Innovations in Endodontic Irrigation

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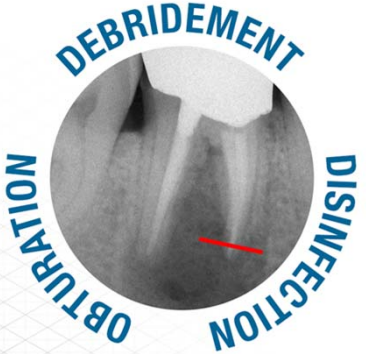
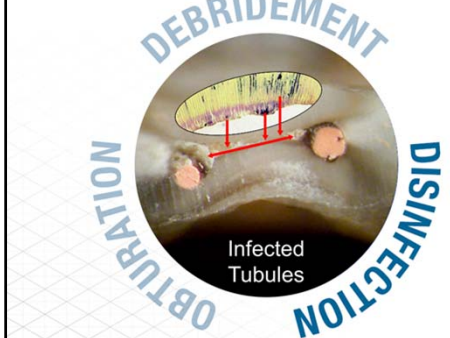
Scientific Studies

- ☑ Safety
- ☑ Efficacy
- ☑ Antimocrobial

Chemistry

Mechanical Delivery





Infected Tubules

The fate and the role of bacteria left in root dentinal tubules

L. B. PETERS, F. R. WESSELINK & W. R. MOORER

Department of Cariology and Endodontology, Academic Centre for Dentistry Amsterdam, Louwesweg 1, 1066 EA Amsterdam, The Netherlands

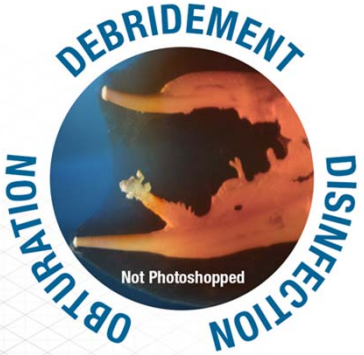
Summary

Introduction

Keywords bacteria, dentinal tubules, endodontic failure

> 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 repopulating the (former) canal space.

Peters, Wesselink, Moorer
IEJ 1995 pg 95



Lasers

Chemistry

Irritants

Preparation Irrigants	Intracanal Medicaments
NaOCl (0.5 > 6%)	Calcium Hydroxide
Hydrogen Peroxide	CHX
Citric Acid	Formocresol
Ozonated Water	Alcohol
EDTA	CMCP
BioPure	Iodoform Paste
Smear Clear	Beechwood Creosote
QMix	

Which one or combo?

Sodium Hypochlorite

- Current irrigant of choice
- Effective antimicrobial agent
  (Kuruvilla & Kamath 1998, Leonardo et al. 1999)
- Excellent organic tissue solvent (O'Hara et al. 1993)
- Lubricates
- Effective fairly quickly

Gross Canal Cleaning

Gross Canal Cleaning

$$18ClO^- + C_6H_{14}N_2O_2 \rightarrow 18Cl^- + 8H_2O + 2NH_3 + 6CO_2$$

EDTA

17% Aqueous EDTA

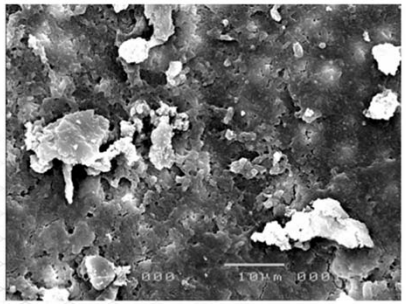
Cetrimide

Is it effective?

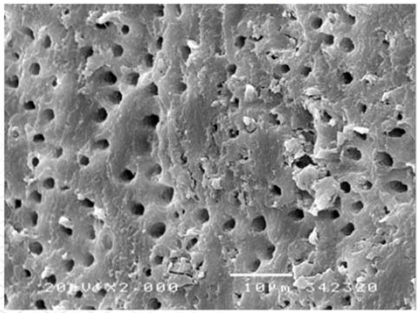
The following photography courtesy of:

Jantarat J., Yanpiset K., Harnirattisai C.

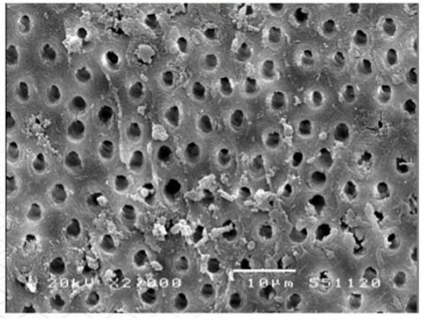
Water



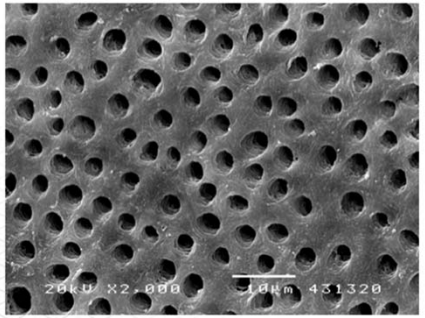
EDTA (17%)



REDTA (17%)



Smear Clear



CHLORHEXIDINE

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 (Basrani B et al, JOE, Aug 2007.)

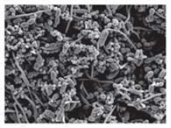
Biofilm Formation of Endodontic Enterococcus Faecalis

- 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

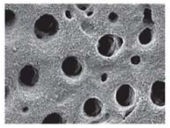
Chemistry of Endodontic Irrigation - Organic Debris

Pre-Irrigation



Wild Biofilm

Post Irrigation



6% NaOCl

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

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

Chemistry of Endodontic Irrigation - Organic Debris

TABLE 1. Summary of the results from the SEM and bacterial culture evaluations

Solution	SEM		Culture Growth
	Presence of Bacteria	Biofilm Status	
6% NaOCl	–	Absent	0%
3% NaOCl	–	Absent	20%
1% NaOCl	+	Disrupted	90%
1% NaOCl/MTAD	+	Disrupted	0%
2% CHX	+	Intact	0%
Positive control	+	Intact	100%
Negative control	–	Absent	0%

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

Chemistry of Endodontic Irrigation - Organic Debris

TABLE 2. Percentage kill of *E. faecalis* by different test agents

Test Agent	N	Mean ± SD
1% NaOCl	32	99.78 ± 0.356[a]
6% NaOCl	96	99.99 ± 0.000[b]
SmearClear™	32	78.06 ± 33.257[b]
2% CHX	32	60.49 ± 44.596[c]
REDTA	32	26.99 ± 29.997[d]
BioPure™ MTAD™	32	16.08 ± 21.191[e]

Unit: %.

Different letters in the column indicate statistically significant homogeneous 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?

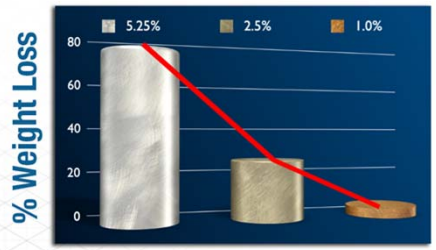
The Physics of Endodontic Irrigation

$18ClO^- + C_6H_{14}N_2O_2$

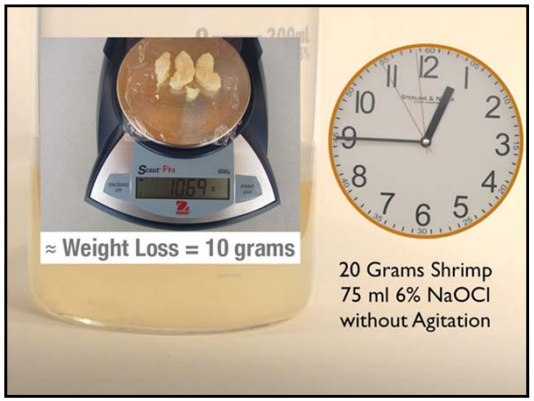
$\downarrow$

$18Cl^- + 8H_2O + 2NH_3 + 6CO_2$

Rate = k(T) * [ClO-] * [C6H14N2O2]



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



Sonic & Ultrasonic Agitation

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

Jensen et al, JOE
11/99 pg 735-8

Sonic & Ultrasonic Agitation

"Although passive activation of sonics and ultrasonics after hand instrumentation produced cleaner canals than hand instrumentation alone, no technique was able to debride the canal system completely."

Jensen et al, JOE
11/99 pg 735-8

Sonic & Ultrasonic Agitation

"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
11/99 pg 735-8

Sonic & Ultrasonic Agitation

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
11/99 pg 735-8

Sonic & Ultrasonic Agitation

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

Jensen et al, JOE
11/99 pg 735-8

But if you squirt...!!!

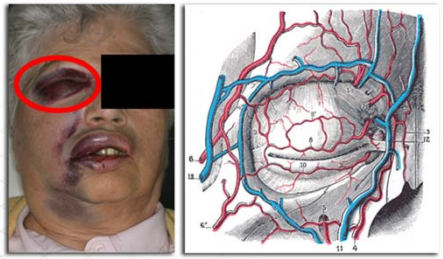
Sonic & Ultrasonic Agitation

Jensen et al, JOE 11/99 pg 735-8

Salzgeber & Brilliant, 1977

Safety

Ahonen & Tjaderhane JOE 10/2011 pg 1460-64



Upper Right Canine

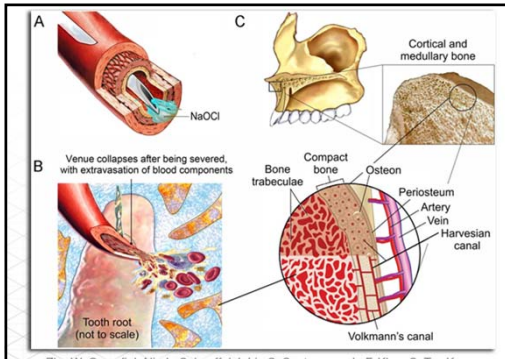
Systemic diffusion into periapical veins

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.

Zhu W, Gyamfi J, Niu L, Schoeffel J, Liu S, Santarcangelo F, Khan S, Tay K, Pashley D, Tay F. Journal of Dentistry, Article in Press, 2013



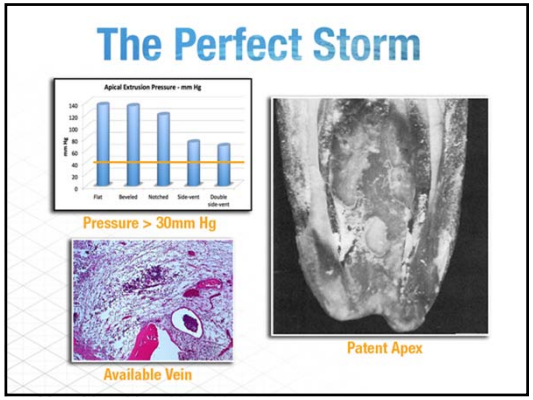
Zhu W, Gyamfi J, Niu L, Schoeffel J, Liu S, Santarcangelo F, Khan S, Tay K, Pashley D, Tay F. Journal of Dentistry, Article in Press, 2013

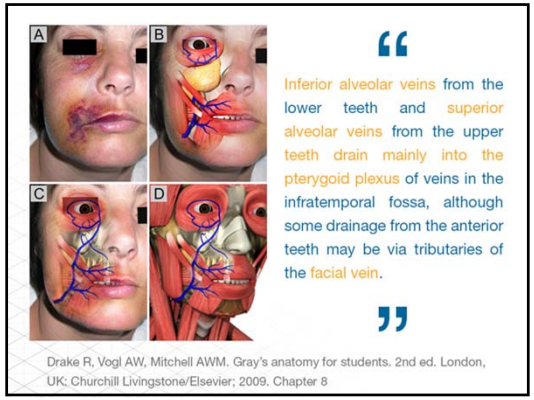
Anatomy of sodium hypochlorite accidents involving facial ecchymosis—A review

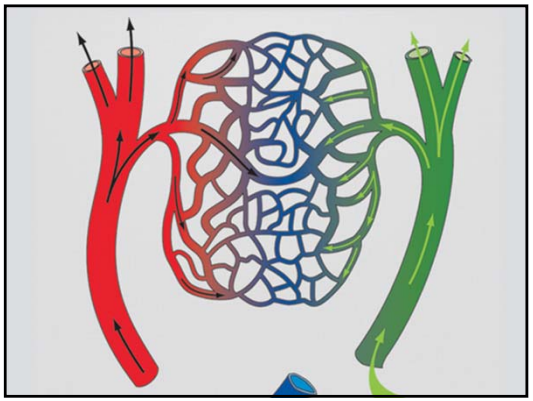
Thus, NaOCl extruded though a **patent tooth root foramen**, an **immature apex** or a **root canal perforation** may easily and rapidly infuse into the **facial vein**, should there be an anatomic variation in the facial venous vasculature (Drake) and when the apically-directed fluid pressure gradient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

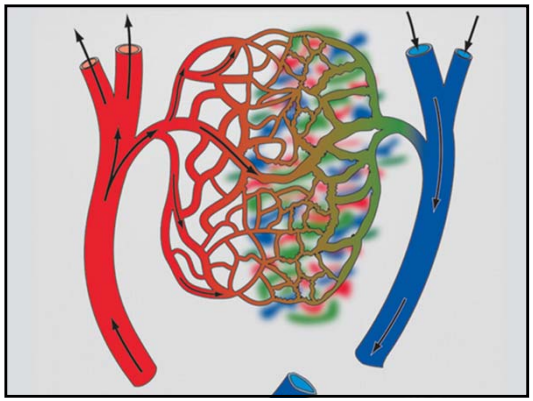
Zhu W, Gyamfi J, Niu L, Schoeffel J, Liu S, Santarcangelo F, Khan S, Tay K, Pashley D, Tay F. Journal of Dentistry, Article in Press, 2013


The Perfect Storm


The Perfect Storm
Apical Extrusion Pressure - mm Hg
Flat
Beveled
Notched
Side-vent
Double side-vent
Pressure > 30mm Hg
Available Vein
Patent Apex

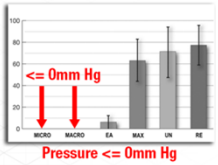

A
B
C
D
Inferior alveolar veins from the lower teeth and superior alveolar veins from the upper teeth drain mainly into the pterygoid plexus of veins in the infratemporal fossa, although some drainage from the anterior teeth may be via tributaries of the facial vein.
Drake R, Vogl AW, Mitchell AWM. Gray's anatomy for students. 2nd ed. London, UK: Churchill Livingstone/Elsevier; 2009. Chapter 8



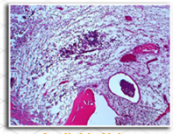



1) excruciating severe pain for two to five minutes
2) immediate swelling (ballooning) of the area
3) spread of the tissue reaction to the surrounding areas
4) profuse hemorrhage, either interstitially and/or
5) intraorally through the tooth.

Not the Perfect Storm



Pressure <= 0mm Hg



Available Vein

Patent Apex

Anatomy of sodium hypochlorite accidents involving facial ecchymosis—A review

Conclusion

When the irrigant flow rate is below 3.4 ml/min, the fluid pressure generated is below the mean intraosseus space blood pressure value of 30 mm Hg.

Zhu W, Gyamfi J, Niu L, Schoeffel J, Liu S, Santarcangelo F, Khan S, Tay K, Pashley D, Tay F. Journal of Dentistry, Article in Press, 2013

Zhu W, Gyamfi J, Niu L, Schoeffel J, Liu S, Santarcangelo F, Khan S, Tay K, Pashley D, Tay F. Journal of Dentistry, Article in Press, 2013

Apical Vapor Lock

Apical Vapor Lock

Tay et al JOE 4/10 pg. 745-50

Vapor

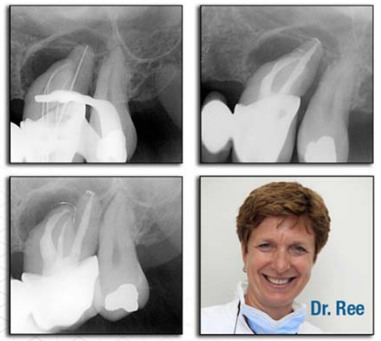
Lock

Final Irrigation Protocol

The EndoVac Setup

Efficacy

Case by Dr. Marga Ree

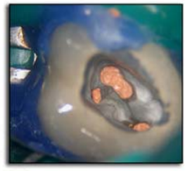


Case by Dr. Marga Ree

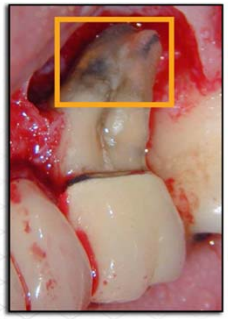
Instrumentation
MB1 & MB2 = #35/08
DB = #40/10
P = #60/10

Irrigation
5% NaOCl
17% EDTA

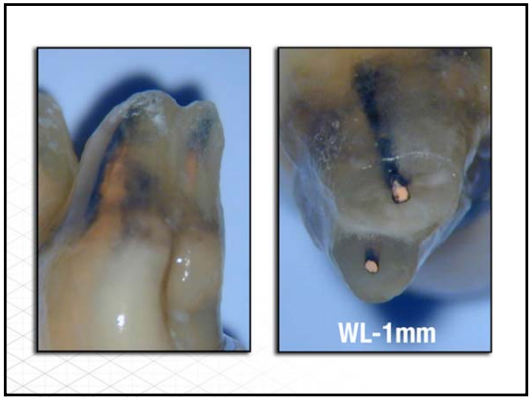
Ultrasonic Activiation



One (1) Month Recall



Diagnostic Flap



"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."

Professor Torabinejad, Principles and Practice of Endodontics (1989)

Chow's Paradigm

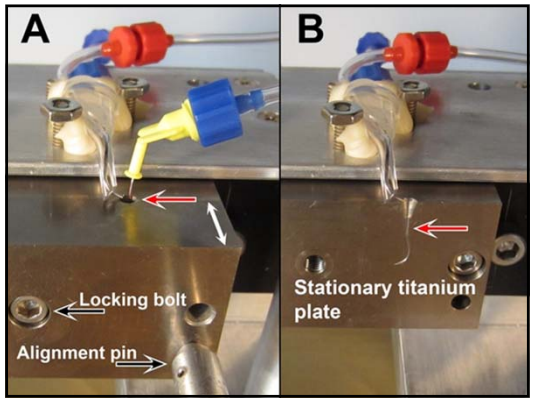
- ☑ Reach the apex
- ☑ Create a current (wall shear stress)
- ☑ Remove Debris

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

Goode N, Khan S, Eid A, Niu L, Gosier J, Susin L, Pashley D, Tay F. Journal of Dentistry 41 (2013) 636–641.



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.

Goode N, Khan S, Eid A, Niu L, Gosier J, Susin L, Pashley D, Tay F. Journal of Dentistry 41 (2013) 636–641.

Wall Shear Stress

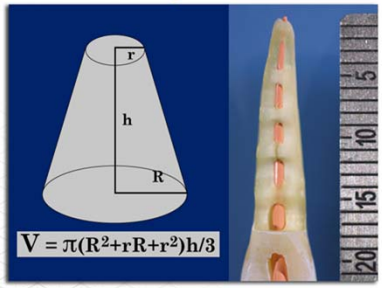
Conclusion:

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.

Goode N, Khan S, Eid A, Niu L, Gosier J, Susin L, Pashley D, Tay F. Journal of Dentistry 41 (2013) 636–641.

PUI vs. EndoVac

Volume Exchange ≈ .0058 ml/canal



ANP - EndoVac

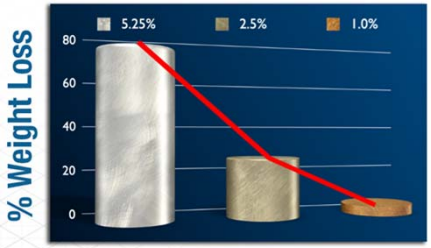
≈ 1.8 ml/canal

Passive Ultrasonics

≈ .0058 ml/canal

≈ 1.8/0058 = 310x

Rate = k(T) * [ClO-] * [C6H14N2O2]



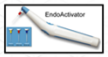
Hand et al, JOE 2/78 pg 60-4

Irrigant Delivery Systems

"F" File

EndoActivator

Pressure Ultrasonic Needle



Passive Ultrasonic Irrigation

Side Vent Needle

EndoVac

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.

Desai & Himel JOE 4/2009 pg. 545-9

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

Khan S, Niu L, Eid A, Looney S, Didato A, Roberts S, Pashley, DMD P, Tay F. JEndo, Vol 39, No. 4, April 2013

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.

Khan S, Niu L, Eid A, Looney S, Didato A, Roberts S, Pashley, DMD P, Tay F. JEndo, Vol 39, No. 4, April 2013

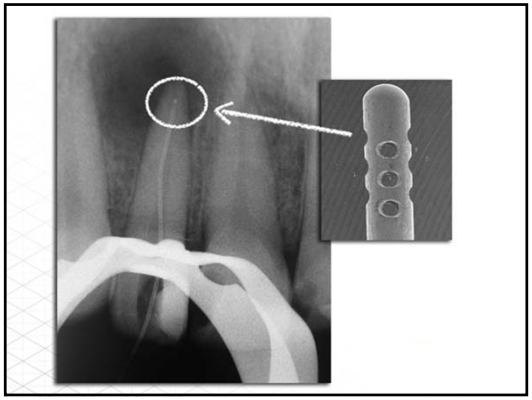
Less Post Op Pain

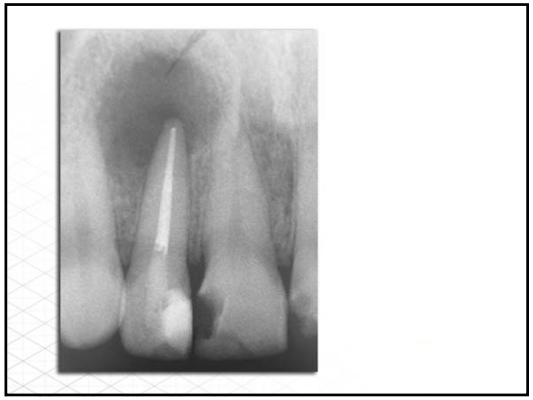
The outcome of this investigation indicates that the use of a negative apical pressure irrigation device can result in a significant reduction of postoperative pain levels in comparison to conventional needle irrigation

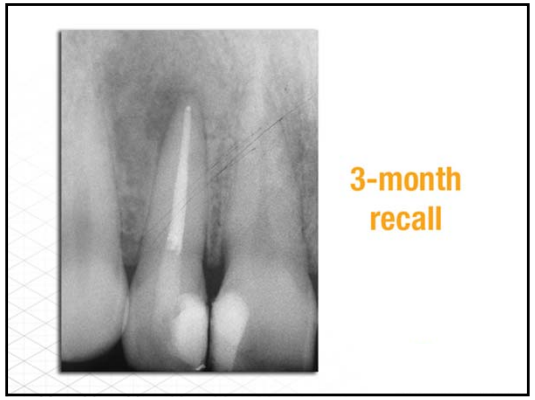
Gondim and Kim et. al. J Endod 2010;36:1295–1301)

Emergency

-Courtesy Dr. Filippo Santarcangelo

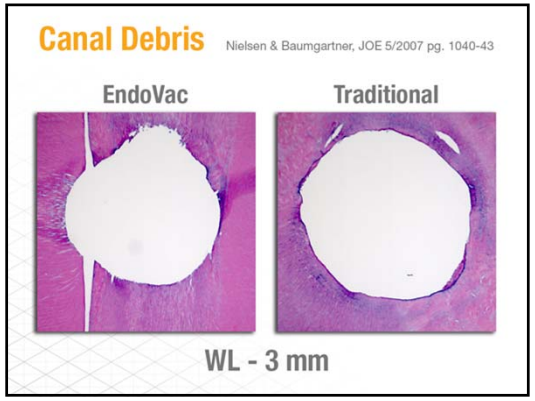





3-month
recall


-Courtesy Dr. Filippo Santarcangelo

Efficacy


Canal Debris
Nielsen & Baumgartner, JOE 5/2007 pg. 1040-43
EndoVac
Traditional
WL - 3 mm

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

Group	Mean (%)	Standard Deviation	p Value
EndoVac 1 mm	1.565	3.09 →	0.0347*
Needle 1 mm	5.730	13.65	V
EndoVac 3 mm	0.421	0.86 →	0.1119
Needle 3 mm	2.825	6.26	

*Significant $p < 0.05$.

WL - 1 mm WL - 3 mm

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

Group	Mean (%)	Standard Deviation	p Value
EndoVac 1 mm	5.730	3.09 →	0.0347*
Needle 1 mm	2.825	13.65	V
EndoVac 3 mm	0.421	0.86 →	0.1119
Needle 3 mm	2.825	6.26	

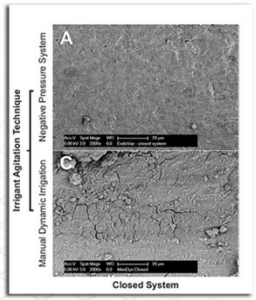
Why?

*Significant $p < 0.05$.

WL - 1 mm WL - 3 mm

Canal Debris

Parente & Tay et al, IEJ 2010 Nov;43(11):1001-12

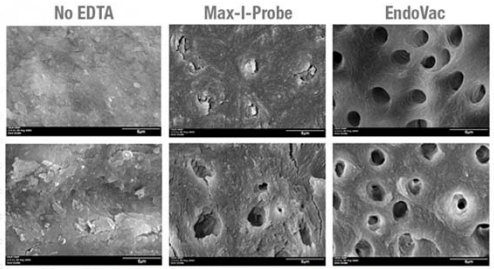


"Results: The ability of manual dynamic agitation to remove smear layer and debris in a closed canal system was significantly less effective ... than the EndoVac ($P < 0.001$)."

WL - 1 mm

Canal Debris

Parente & Tay et al, IEJ 2010 Nov;43(11):1001-12



WL - 1 mm $p < .001$

Antimicrobial - Clinical

Bacteria in tubules after ANP

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

Todd A. Miller, DDS, and J. Craig Baumgartner, DDS, PhD†*

Miller & Baumgartner JOE 3/2010 pg. 509-11

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

Patrícia R.R. Brito, MSc, Letícia C. Souza, MSc,* Julio C. Machado de Oliveira, PhD,* Flávio R.F. Alves, PhD,* Gustavo De-Deus, PhD,† Hélio P. Lopes, LD,* and José F. Siqueira, Jr, PhD**

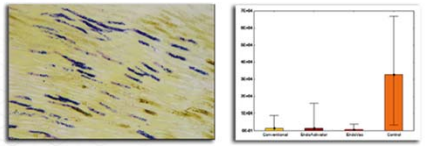
Brito et al JOE 09/2009 pg. 1422-27

Antimicrobial - Clinical

Bacteria in tubules after ANP

Comparison of the Antimicrobial Efficacy of Irrigation Using the EndoVac

Pulverized Teeth



Comparison of the Effectiveness of Three Irrigation

Instrumented deep into wall

Infected Tubules

The fate and the role of bacteria left in root dentinal tubules

L. B. PETERS, F. B. WESSELINK & W. R. MOORER

Department of Cariology and Endodontology, Academic Centre for Dentistry Amsterdam, Louwesweg 1, 1066 EA Amsterdam, The Netherlands

Summary

Introduction

Keywords bacteria; dentinal tubules; endodontic failure

"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 repopulating the (former) canal space."

Peters, Wesselink, Moorer
IEJ 1995 pg 95

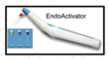
Lasers?

Isthmus Cleaning

"F" File

EndoActivator

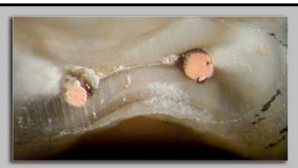
Pressure Ultrasonic Needle



Passive Ultrasonic Irrigation

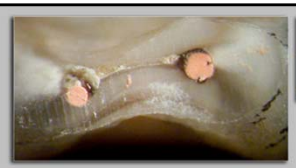
Side Vent Needle

EndoVac



Isthmus
Cleaning Studies
@ WL - 1mm

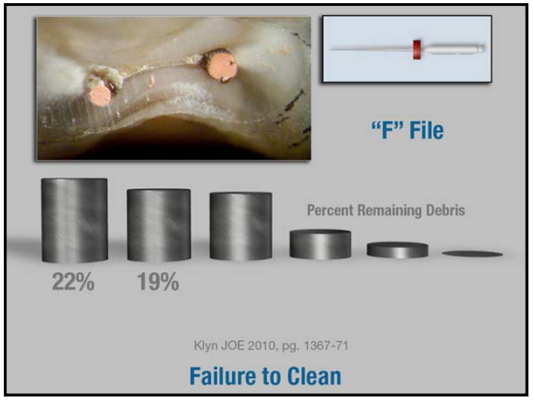
Failure to Clean

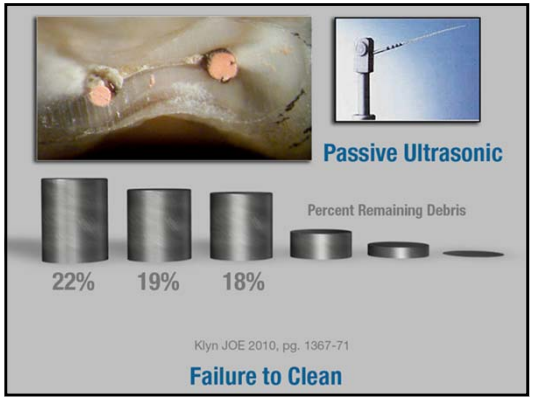


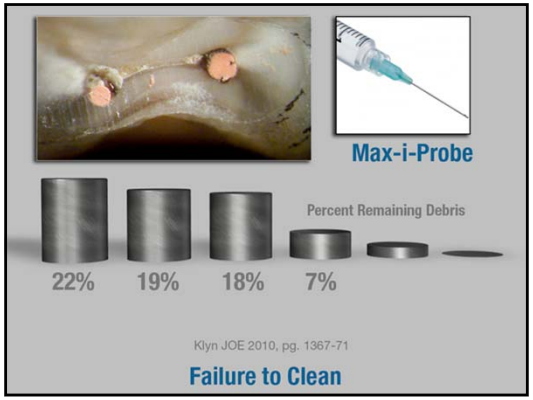
EndoActivator

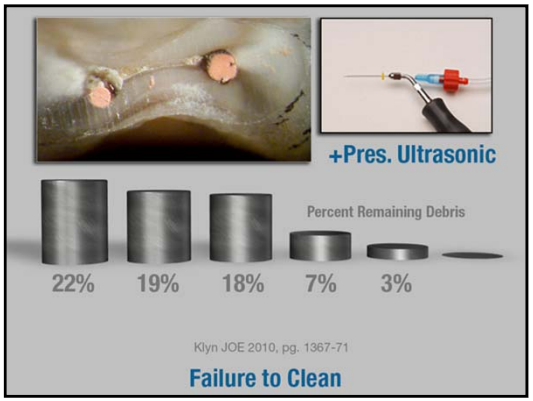
Klyn JOE 2010, pg. 1367-71

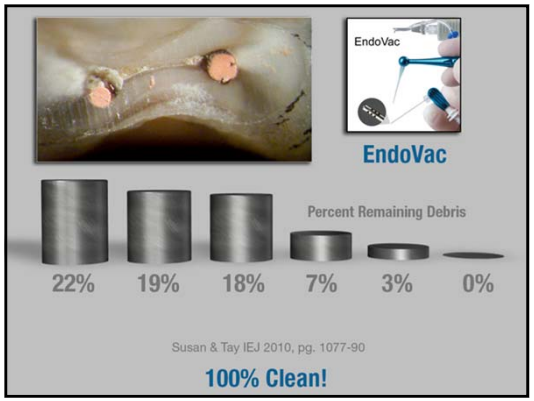
Failure to Clean

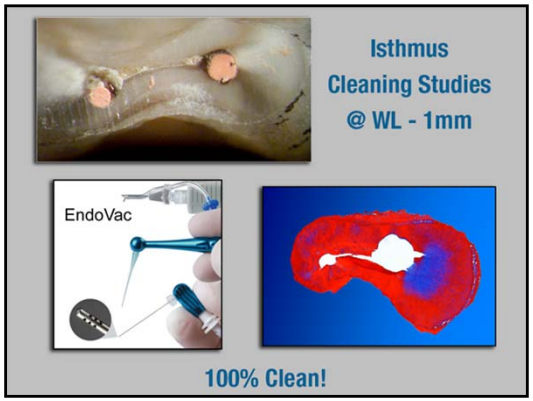

"F" File
Percent Remaining Debris
22%
19%
Klyn JOE 2010, pg. 1367-71
Failure to Clean


Passive Ultrasonic
Percent Remaining Debris
22%
19%
18%
Klyn JOE 2010, pg. 1367-71
Failure to Clean


Max-i-Probe
Percent Remaining Debris
22%
19%
18%
7%
Klyn JOE 2010, pg. 1367-71
Failure to Clean


+Pres. Ultrasonic
Percent Remaining Debris
22%
19%
18%
7%
3%
Klyn JOE 2010, pg. 1367-71
Failure to Clean


EndoVac
EndoVac
Percent Remaining Debris
22%
19%
18%
7%
3%
0%
Susan & Tay IEJ 2010, pg. 1077-90
100% Clean!


Isthmus
Cleaning Studies
@ WL - 1mm
EndoVac
100% Clean!

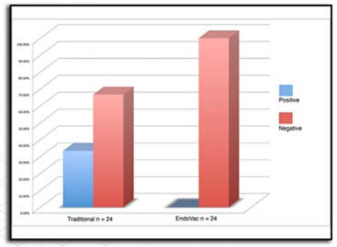
Antimicrobial

Antimicrobial efficacy of two irrigation techniques in tapered versus non-tapered canal preparation An in vitro study. 100% Negative Cultures in EndoVac Group and 67% Negative Cultures in Traditional Postive Pressure Group

Hockett J, Dommisch J, Johnson JD, Cohenca N. JOE Nov 2008

Antimicrobial in vitro

Traditional vs. EndoVac

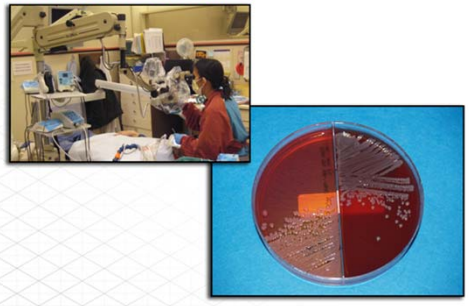


p-.004

Hockett et al, JOE 11/2008 pg. 1374-7

Antimicrobial - Clinical

University of Washington

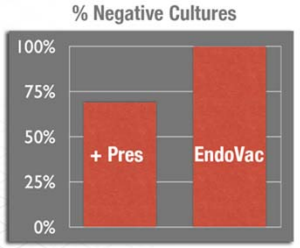


Antimicrobial - Clinical

University of Washington

Antimicrobial - Clinical

University of Washington



Case History

Clinician: Dr. F. Santarcangelo

Pre-op

14 year old boy

Case History

Clinician: Dr. F. Santarcangelo

Working

14 year old boy

Case History

Clinician: Dr. F. Santarcangelo

Working

14 year old boy

Case History

Clinician: Dr. F. Santarcangelo

Pre-op (Single-visit)

14 year old boy

Case History

Clinician: Dr. F. Santarcangelo

6 M Recall

14 year old boy

Case History

Clinician: Dr. F. Santarcangelo

14 year old boy

Distal Apex Close at 6 Months

Case History

Clinician: Dr. F. Santarcangelo

14 year old boy

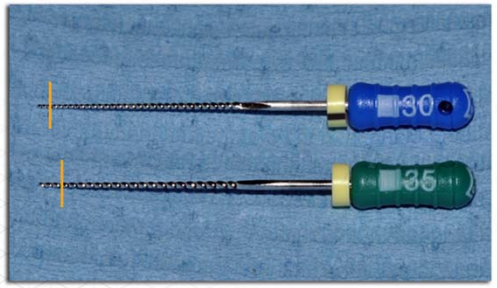
Immediate Post-op

Four (4) year Postop

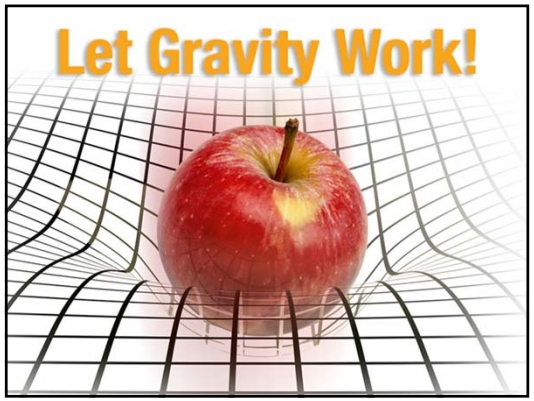
Clinical Considerations

System Synergy

Apical Shape



Let Gravity Work!



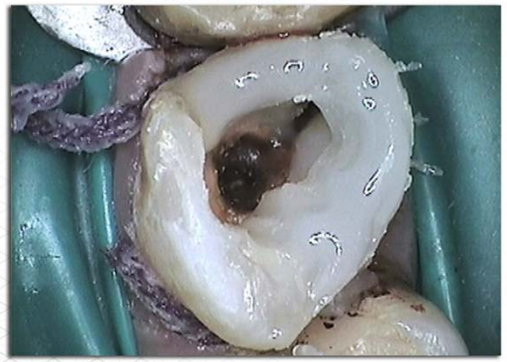
Pretreatment

Courtesy Dr. Bojidar Kafelov, Sofia, Bulgaria

Courtesy Dr. Bojidar Kafelov, Sofia, Bulgaria

Courtesy Dr. Bojidar Kafelov, Sofia, Bulgaria

Courtesy Dr. Bojidar Kafelov, Sofia, Bulgaria

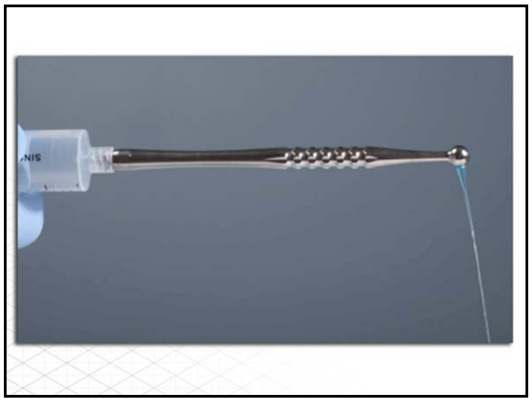


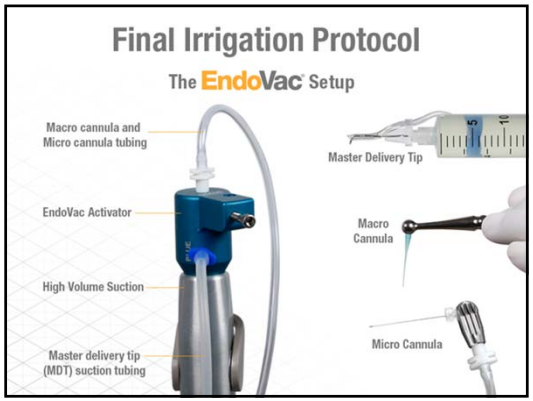
Courtesy Dr. Bojidar Kafelov, Sofia, Bulgaria

Courtesy Dr. Bojidar Kafelov, Sofia, Bulgaria


Courtesy Dr. Bojidar Kafelov, Sofia, Bulgaria


Light Cured Rubber Dam




Final Irrigation Protocol
The EndoVac Setup
Macro cannula and
Micro cannula tubing
EndoVac Activator
High Volume Suction
Master delivery tip
(MDT) suction tubing
Master Delivery Tip
Macro
Cannula
Micro Cannula

User Friendly?

Cost?

$7-$10
per case

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

Cost of
Success?

Priceless!