressure!

Cost of Success?

Priceless!