Endodontiske materialer

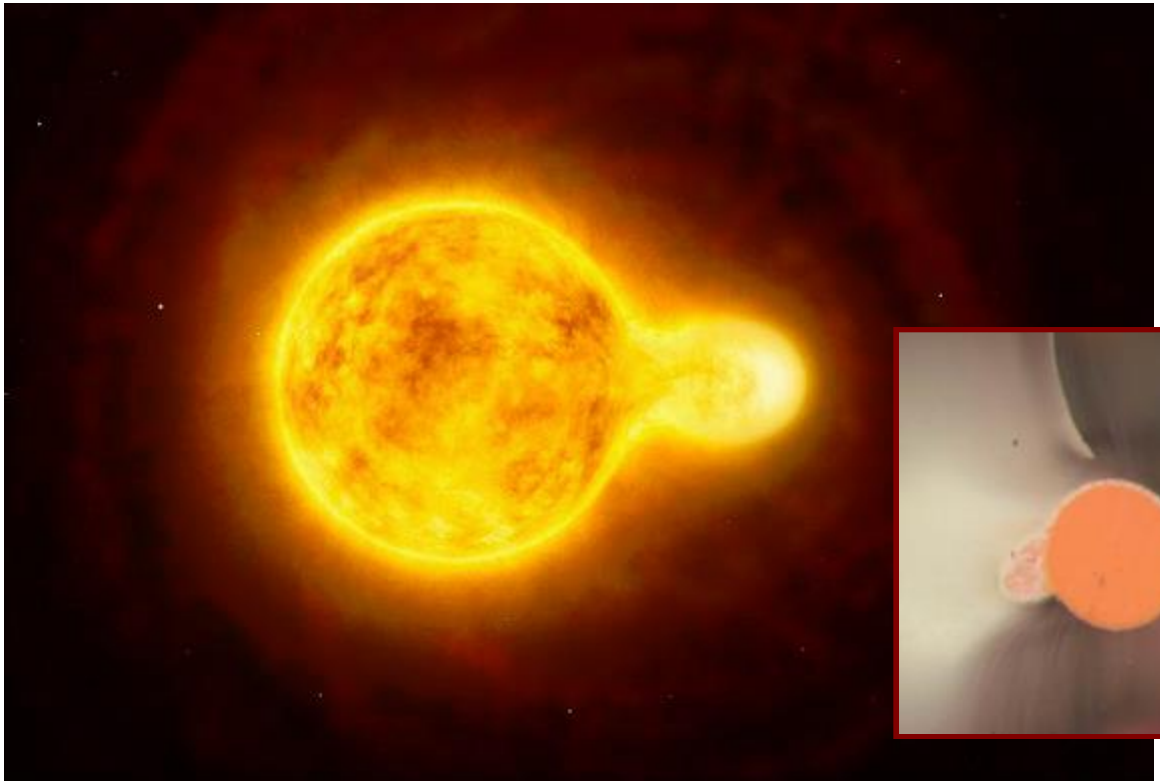
Avd endodonti, UiO
2015 01 16

J Biomed Mater Res B Appl Biomater. 2012 Oct;100(7):1729-35. Cytotoxicity of endodontic sealers after one year of aging in vitro.
Brackett MG1, Lewis JB, Kious AR, Messer RL, Lockwood PE, Brackett WW, Wataha JC.

Table I. Dental Endodontic Sealers Tested in the Current Study

Material (Manufacturer)	Code	Lot Number	Composition (from Manufacturer)
AH-Plus-Jet® (Dentsply International, York, PA)	AHP	0607001088	*Epoxide paste:* Di-epoxide, calcium tungstate, zirconium oxide, aerosol, pigment. *Amine paste:* I-adamantane amine, N,N′-dibenzyl-5-oxa-nonandiamine-1,9, TCD-diamine, calcium tungstate, zirconium oxide, aerosil, silicone oil.
Epiphany® (Pentron Clinical Technologies, LLCC. Wallingford, CT)	EPH	149468	*Resins:* Bis-GMA, UDMA, PEGDMA, EBPADMA *Fillers:* barium sulfate, bismuth oxychloride, calcium hydroxide, silica, silane-treated barium boroaluminosilicate glass (with a small amount of aluminum oxide); coloring pigment; *Dual-cured initiators:* cumene hydroxyperoxide, thiosinamine, camphorquinone. *Stabilizer:* butylated hydroxytoluene (2,6-di-tert-butyl-4-methylphenol)
EndoRez® (Ultradent Products, Inc. South Jordan, UT)	ER	102104	Urethane dimethacrylate resin as a matrix, zinc oxide, barium sulfate, resins, pigments.
Guttaflow® Coltène Whaledent, Switzerland	GF	D-89122	Polydimethylsiloxane, gutta-percha powder, zinc oxide, zirconium dioxide, nano-silver, paraffin-based oil, hexachloroplatinic acid, silicic acid
InnoEndo® Heraeus-Kulzer, Armonk, NY	IN	40001987	Resins: Bis-GMA, UDMA, PEGDMA, EBPADMA Fillers: barium sulfate, bismuth oxychloride, calcium hydroxide, silica, silane-treated bariumboraluminosilicate glass; *Dual-cured initiators*: cumene hydroxyperoxide, thiosinamine, camphorquinone Stabilizer: butylated hydroxytoluene (2,6-di-tert-butyl-4-methylephenol); Pigment: Red #40 (CAS no. 25997–17–3)
Pulp Canal Sealer® (Sybron Dental Specialties Orange, CA)	PCS	6–1108	Liquid: Eugenol. Powder: Zinc oxide, staybelite resin, bismuth subcarbonate, barium sulfate, sodium borate anhydrate.

This artist's impression shows the yellow hypergiant star HR 5171. This is a very rare type of star with only a dozen known in our galaxy. Credit: ESO



http://www.richarddawkins.net/news_articles/2014/3/13/largest-yellow-star-ever-seen-revealed-in-new-light#

Root canal sealers

in part from Tyagi et al 2013

- ZOE
- Epoxy
- Ca(OH)2
- Silicone
- MTA
- Ca-Si-P
- Methacrylate
- Ca-P

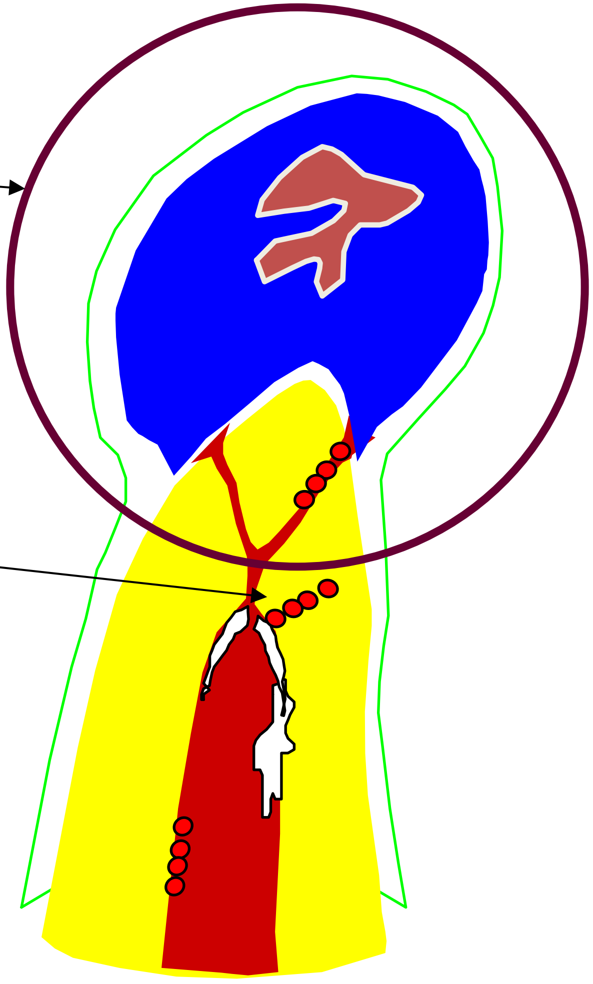
- PCS, Grossman, **TubliSeal**
- AH26, **AHplus**
- Apexit, **Sealapex**
- RoekoSeal, **GuttaFlow**
- ProRoot, **Fillapex**
- **Endosequence**, **Totalfill**, Bioaggregate
- EndoRez, **RealSeal**, Smartseal
- Capseal

Endodontics is:

Prevention or treatment of apical periodontitis

which in practice means

Protection against or elimination of root canal infection



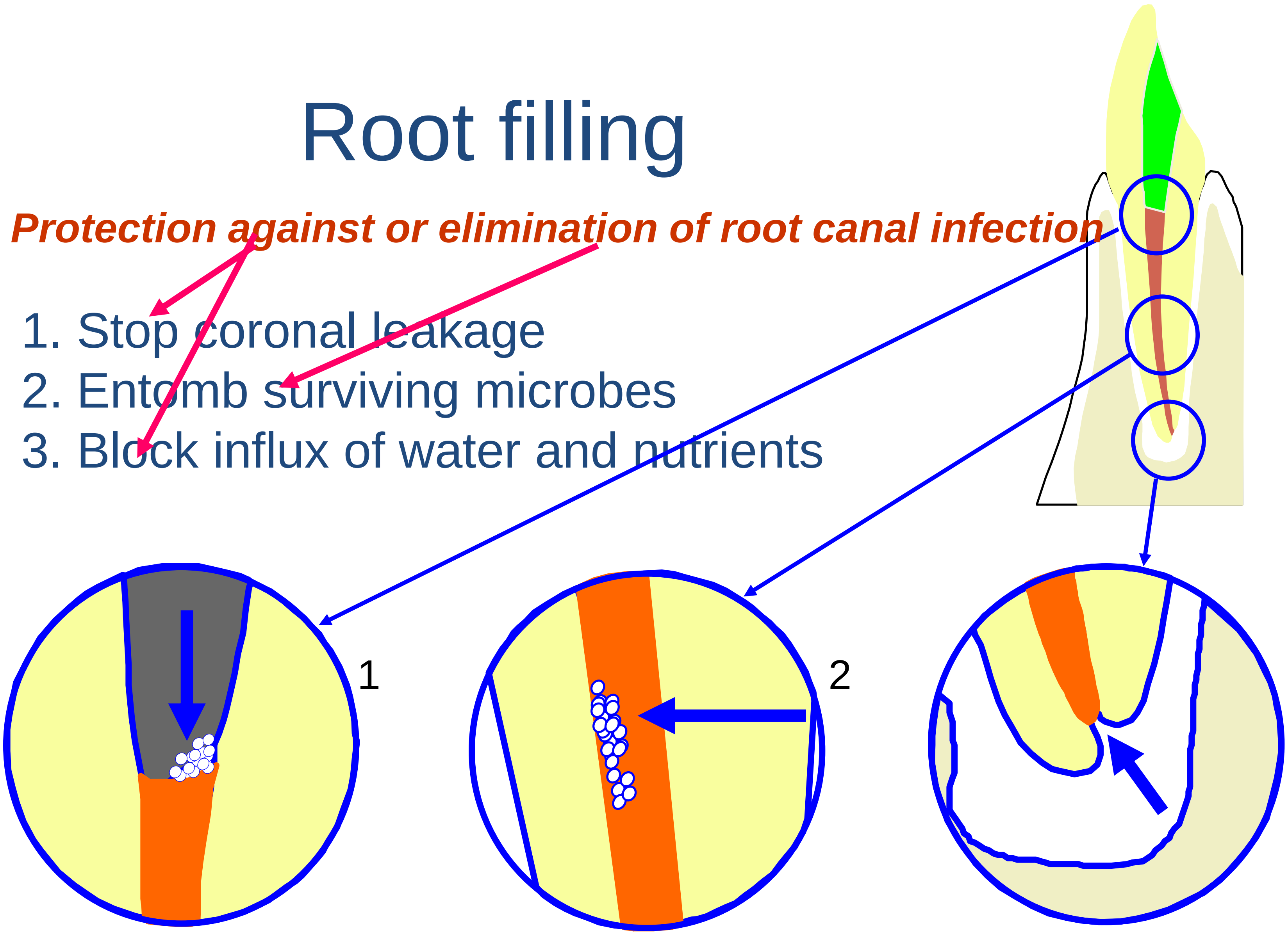
Irrigation, medication and *root filling* are all means towards this end

Ørstavik 1988

Root filling

Protection against or elimination of root canal infection

1. Stop coronal leakage
2. Entomb surviving microbes
3. Block influx of water and nutrients

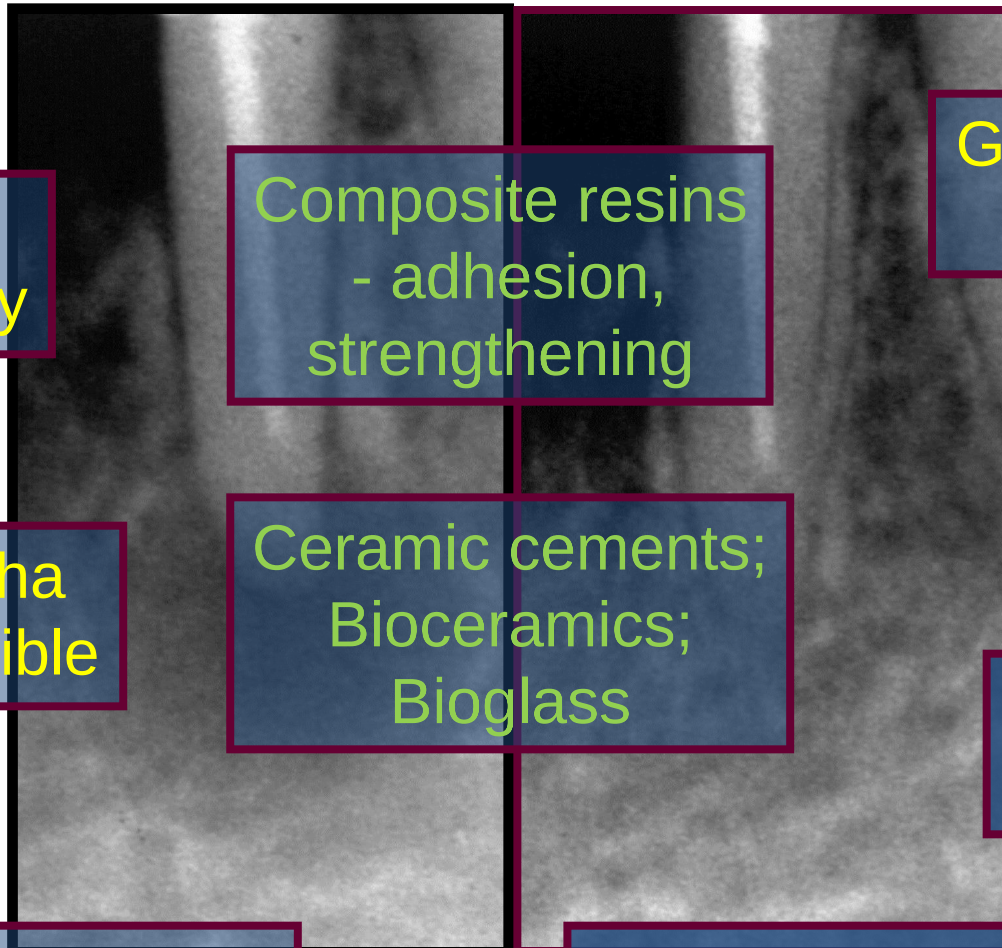


from Sundqvist & Figdor, in 'Essential Endodontology', 1998

Gutta-percha - adaptability

ZEUG - dimensionally stable

Silicon - biocompatible



Chloroform - adaptability

Composite resins - adhesion, strengthening

Glassionomer - why not?

Colophony - adhesion

Chloropercha - biocompatible

Ceramic cements; Bioceramics; Bioglass

$Ca(OH)_2$ - bio-active

N2 & Endométhasone - antibacterial

Epoxy - hardness and adhesion

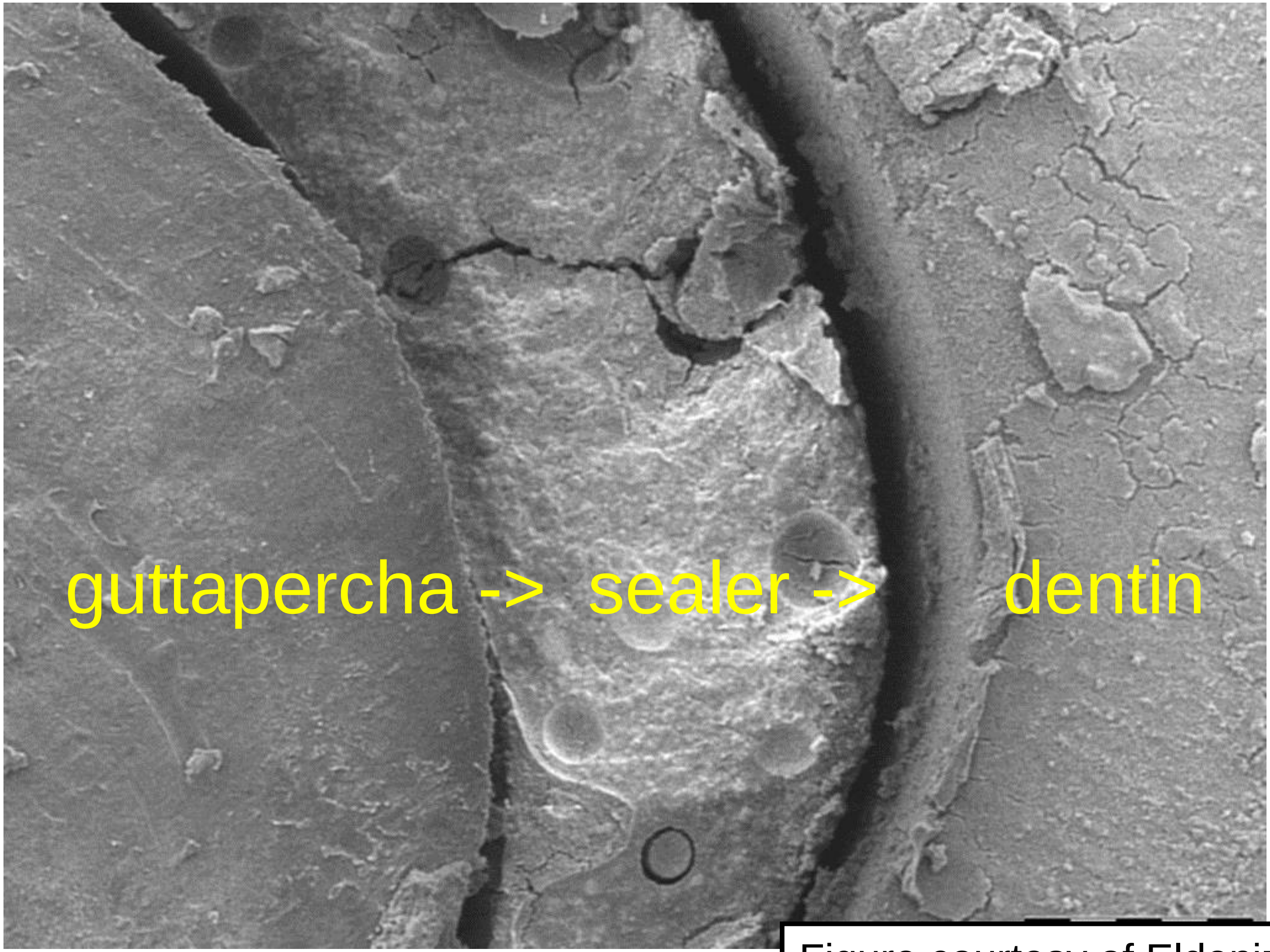


Figure courtesy of Eldeniz et al.

Acroseal

Septodont

Composition

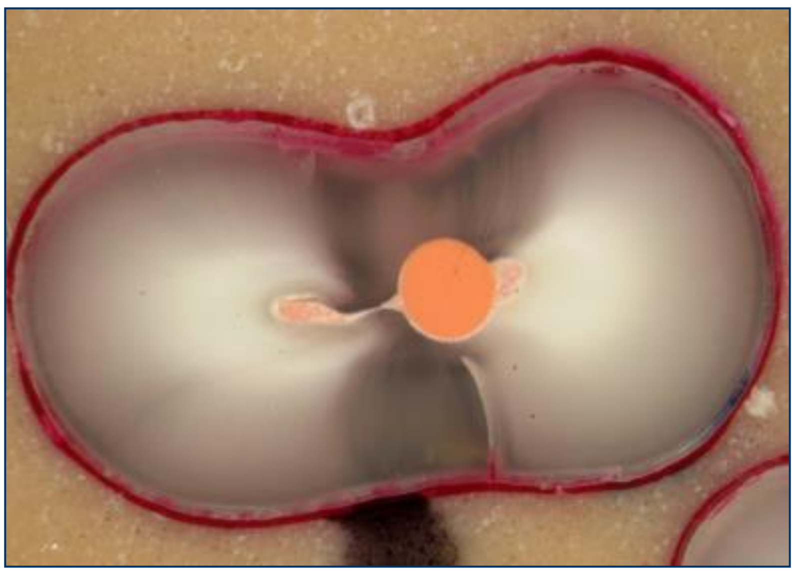
Base: Glycyrrhetic acid (enoxolone) [licorice], *methenamine*, radiopaque excipient.

AH26

Catalyst: Calcium hydroxide, DGEBA [(diglycidyl ethers *bisphenol-A*)] , radiopaque excipient.

A variant of Ahplus; Company website

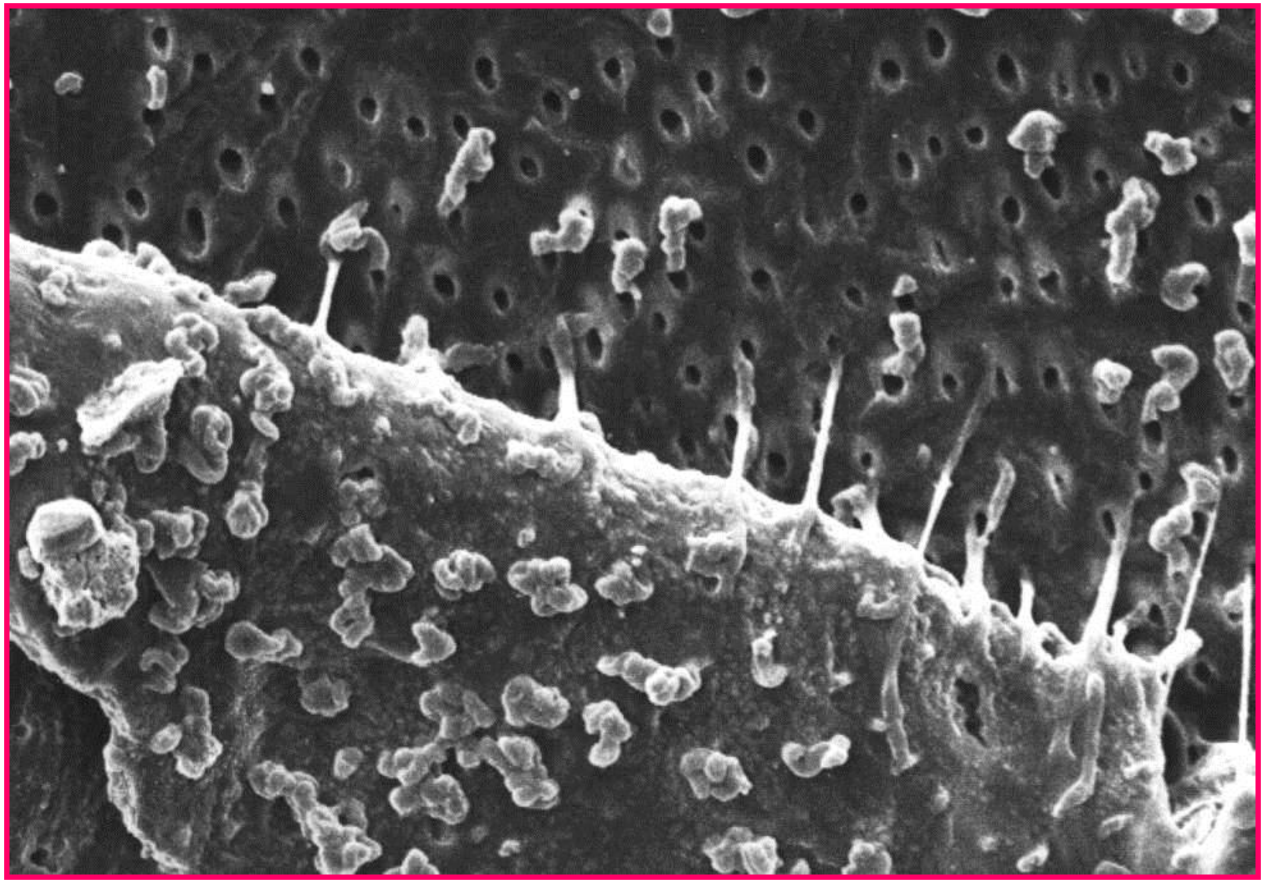
Silicone-Based Endodontic Sealers



- (Lee Endofil)
- ***RoekoSeal***
- ***GuttaFlow***

Coltène-Whaledent

Silicon-based sealers



Silicone-plugs penetrating dentinal tubules and curling back up when torn from surface

Silicon-based sealers (GuttaFlow)

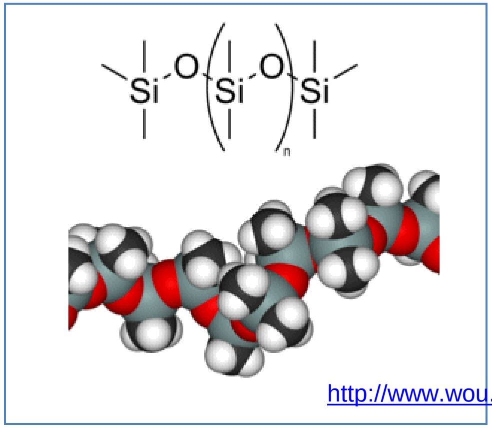
- Pros
  - Very good documentation
  - Clinically tested
  - Good tissue tolerance
- Cons
  - No antimicrobial effect? Silver added to GF
  - Low mechanical strength

Composition of GuttaFlow:

Guttapercha finely ground

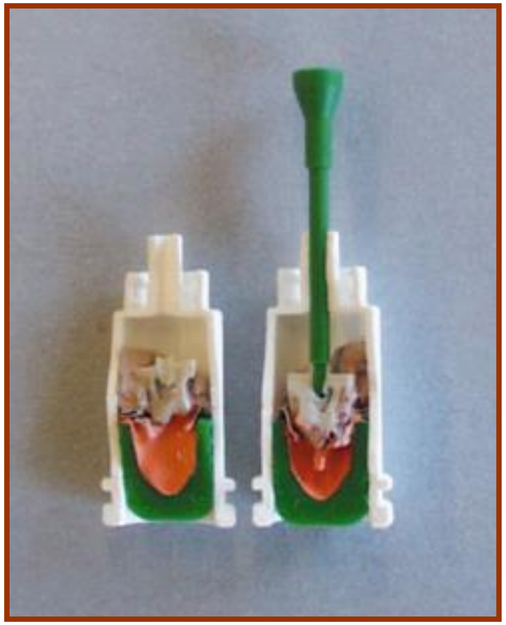
Sealer:

- **Polydimethylsiloxane**
- **Silicone oil**
- **Paraffin-base oil**
- **Hexachloroplatinic acid (catalytic agent)**
- **Zirconium dioxide (radiopacity)**
- **Silver (conservation agent)**
- **Color pigments**



http://www.wou.edu/las/physci/ch462/BouncingPutty.htm

Finely ground gutta percha in silicone: GuttaFlow



GuttaFlow

Cortesy M.J. Roggendorf

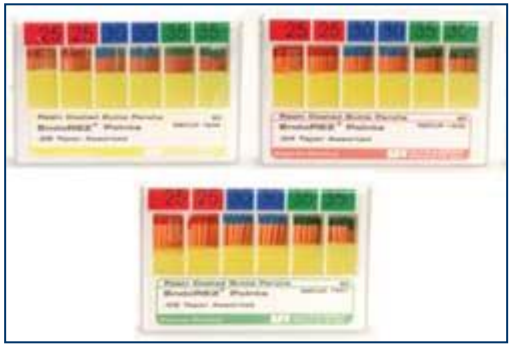
Resin-based sealers

- Pros
  - Known technology
  - Known bioeffects
- Cons
  - No antimicrobial effect?
  - Long term seal?
  - Disintegration?

”EndoREZ™ is a UDMA resin-based, root canal sealer with hydrophilic properties that improve sealing ability even in canals that are moist with water.”

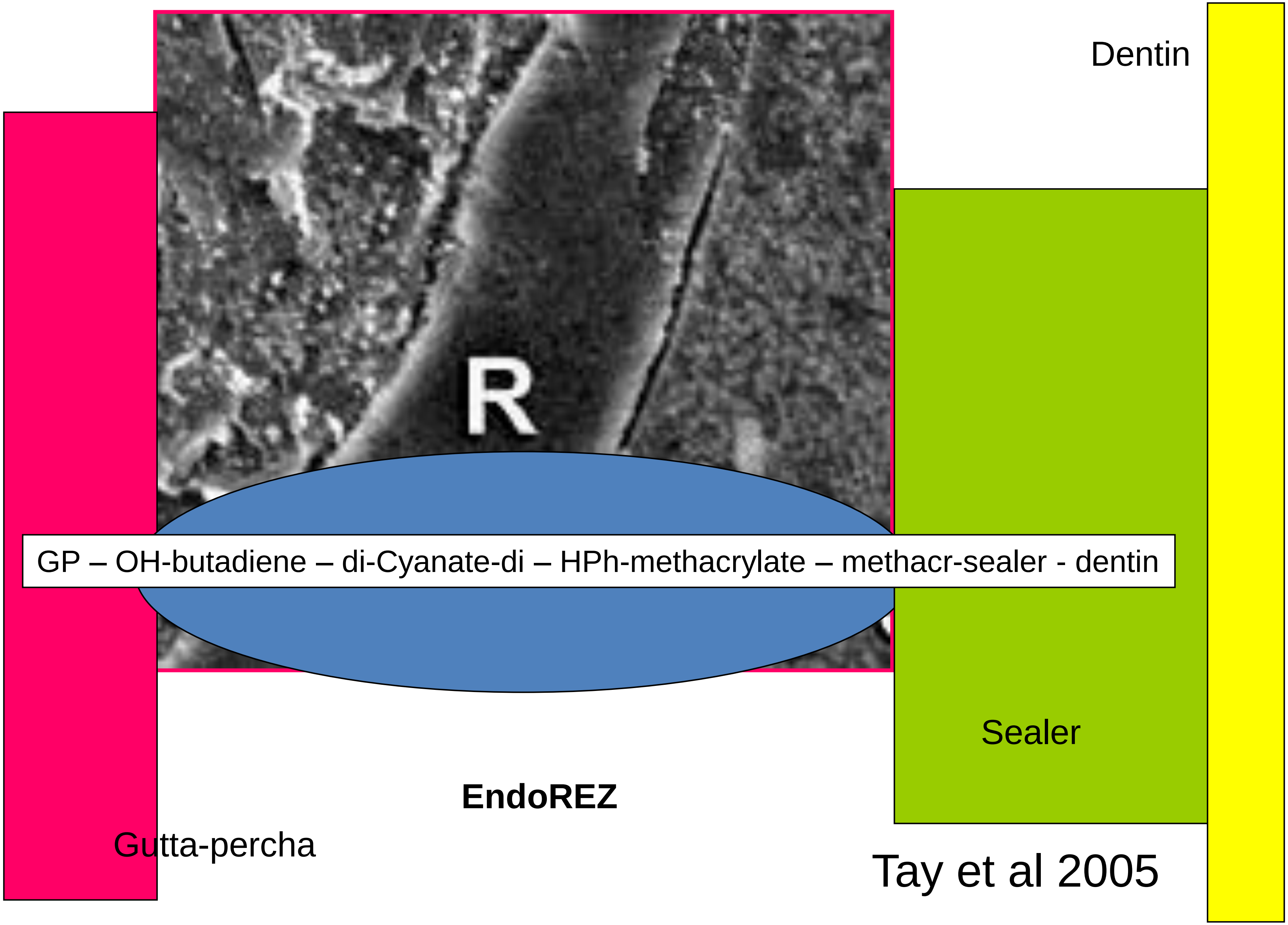
Ultradent, company website

EndoREZ Points



”an unusual resin is created by first reacting one of the isocyanato groups of a diisocyanate with the hydroxyl group of a hydroxyl-terminated polybutadiene, as the latter is bondable to hydrophobic polyisoprene. This is followed by the grafting of a hydrophilic methacrylate functional group to the other isocyanate group of the diisocyanate, producing a gutta-percha resin coating that is bondable to a methacrylate-based resin sealer.”

Tay et al 2005


Dentin
R
GP – OH-butadiene – di-Cyanate-di – HPh-methacrylate – methacr-sealer - dentin
Sealer
EndoREZ
Gutta-percha
Tay et al 2005

A thermoplastic, synthetic polymer, Resilon™, with Epiphany™ or RealSeal sealer

- *The thermoplasticity of* Resilon *is because of polycaprolactone, a biodegradable polyester with a moderately low melting point, while its bondability is derived from the inclusion of resin with methacryloxy groups*. **This filling material also contains [bioactive] glass fillers, and barium chloride as fillers, and is capable of coupling to resin sealers, an example of which is Epiphany [or RealSeal].** ***Epiphany*** ***Root Canal Sealant is a dual-curable resin composite containing a new redox catalyst, that enables optimal auto-polymerization under acidic environments.***

Tay et al 2005

Leak-Resistant. Unlike gutta percha, RealSeal leaves no gap for leakage. Coronal and apical leakage are substantially reduced. **[Test results?]**

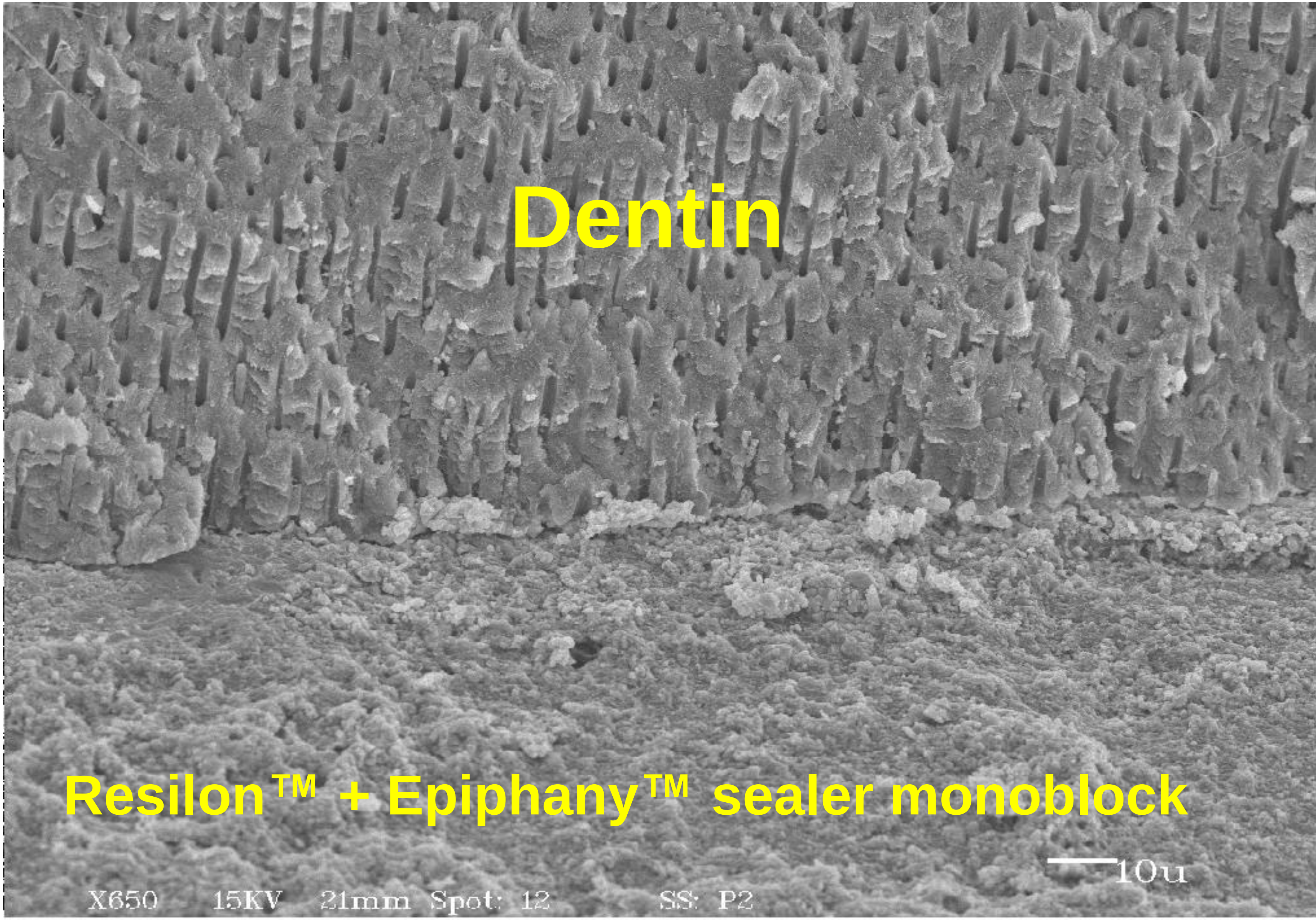
Strengthening. Gives the root significant toughness. **[Test results?]**

Technique-Compatible. Works with your current filling method. **[OK]**

Retreatable. With chloroform and/or heat. Like Grossman's formula, retreatments are easy. **[OK]**

Radiopaque. Just like your current method of obturation, detection is not a problem. **[OK]**

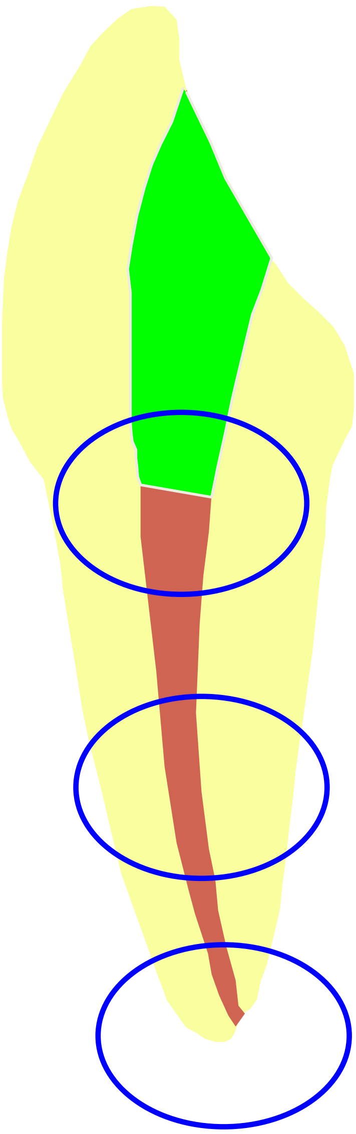
Company website: http://www.sybronendo.com/index/sybronendo-fill-realseal-02



Title:
Comment:

Date: 06–03–2003 Time: 15:15
Filename: TEMP.TIF

Physical properties



Physical properties

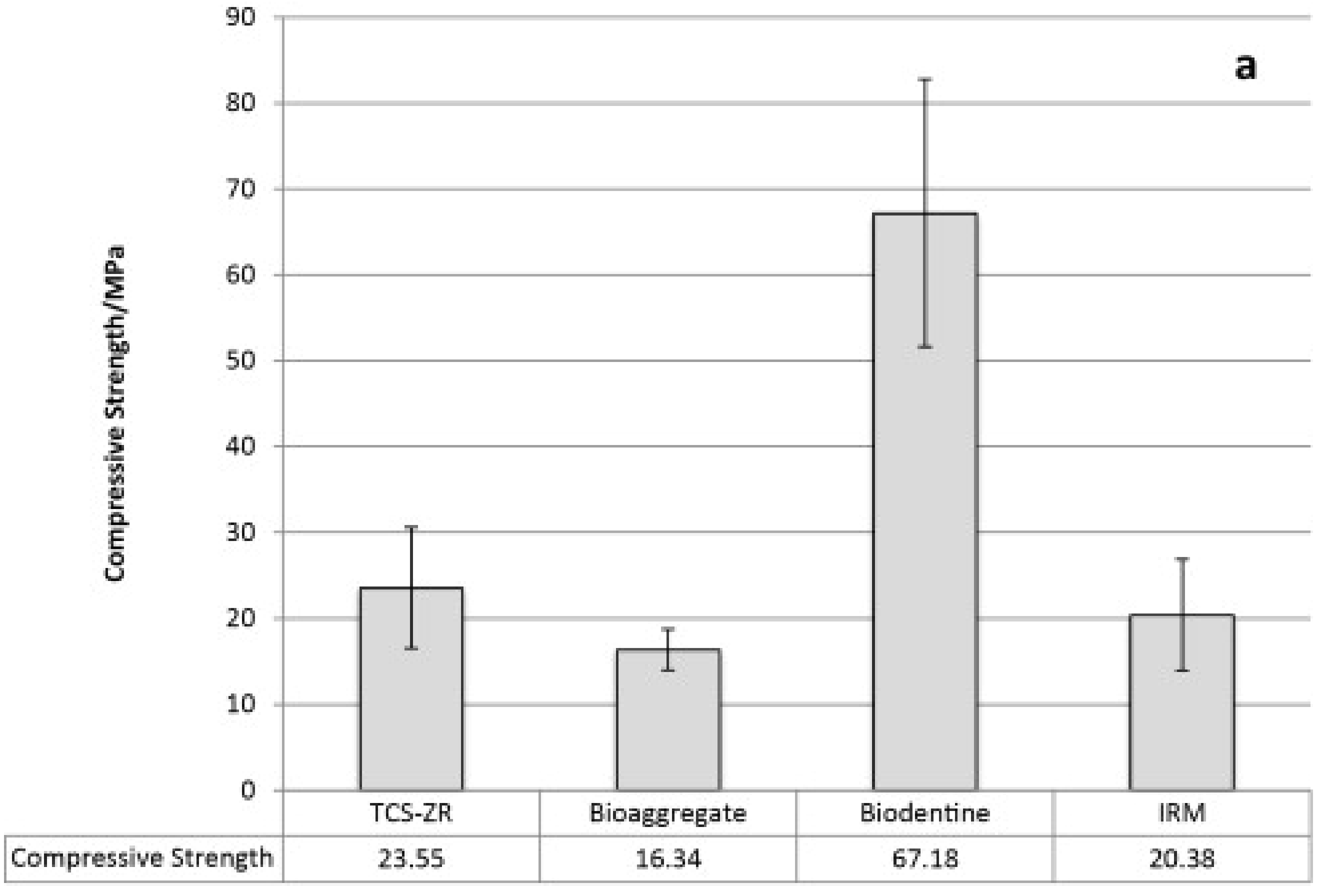
Sealer	Radiopacity (n=3)
AH Plus	9,90±1,56
Epiphany	9,43±0,15
Endo-REZ	6,06±0,20
Roeko Seal	5,37±0,35
MTA Angelus	4,72±0,45
Gutta Flow	4,67±0,29
Apexit	4,60±0,10
Acroseal	4,50±0,10
Biodentine	2,80±0,48

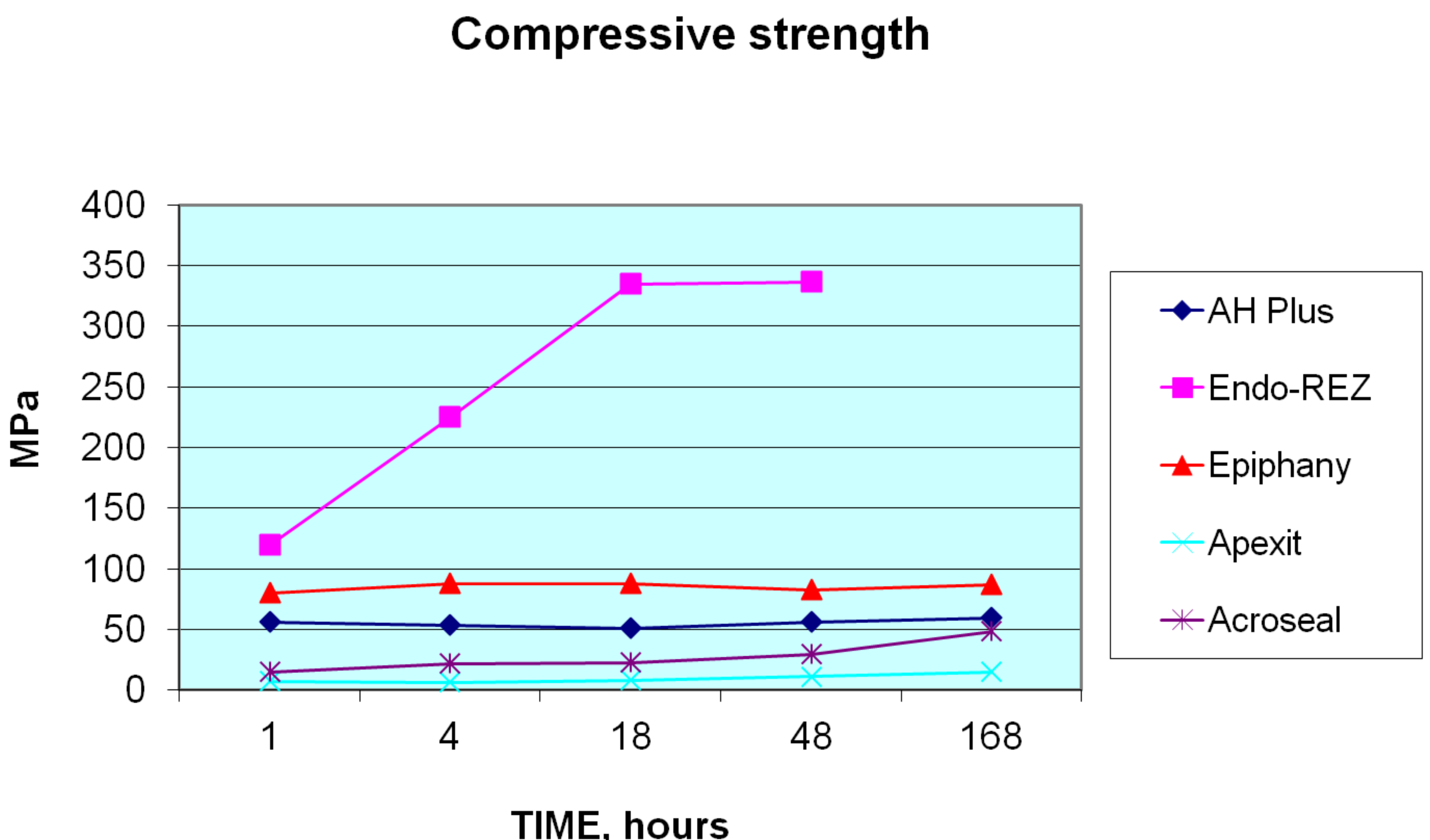
Eldeniz et al.

There may be too much or too little: 6mm Aluminum equals dentin, minimum requirement is 3 mm, but that is on the low side clinically

Investigation of the physical properties of tricalcium silicate cement-based root-end filling materials

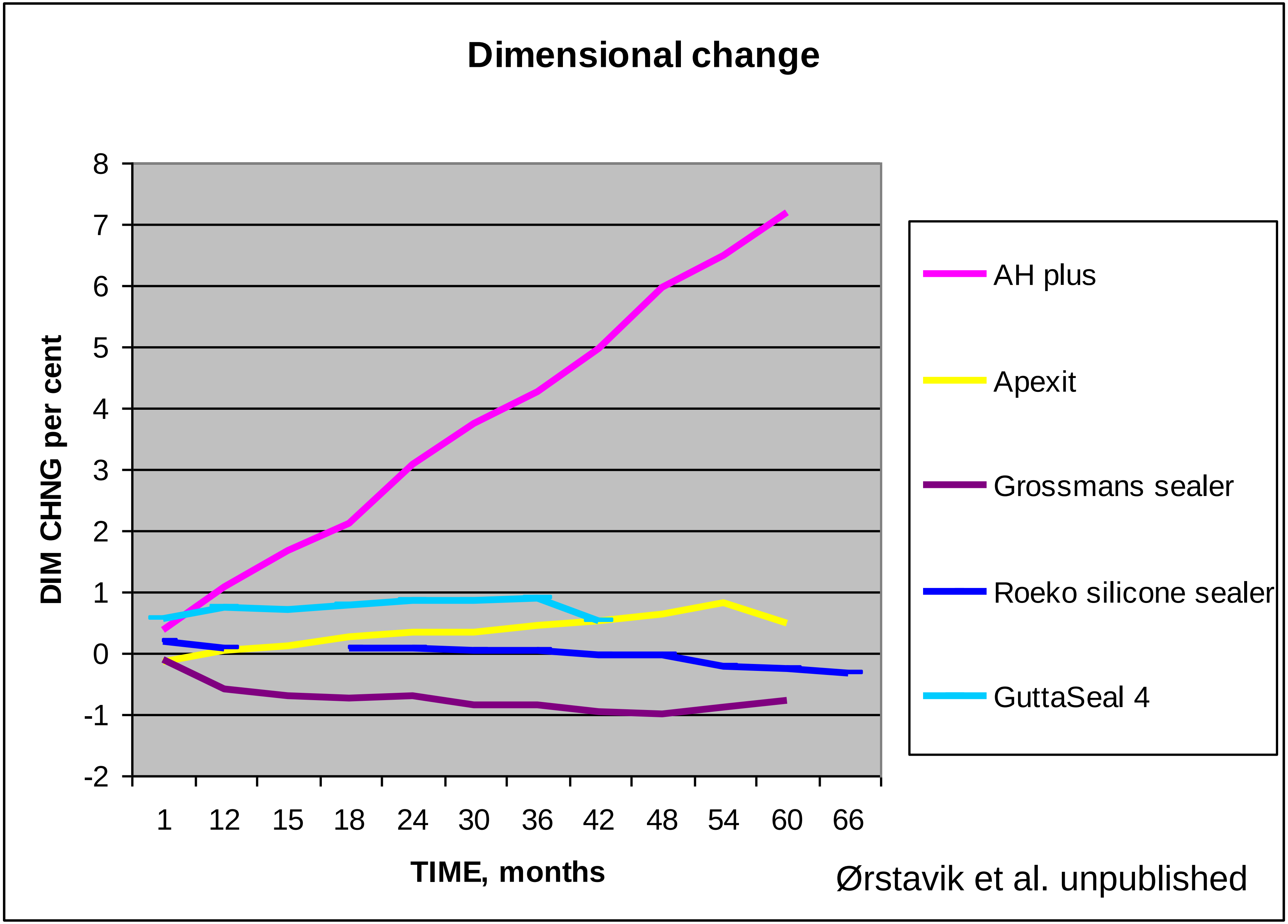
L. Grech, B. Mallia, J. Camilleri, Dental Materials 29, Issue 2, February 2013, e20–e28





Eldeniz et al. in prep

MTA ProRoot: 27 Mpa after 7 days


Dimensional change
DIM CHNG per cent
8
7
6
5
4
3
2
1
0
-1
-2
1
12
15
18
24
30
36
42
48
54
60
66
TIME, months
AH plus
Apexit
Grossmans sealer
Roeko silicone sealer
GuttaSeal 4
Ørstavik et al. unpublished

J Endod. 2013 Oct;39(10):1281-6

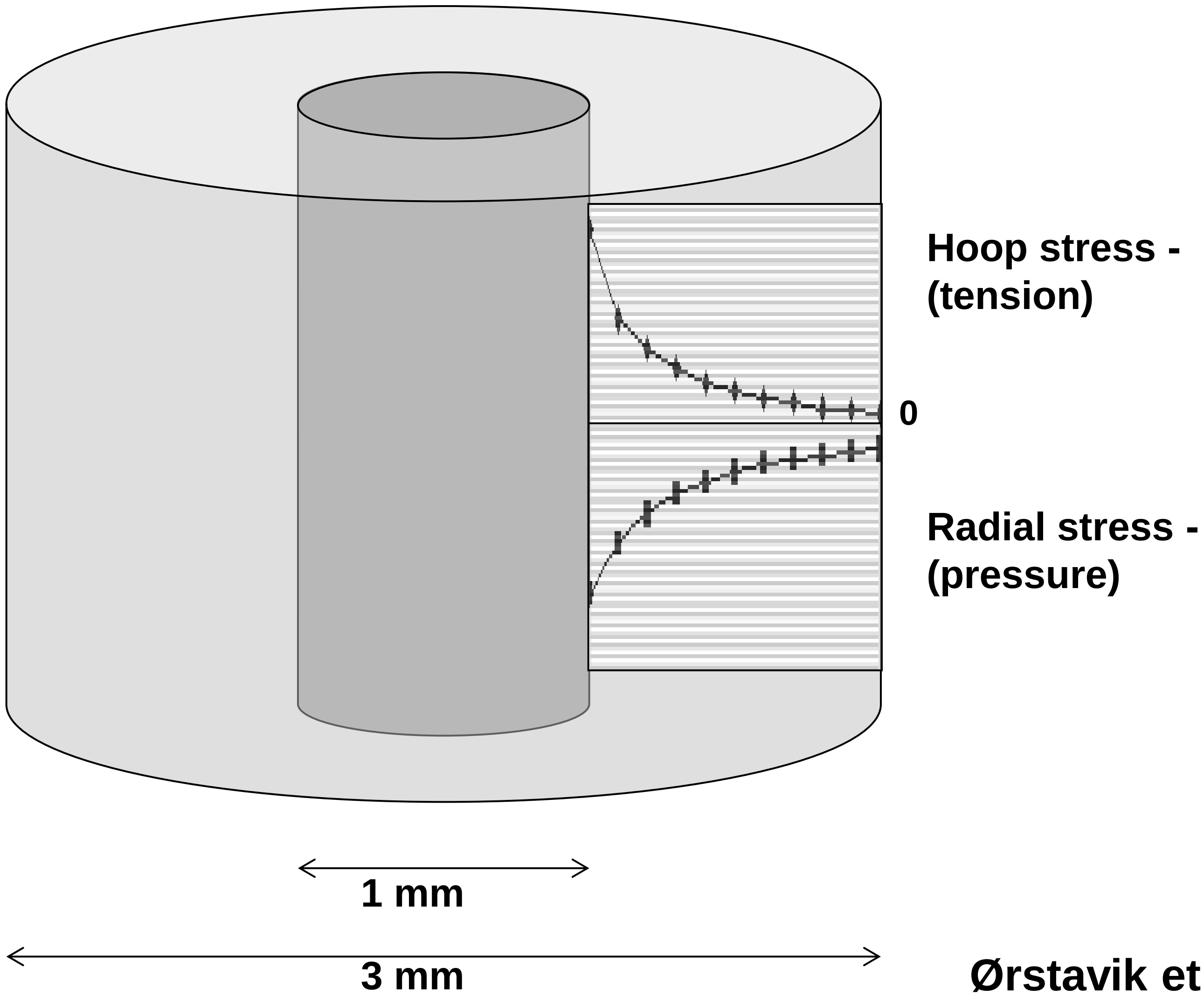
Physical properties of 5 root canal sealers.

Zhou HM, Shen Y, Zheng W, Li L, Zheng YF, Haapasalo M.

Table 1.

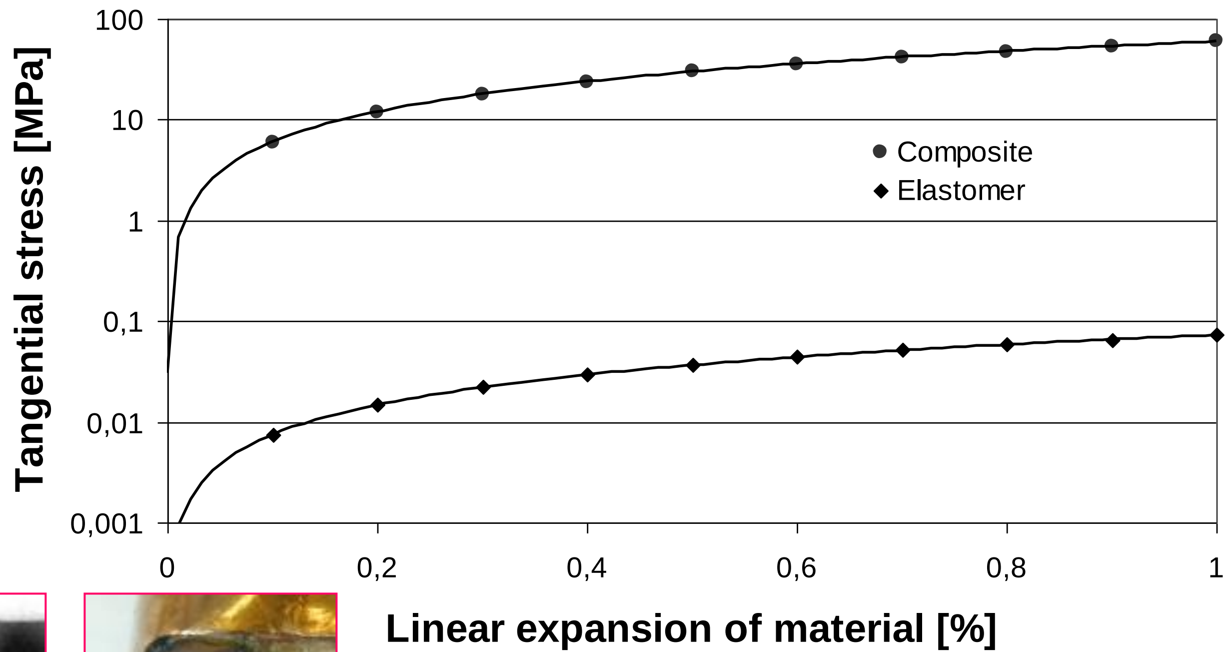
Physical Properties of the Sealers (mean ± standard deviation)

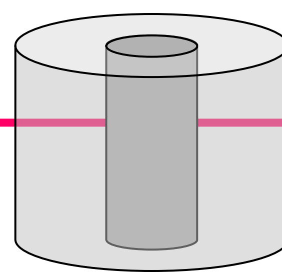
	Endosequence BC sealer	MTA Fillapex (Angelus)	AH Plus (epoxy, Dentsply)	ThermaSeal (epoxy, Dentsply)	PCS (zeug)	GuttaFlow
Flow (mm)	23.1 ± 0.69	24. 9 ± 0.54	21.2 ± 0.27	21.3 ± 0.47	23.1 ± 1.21	20.5 ± 0.32
Film thickness (μm)	22 ± 4.58	23.92 ± 7.05	16.07 ± 4.5	16.6 ± 5.26	13.35 ± 2.8	15.67 ± 1.4
Working time (min)	>1440	45 ± 15	240 ± 40	300 ± 40	453 ± 31	15 ± 5
Setting time (h)	2.7 ± 0.3	2.5 ± 0.3	11.5 ± 1.5	23.0 ± 1.5	26.3 ± 2.5	0.7 ± 0.1
Solubility∗ (%)	2.9 ± 0.5	1.10 ± 0.15	0.06 ± 0.04	0.0015 ± 0.07	0.07 ± 0.03	0.02 ± 0.001
Dimensional change† (%)	0.087 ± 0.04	−0.67 ± 0.01	−0.034 ± 0.01	0.04 ± 0.02	−0.86 ± 0.03	0.037 ± 0.02



Ørstavik et al. 2003

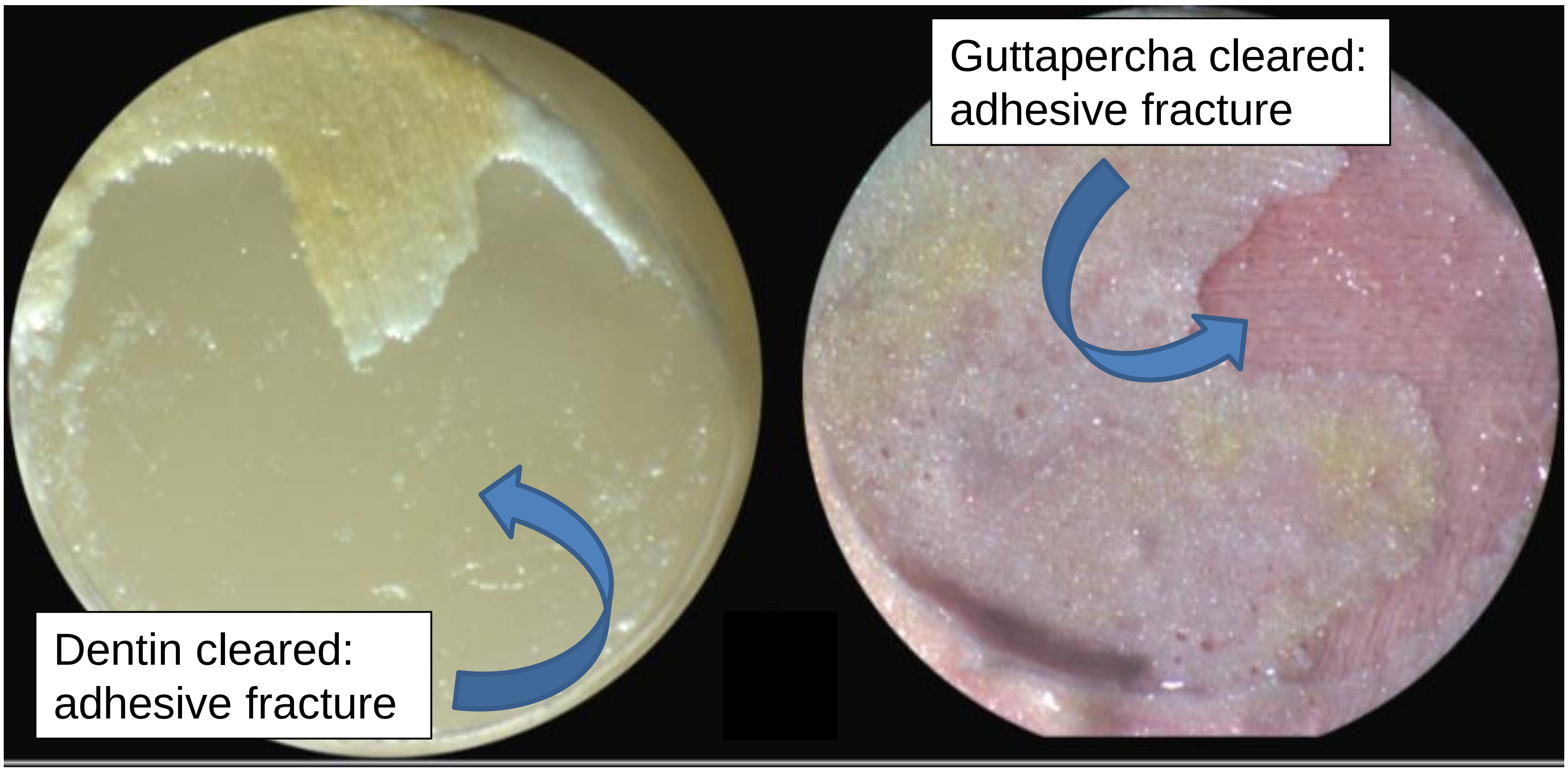
E moduli: Calciumsilicate (CHS) ca 250 GPa, Composite ca 15 Gpa, elastomer ca 1 MPa





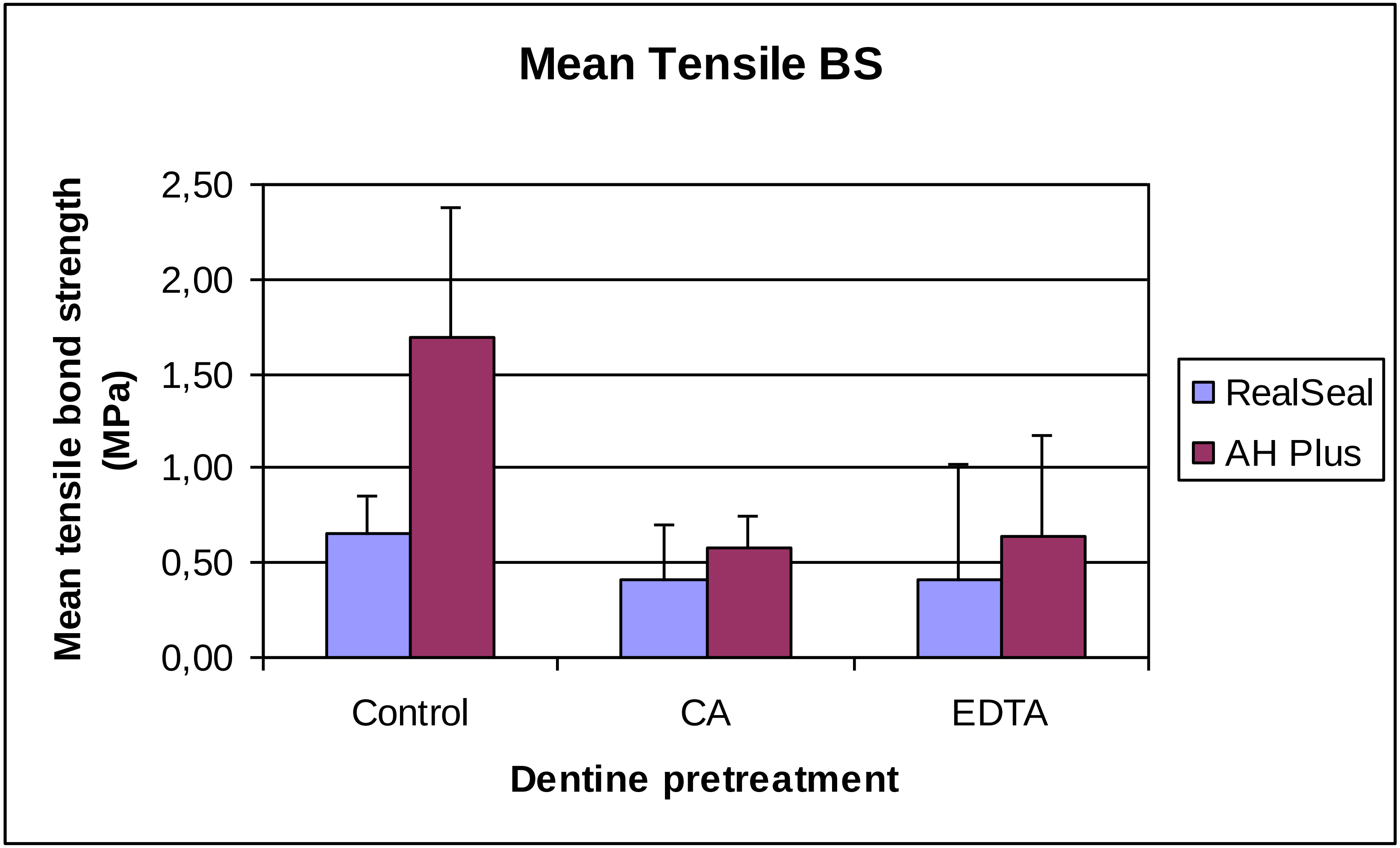
From Ørstavik et al. 2001

Smear layer and adhesion; cohesive and adhesive fracture



Saleh et al. Seldom cohesive fracture of sealer

Smear layer and adhesion



Saleh et al.: removal of smear layer did NOT increase adhesion

Fracture resistance of roots endodontically treated with a new resin filling material

TABLE

FORCE MEASURED IN NEWTONS REQUIRED TO CAUSE VERTICAL ROOT FRACTURE (N = 16).

GROUP		MEAN*	STANDARD DEVIATION
1	Control—No Obturation	465.39[ab]	76.85
2	Lateral Gutta-percha	391.51[a]	146.79
3	Vertical Gutta-percha	392.37[a]	77.03
4	Lateral Resilon†	504.22[b]	195.94
5	Vertical Resilon	498.23[b]	135.32

* Superscript letters a and b represent statistically significant differences ($P < .05$).
† Resilon is manufactured by Resilon Research, North Branford, Conn.

Teixeira et al 2004: slightly stronger teeth after root filling with Resilon

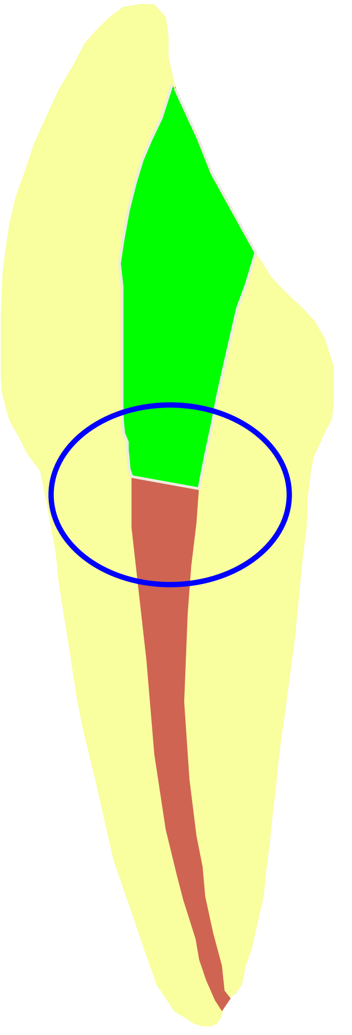
Fracture resistance of roots obturated with three different materials.

Mean, standard deviation, and minimum and maximum values of forces for experimental groups (in Newtons)

Group	n	Mean	SD	Min	Max
1 (AH26 + gutta-percha)	15	**1021.04**	226.74	684.31	1365.01
2 (Resilon + Epiphany)	15	**886.33**	175.15	600.00	1223.96
3 (Ketac-Endo Aplicap + gutta-percha)	15	**741.38**	175.46	426.73	1053.56
4 (No obturation)	15	**831.40**	163.07	598.00	1202.00

Ulusoy et al 2007: At least as good fracture resistance with AH

Leakage



In vitro model for coronal leakage

Upper chamber with bacteria

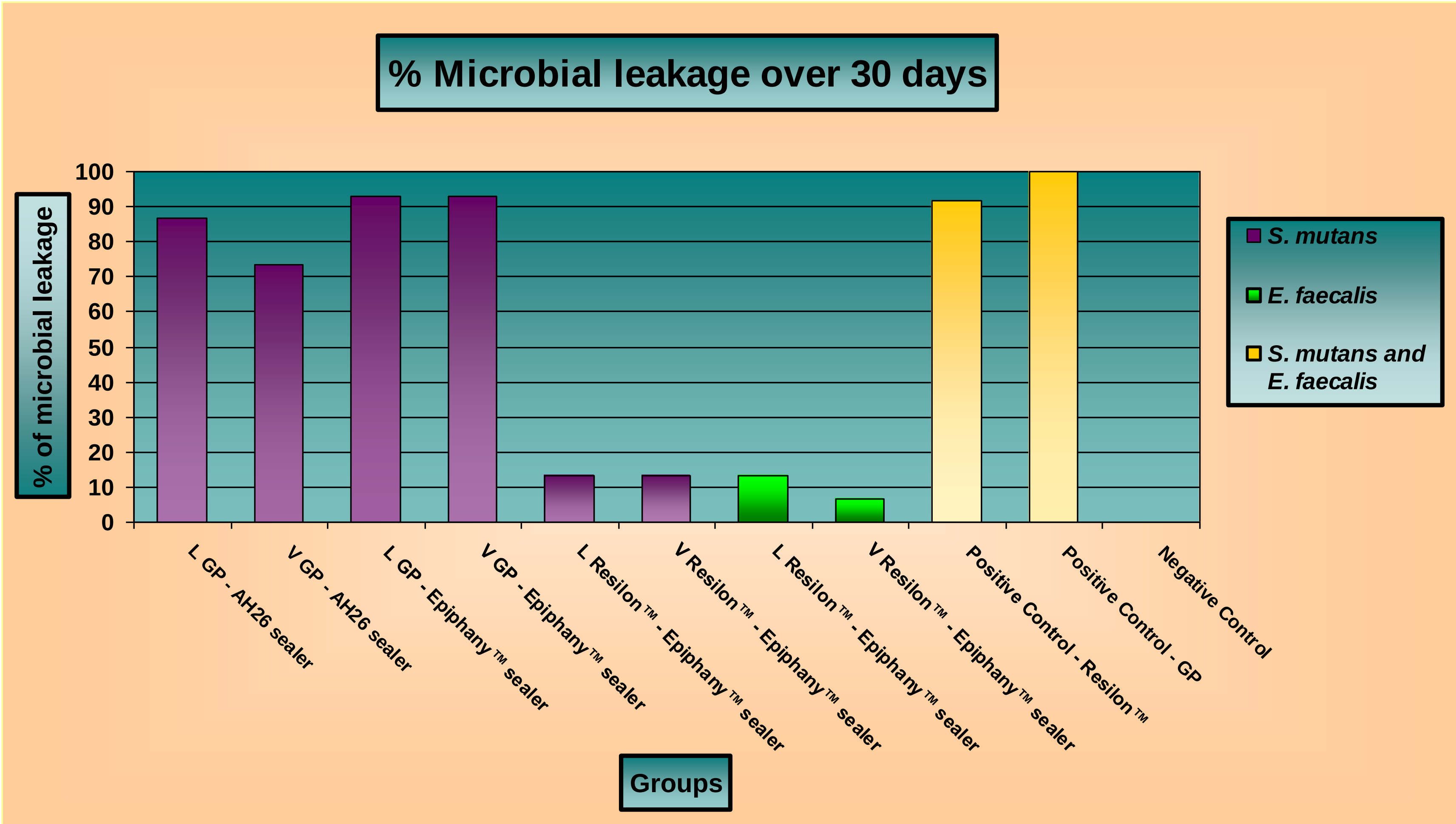
Sterilised, root filled root

Barthel et al, 1999

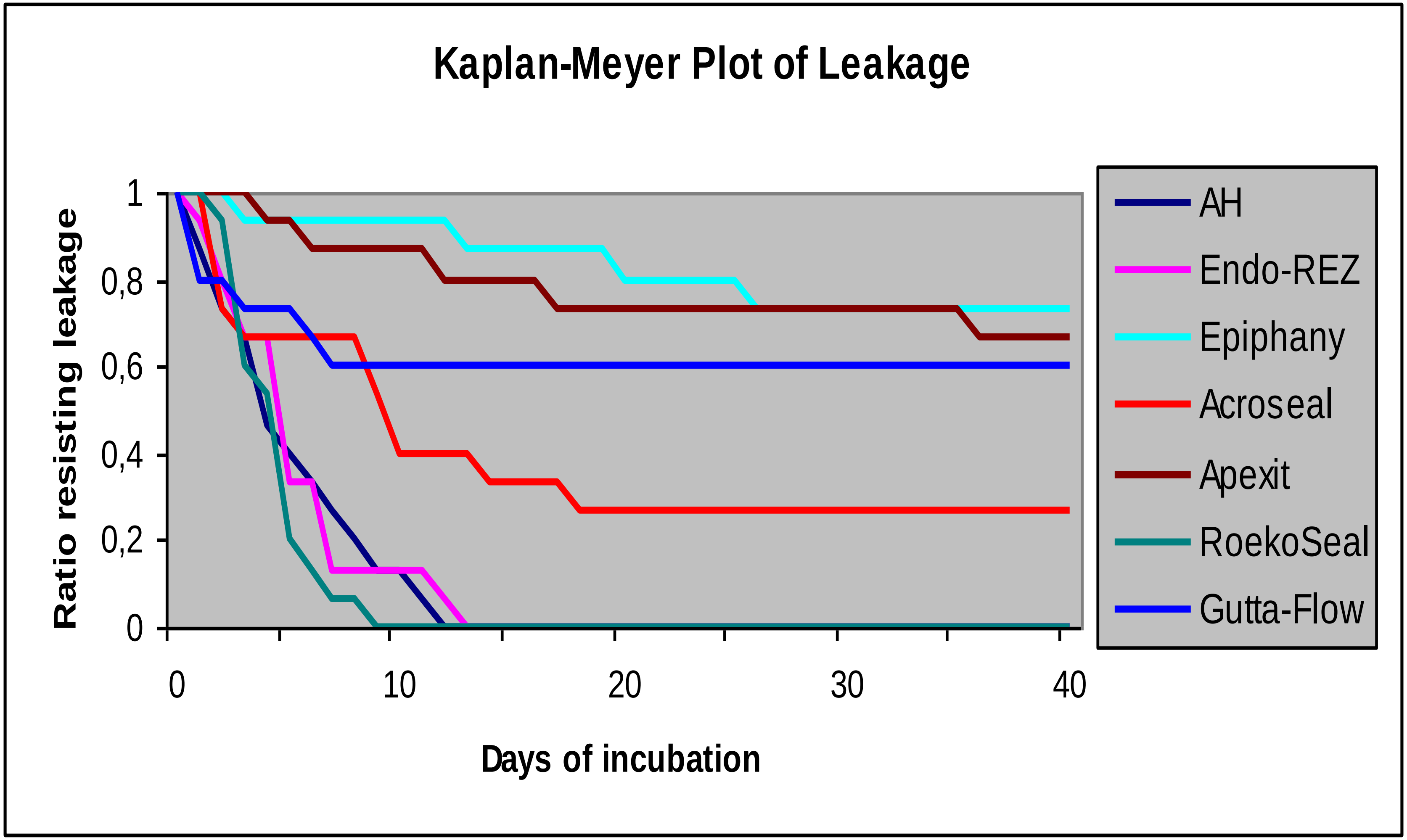
Wax seal

Lower chamber, sterile medium

Bacteria penetrating the root filling multiply in the clear medium of the lower chamber, making it turbid.

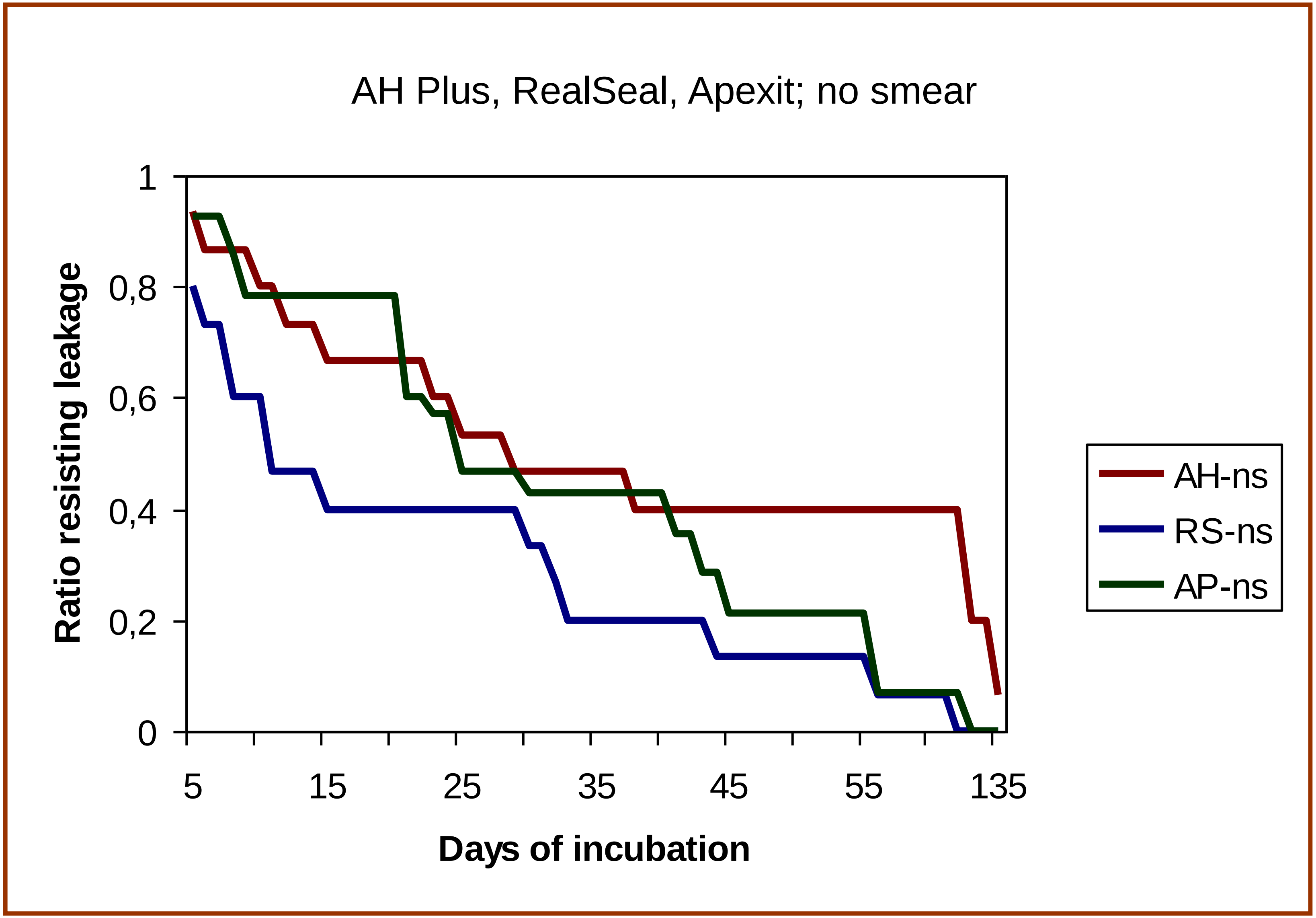


Shipper et al.2004



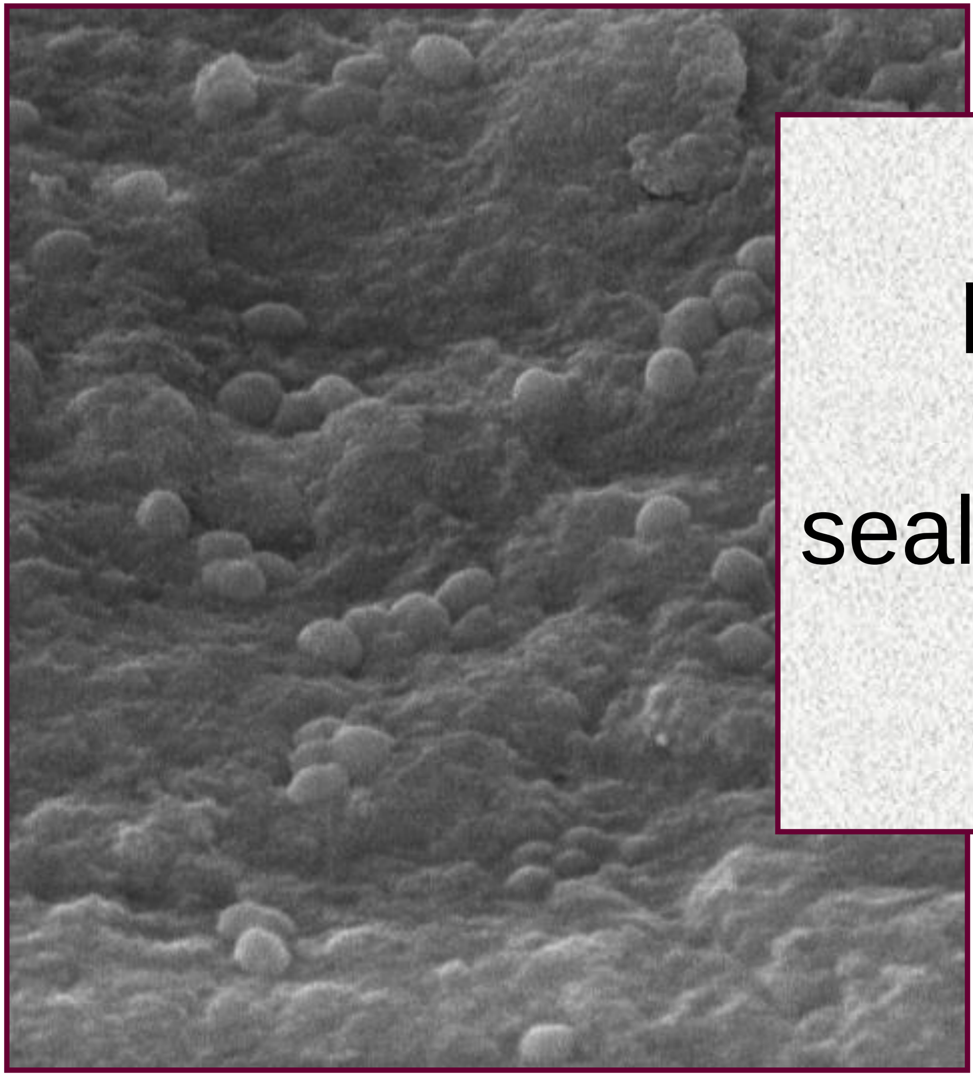
Streptococcus

Eldeniz et al. Similar resistance to leakage for AH and Resilon

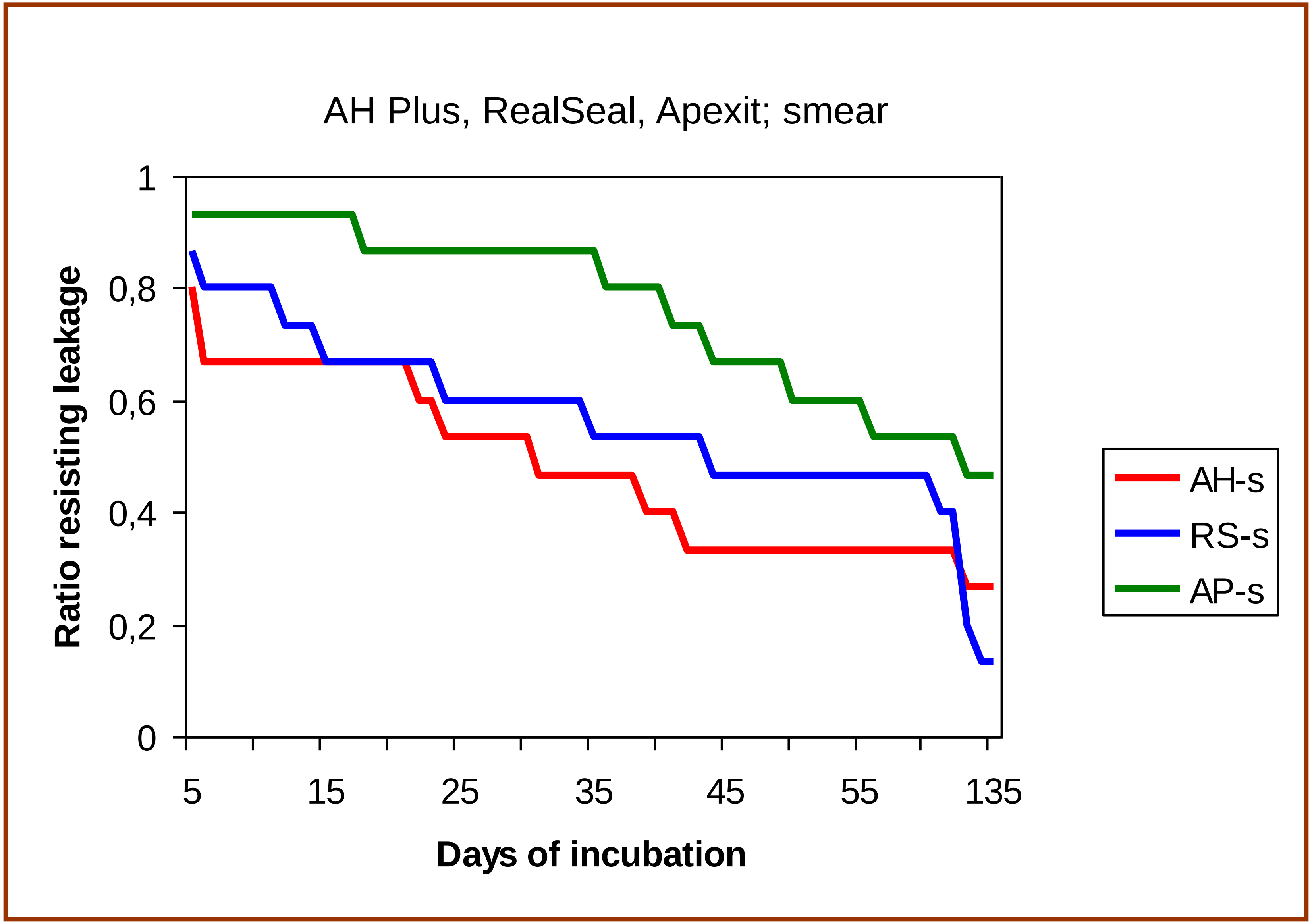


Enterococcus

Saleh et al. 2008



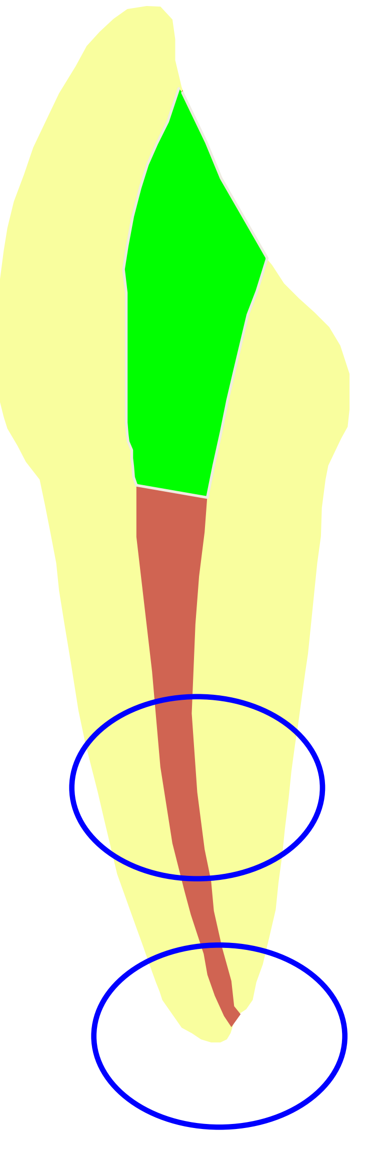
Bacteria penetrating along sealer-guttapercha interface: AH Plus



Enterococcus

Saleh et al. 2008

Antibacterial properties



Role of the root filling in eliminating microbes

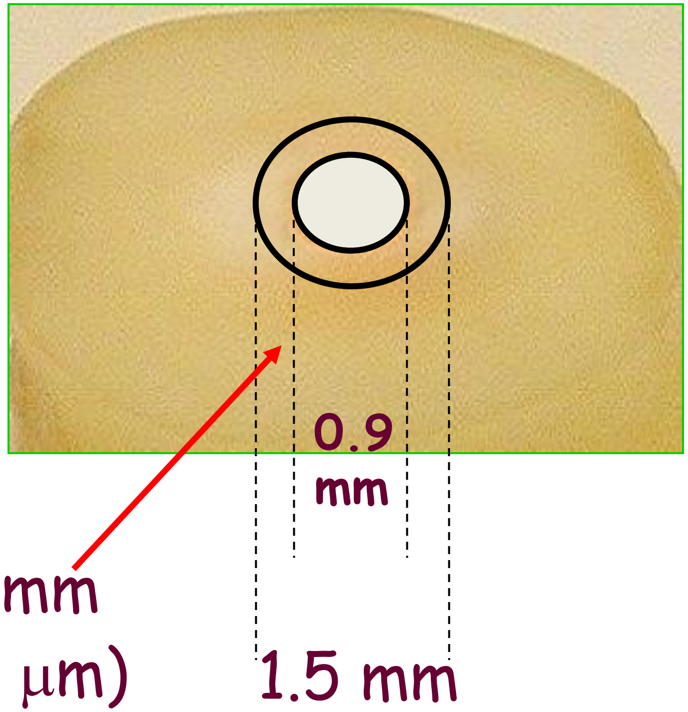
From Saleh et al. 2003

- Root stubs preinfected with *Enterococcus faecalis*
- A gutta-percha point # 90 covered with sealer used to fill the canal
- 6 sealers and one group with calcium hydroxide

Specimen with root filling
in situ

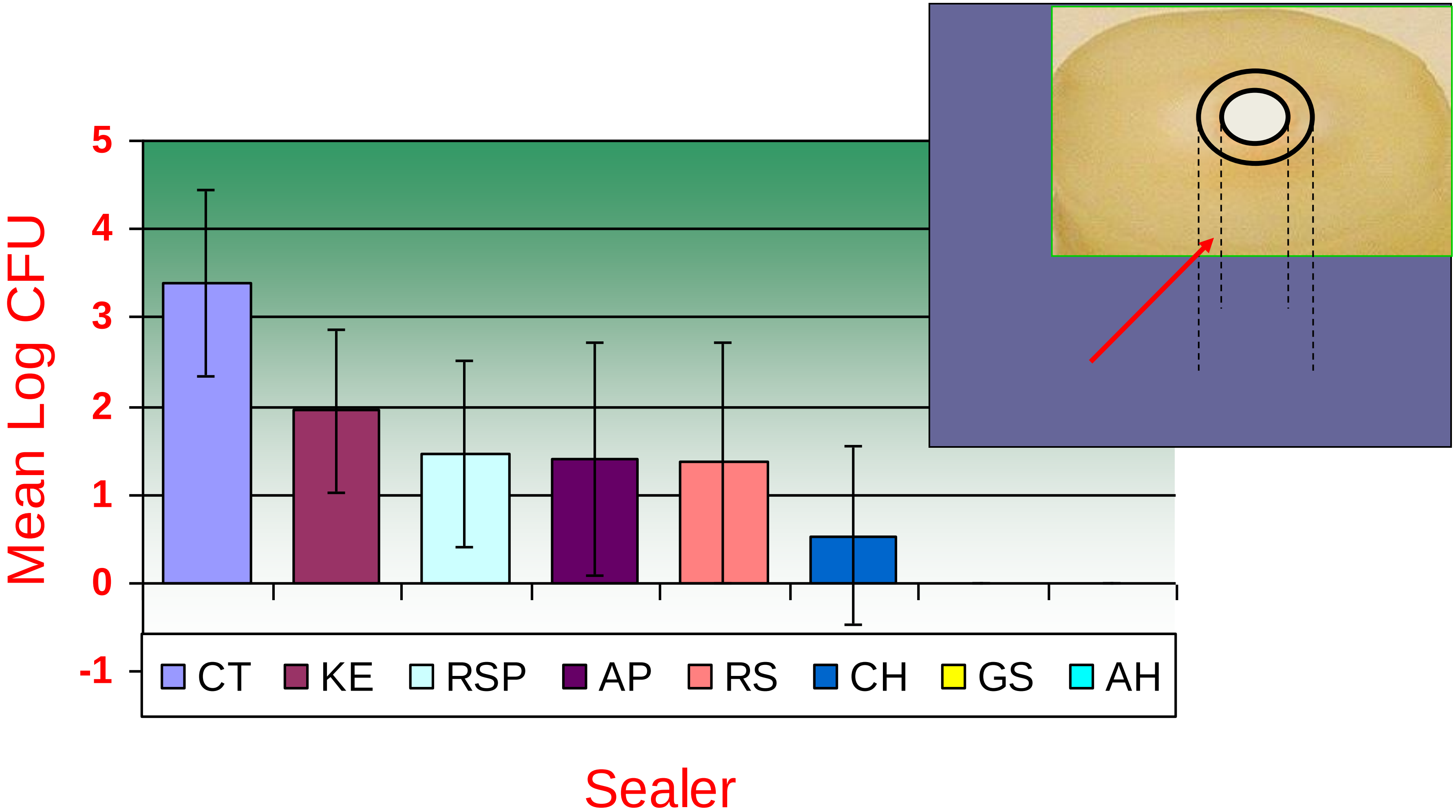
- Infected dentin slabs
- Root filled with GP and sealers
- Collection of dentin powder for culturing

Largo® Peeso
Reamer size 5
(ISO size 150)



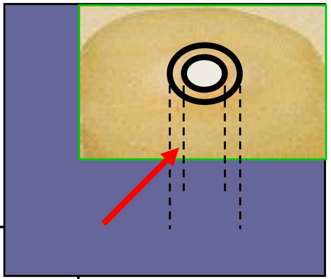
Saleh et al. 2003

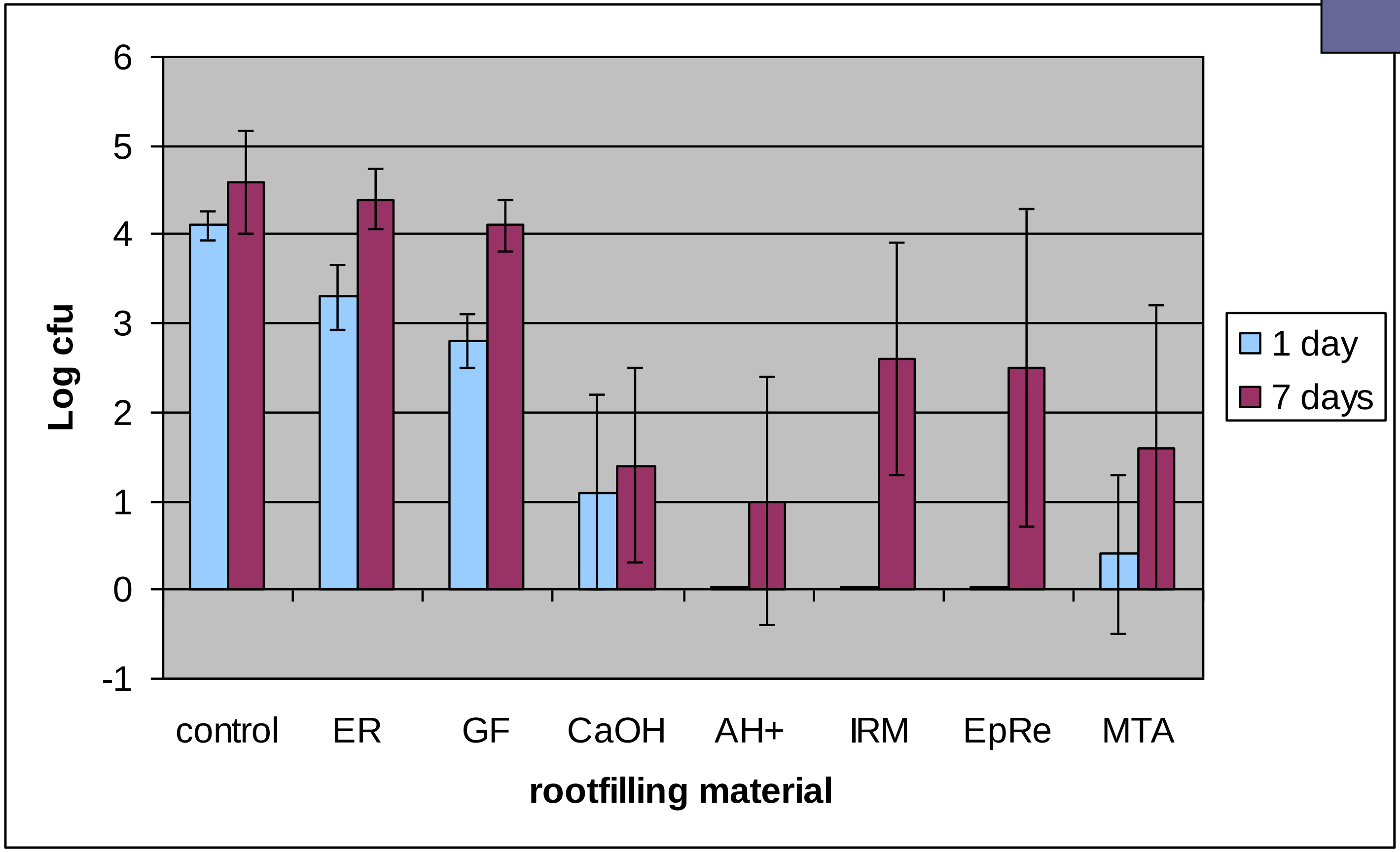
Saleh et al. 2003



(CT: control; KE: Ketac-Endo; RSP: RoekoSeal Automix + Primer; AP: Apexit; RS: RoekoSeal Automix; CH: Calcium Hydroxide; GS: Grossman's sealer; AH: AH Plus)

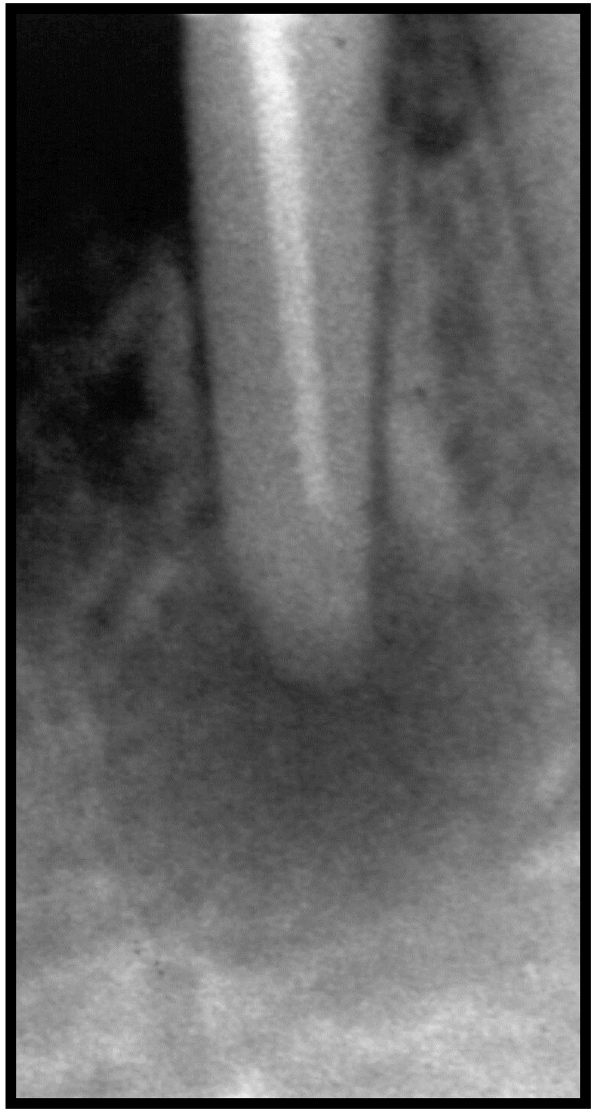
Prestegaard et al. 2014 in press





ER: EndoREZ; CaOH: Calcium Hydroxide; AH+: AH Plus); EpRe: Epiphany/Resilon. Short bars mean fewer bacteria

Clinical-radiological testing

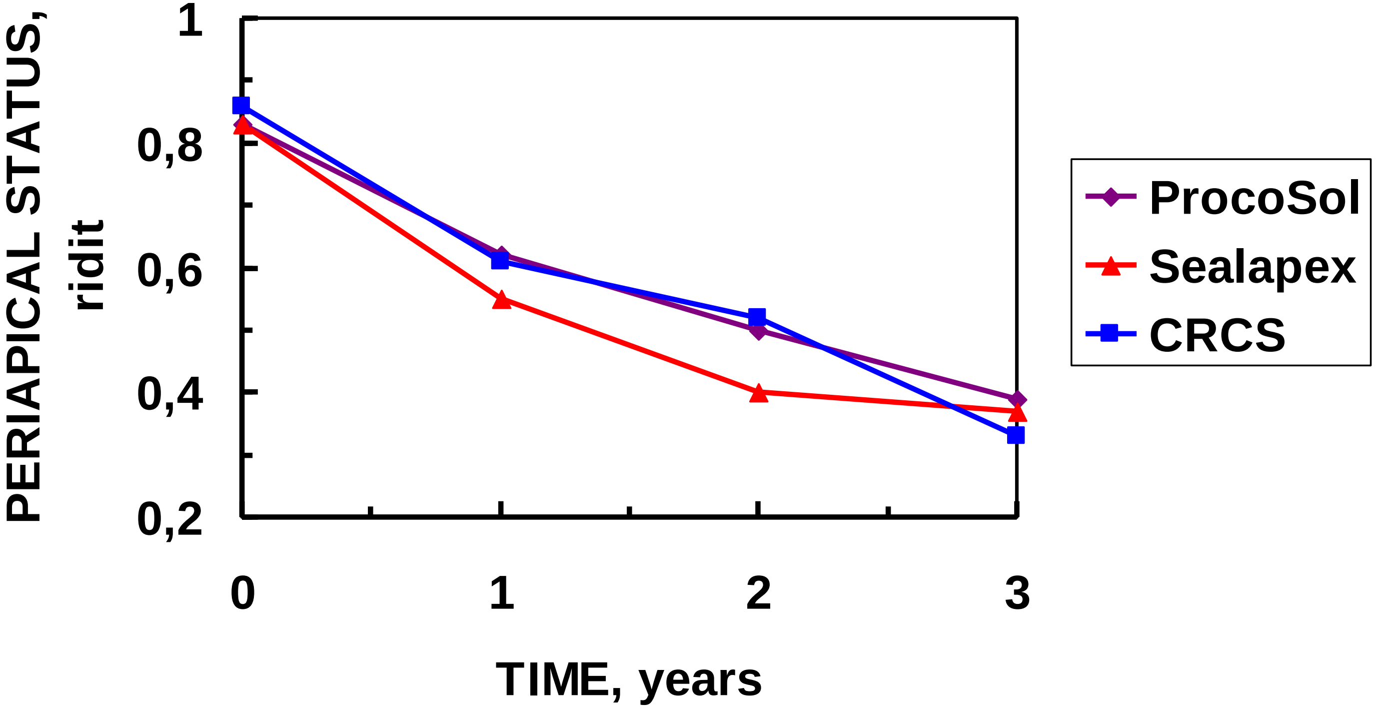


Critical factors in clinical testing

- ***Randomization***: Each case stand an equal chance of being subject to either treatment
- ***Confidence interval****: The range of probable value for an observation estimate*
- Cohort study: Two or more groups; no randomization; typically different populations
- Case-control: typically retrospective: what separates cases that succeed from those that do not?
- Case series: self-explanatory

    » Decreasing value

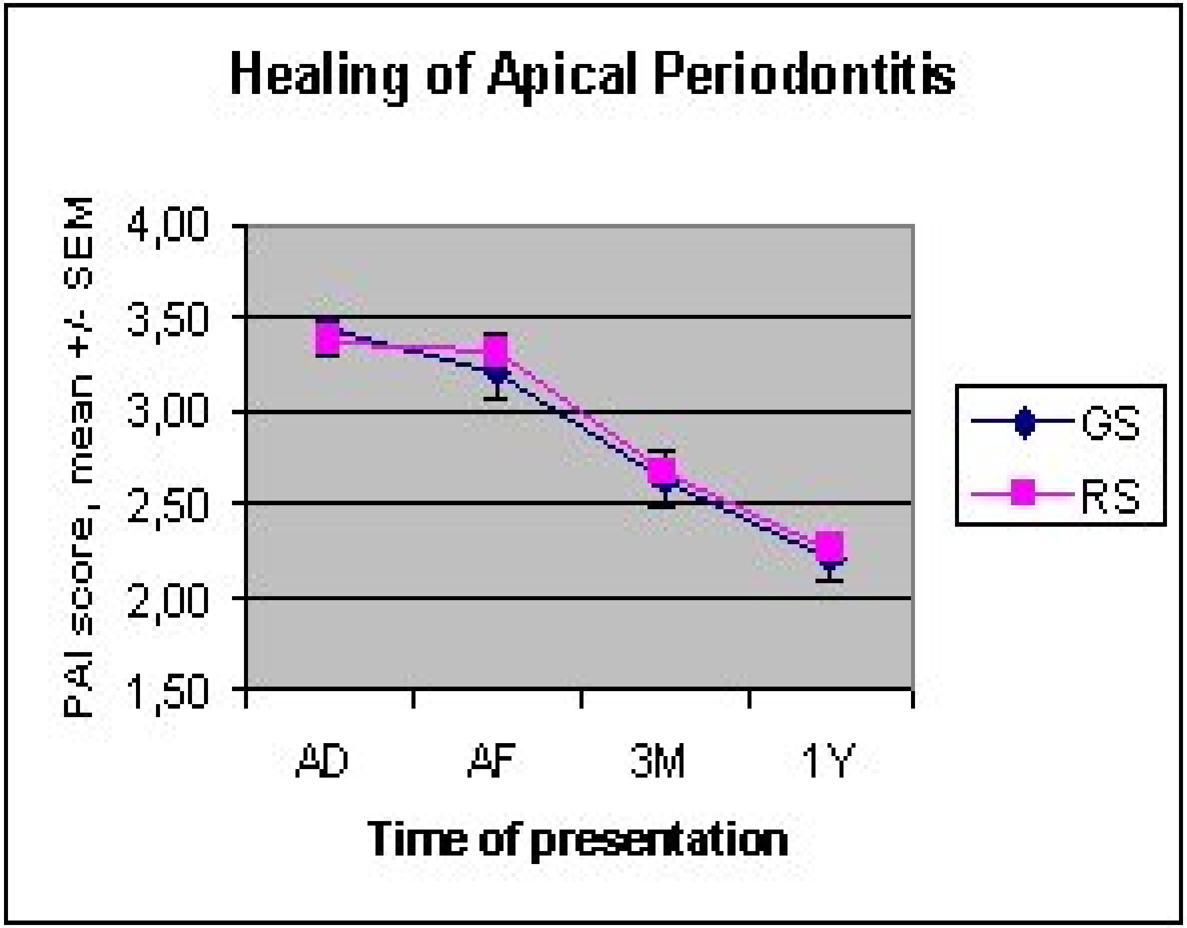
Preoperative Apical Periodontitis: Effect of Sealer



Waltimo et al., 2001

Range of s.e. of means: 0.03-0.17

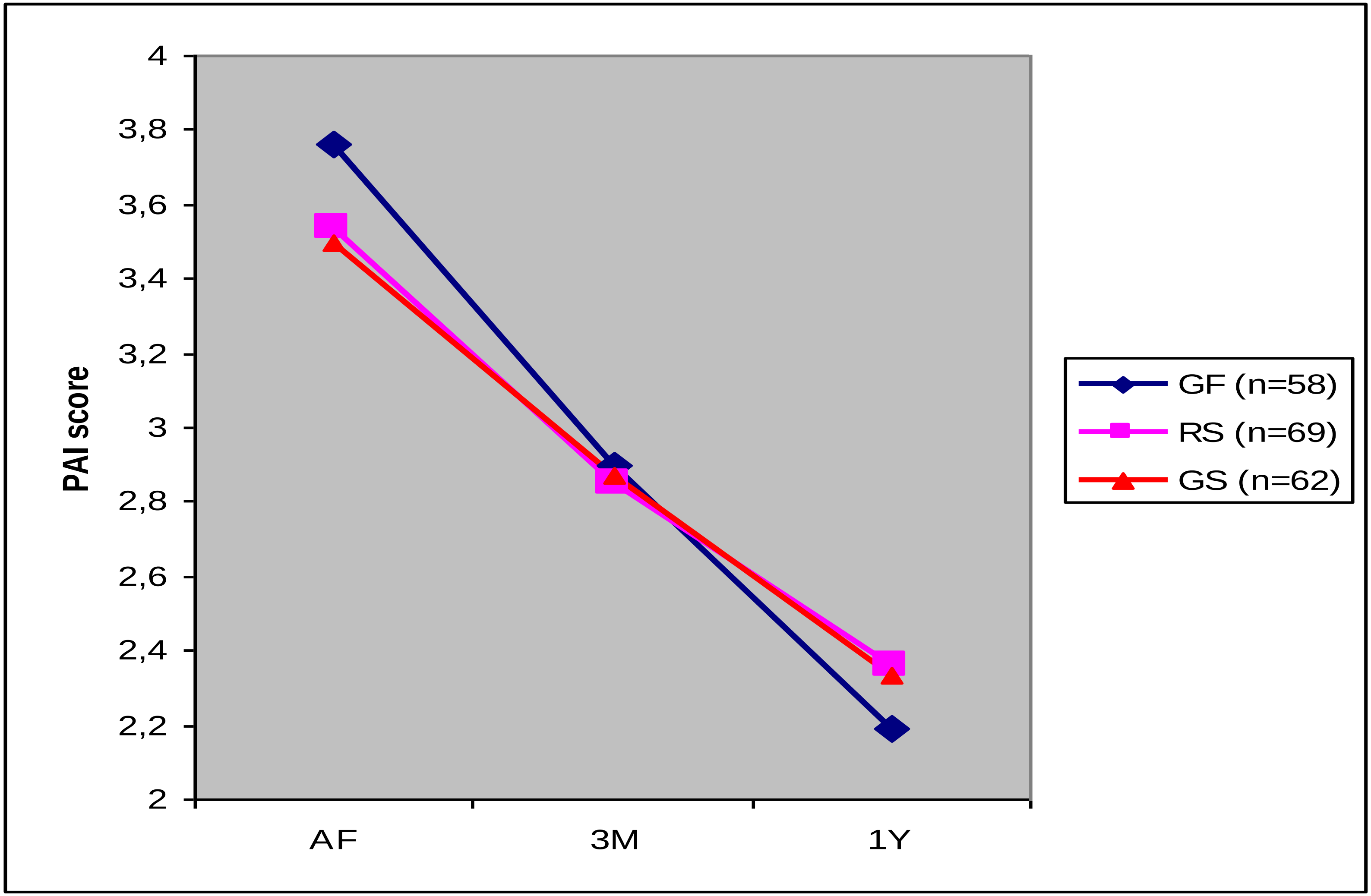
Clinical research: RoekoSeal in comparison with Grossman's sealer



Level 1 clinical evidence: randomized, unbiased

Huumonen et al., 2003

GuttaFlow



Sequence of decision

- Clinical:
  - Very difficult to prove superiority – only similar level of performance, or ’feasibility’ (Sealapex, AH, Grossman, RoekoSeal, GuttaFlow, EndoREZ, Epiphany)
- Biological:
  - Avoiding harm
  - Supporting regeneration
- Technological
  - Avoiding mishaps
  - Speed and ease of application and control
- Expert opinion
  - without explicit critical appraisal, or based on physiology, bench research or "first principles" (logical deduction)

Conclusions

- Adhesive root fillings and silicones have stimulated research
- They have forced us to identify the important functions of root fillings
- Their clinical performance is similar to conventional root filling materials, or worse
- None have documented superior performance

DE «NYE» KERAMENE OG BIOKERAMENE

Types and terms and brands

- Cement
- Bioceramics
- Bioglass
- Biocompatible, biomimetic
- Clinical usage
  - Dental
    - Preformed
    - Setting
  - Medical

- MTA, Portland cement, Biodentine
- Endosequence (iRoot, TotalFill) BC or SP
- Bioaggregate
- (Ceramir)
- Implants, cements, sealers
- (Bioceramic hip, knee, orbital implants)

MTA: the starting point for ceramics in endodontics

- **MTA PATENT (**J Conserv Dent. 2008 Oct-Dec; 11(4): 141–143.)
- The MTA patent stated that 'MTA consists of 50-75% (wt) calcium oxide and 15-25% silicon dioxide. These two components together comprise 70-95% of the cement. When these raw materials are blended, they produce tricalcium ***silicate***, dicalcium ***silicate***, tricalcium ***aluminate***, and tetracalcium ***aluminoferrite***. On addition of water, the cement hydrates, forming silicate hydrate gel.' Also 'MTA is Type 1 Portland cement (American Society for Testing Materials), with a fineness (Blaine number) in the range of 4500-4600 cm^2/g. A radiopacifier (bismuth oxide) is added to the cement for dental radiological diagnosis.'
- http://patents.com/us-5769638.html

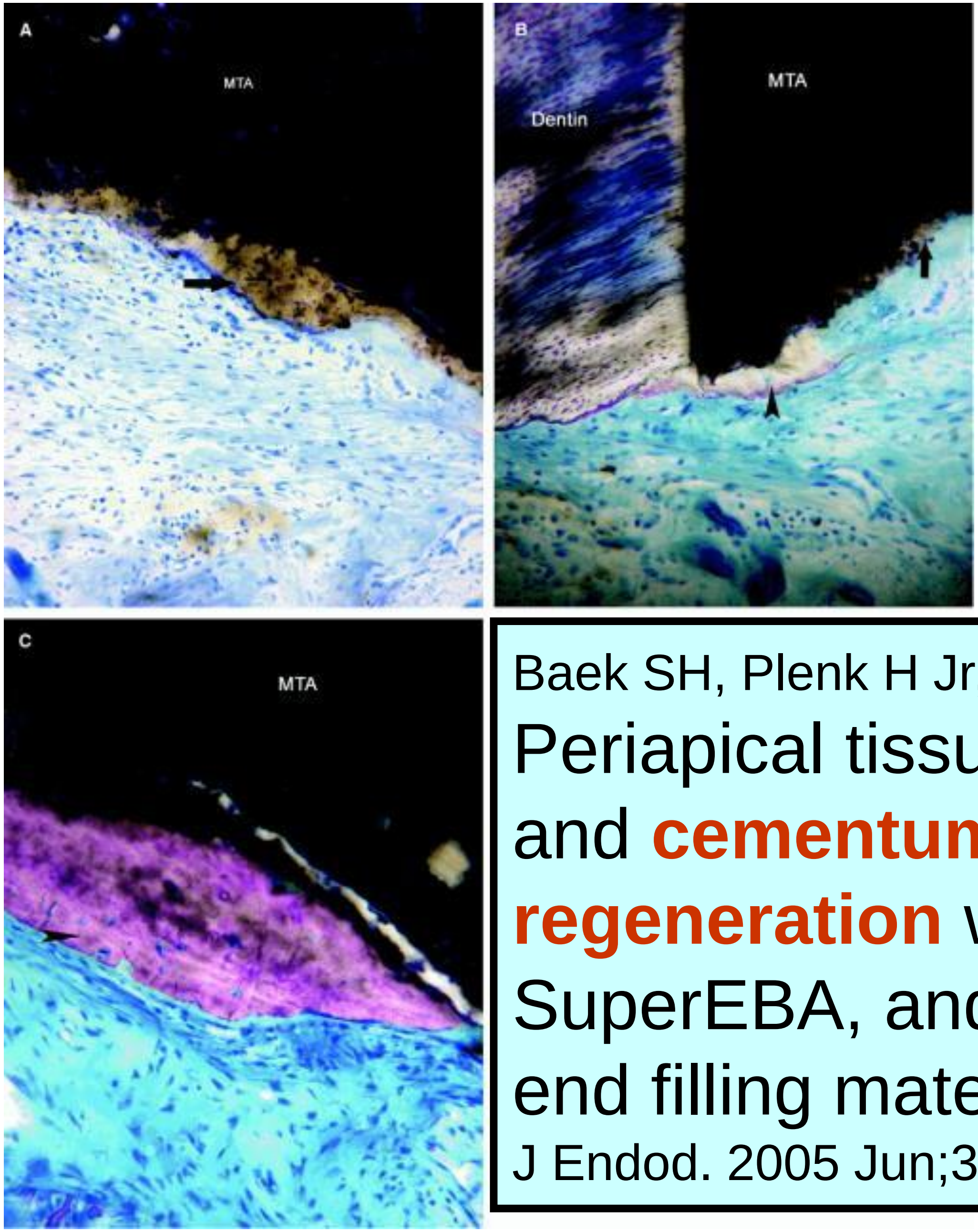
MTA

Retrograde fillings
Perforations
Dens invaginatus
Apexification
Apexogenesis
- Sealing
- Biocompatible
- Antimicrobial

Pulp capping
Pulpotomy

Root filling??

Comparative studies



Baek SH, Plenk H Jr, Kim S.

Periapical tissue responses and **cementum regeneration** with amalgam, SuperEBA, and MTA as root-end filling materials.

J Endod. 2005 Jun;31(6):444-9.






Arash Sanjabi, Oslo 2005

Silicate

- What is a silicate?

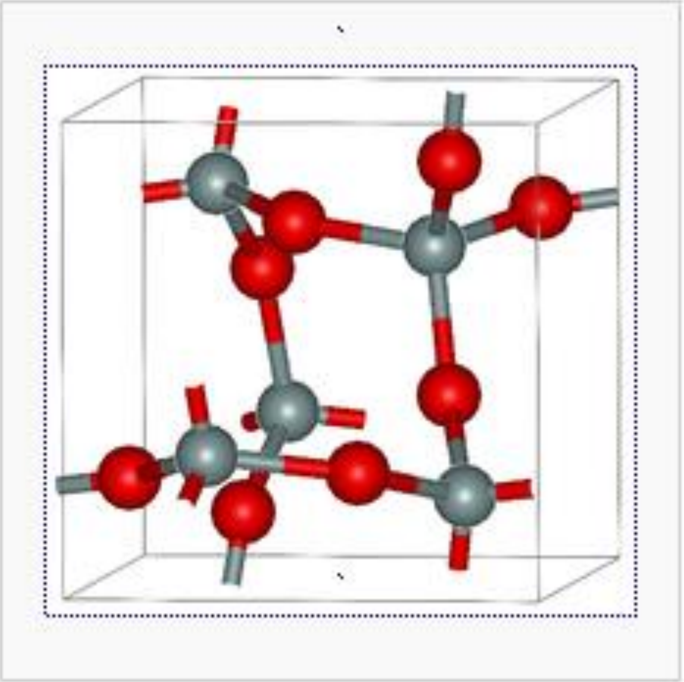
  A **silicate** is a compound containing an anionic silicon compound. The great majority of silicates are oxides [SiO, but hexafluorosilicate ($[SiF_6]^{2-}$) and other anions are also included. …. "Orthosilicate" is the anion SiO_4^{4-} or its compounds. Related to orthosilicate are families of anions (and their compounds) with the formula $[SiO_{2+n}]^{2n-}$.
  (http://en.wikipedia.org/wiki/Silicate)

Silicate

Silica

SiO_2 many crystalline forms:

quartz, **cristoballite**



Unit cell of α-cristobalite; red spheres are oxygen atoms.

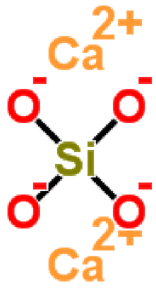
Calcium silicate

Silica

SiO_2 many crystalline forms

Di-**calcium**-silicate

Ca_2SiO_4



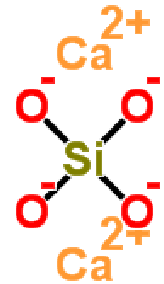
Calcium silicate

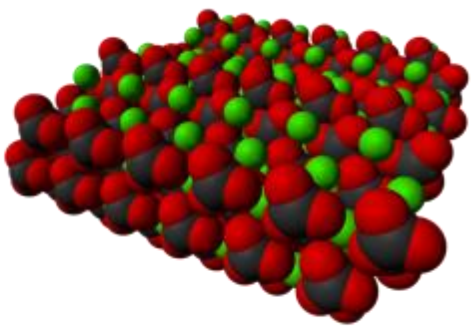
Silica

SiO_2 many crystalline forms

Di-**calcium**-silicate

Ca_2SiO_4



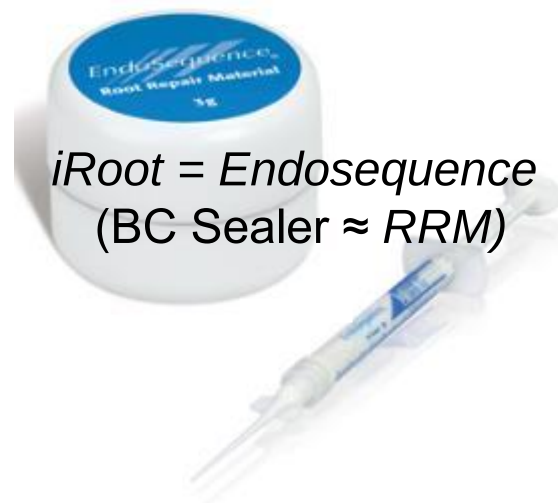


Tri-calcium-silicate

”$3CaO.SiO_2$”:3Ca+3Si+9O

From MTA to ERRM

- MTA
- MTA ***minus*** aluminum:
  - Biodentine
- MTA ***minus*** aluminum, but **plus** CaP:
  - BioAggregate; ERRM, Endosequence, iRoot, TotalFill



iRoot = Endosequence

(BC Sealer ≈ *RRM)*

Innovative BioCeramix, Inc

BioAggreate

BioAggregate Root Canal Repair Filling Material

Innovative BioCeramix Inc. (IBC) has successfully developed a new generation of a dental root canal filling material. BioAggregate® Root Canal Repair Filling Material (BioAggregate®) is a fine white hydraulic powder cement mixture for
dental applications. It utilizes the advanced science of nanotechnology to produce ceramic particles that, upon reaction
with water produce biocompatible and aluminum-free ceramic biomaterial.

The BioAggregate® Powder promotes a complicated set of reactions upon mixing with BioA Liquid (deionized water), which leads to the formation of a nano-composite network of gel-like calcium silicate hydrate intimately mixed with hydroxyapatite bioceramic, and forms a hermetic seal whenapplied inside the root canal.

BioAggregate® has excellent handling characteristics after mixing with water, which aids in the repair process of the affected tooth. BioAggregate's® radiopacity properties, convenient setting and hardening time, easy workability and handling properties, make it an ideal root canalrepair filling material. BioAggregate® is packaged to provide all the necessary materials for six complete root canal repair filling treatments.

FEATURES & BENEFITS:

Aluminum-Free and Biocompatible Composition

The effects of aluminum toxicity can cause serious health problems. Consequently, BioAggregate® is biocompatible and
completely aluminum free.

ENDOCEM MTA

New generation GRAY MTA
300mg/1package
P/L=300mg/0.12cc

Fast setting time
Excellent biocompatibility
Super sealing property
Long clinical data
Effective bleeding control · Fast neutralization · Least calcification

”pozzolan”,
a Ca-Si variant

ENDOCEM Zr

New generation WHITE MTA
300mg/1package
P/L=300mg/0.14cc

Fast setting time
Tooth color formula
Adequate physical property
Optimized for partial pulpotomy
Effective bleeding control · Fast neutralization · Excellent biocompatibility and sealing property · Excellent radiopacity

ENDOSEAL

New generation ROOT CANAL FILLER
300mg/1package
P/L=300mg/0.14cc

Tooth color formula
Length control and Flowability
Unique physical property
Effective bleeding control · Fast neutralization · Hydraulic property · Biocompatibility and sealing property · Excellent radiopacity


TOTAL FILL
BC OBTURATION KIT™
FKG
BUSA
0470


BioCeramic
Root Repair Material
Figure #: ESBCRRM INTRO
Contents:
• Preloaded Syringe (1g)
• 7 Disposable Tips
• Instructions For Use
• MSDS
EndoSequence
Root Repair Material


iRoot BP

EndoSequence® BC Points™ are unlike traditional gutta percha and are subjected to a patented proprietary process of impregnating and coating each cone with bioceramic nanoparticles to allow for true chemical (cementation) bond between sealer and points.

https://www.dentalaegis.com/products/brasseler/endosequence-bc-points

BioAggregate

Bioceramic Composition

a. Chemically bonded ceramic (bioceramic) raw materials. It's not a mineral (ceramic in nature) aggregate.

b. Aluminum-Free Composition

The effects of aluminum poisoning can range from subtle symptoms to serious diseases. BioAggregate is completely aluminum free and will not pose any toxic threat to the human body. - No toxic heavy metals. (No tricalcium aluminate - C3A - in MTA.)

c. No unnecessary heavy elements (ex. iron)

BioAggregate is pure bioMaterial without any unneccessary contaminants, thus is considered safer for use as medical devices. (No tetracalcium aluminoferrite - C4AF in MTA)

http://www.bioaggregate.com/product

MM-MTA™

Root canal repair cement

The introduction into the market of MTA (Mineral Trioxide Aggregate) in the 90s has been a veritable revolution that allows successful repair of iatrogenic accidents while reducing the associated pathological complications.
Currently, clinically approved MTA products are available within the dental marketplace. However, MTA traditionally has a long setting time and an often grainy consistency which makes placement more difficult.

MICRO-MEGA® now offers the "State-of-the-Art" MM-MTA™, an endodontic repair cement that has excellent physiochemical characteristics delivered in innovative packaging. MM-MTA™ incorporates a faster set time with a pasty consistency for easy handling and placement.

Innovative characteristics

Thanks to its unique characteristics, MM-MTA™ offers indisputable advantages compared to other existing materials:

An adapted packaging:

- Consisting of capsules containing MM-MTA™ powder and liquid, automatic mixing is achieved quickly with a vibrating mixer. In addition, the resulting MM-MTA™ blend is extremely homogenous with transformation properties which are always optimal and reproducible.
- Each capsule contains the exact dosage of MM-MTA™ to avoid waste.

A homogenous consistency:

- MM-MTA™ packaging insures a consistently high-quality product mix for simple handling and easy placement within the root canal.

A reduced setting time (20 minutes):

- The addition of calcium carbonate (CaCO3) considerably reduces the setting time and also allows filling in the same session.

Likheter og forskjeller

- MTA har aluminium blant ingrediensene
- ”Alle” prøver å unngå det, også **Biodentine**

Likheter og forskjeller

- MTA og Biodentine er **”IKKE”** biokeramer, fordi

Likheter og forskjeller

- MTA og Biodentine er **”IKKE”** biokeramer, fordi
- de **IKKE** har et kalsiumfosfat (Ca-P) med i formelen/produksjonen

Likheter og forskjeller

- MTA og Biodentine er **”IKKE”** biokeramer, fordi
- de **IKKE** har et kalsiumfosfat (Ca-P) med i formelen/produksjonen, men har
- **tricalcium silicate,** dicalcium silicate, (tricalcium aluminate og tetracalcium aluminoferrite i det opprinnelige patentet for MTA)

Likheter og forskjeller

- MTA og Biodentine er **”IKKE”** biokeramer, fordi
- de **IKKE** har et kalsiumfosfat (Ca-P) med i formelen/produksjonen, men
- **tricalcium silicate,** dicalcium silicate, (tricalcium aluminate, and tetracalcium aluminoferrite) **som**
- reagerer med vann til et hydratisert skikt (C-S-H) mellom kornene, som stivner etter hvert

Likheter og forskjeller

- **MTA og Biodentine** er **”IKKE”** biokeramer, fordi
- de **IKKE** har et kalsiumfosfat (Ca-P) med i formelen/produksjonen, men dét **HAR biokeramer**, slik som **Endosequence** og **BioAggregate**
- [Ca-P-forbindelser: f.eks. hydroxyapatite (HA), tricalcium phosphate (TCP), biphase calcium phosphate (BCP)]

Bioceramics

- **Ceramic**: an inorganic, nonmetallic solid prepared by the action of *heat and subsequent cooling* (“sintring”).
- **Bioceramics**: the combination of calcium silicate and calcium phosphate applicable for biomedical or dental use
- **Bioceramics** and bioglasses are biocompatible. (http://en.wikipedia.org/wiki/Bioceramic)

Biodentine

- Septodont
- Active Biosilicate Technology™
- *“Biodentine™ was developed by Septodont’s Research Group as a new class of dental material which could conciliate high mechanical properties with excellent biocompatibility, as well as a bioactive behavior.”*

Biodentine

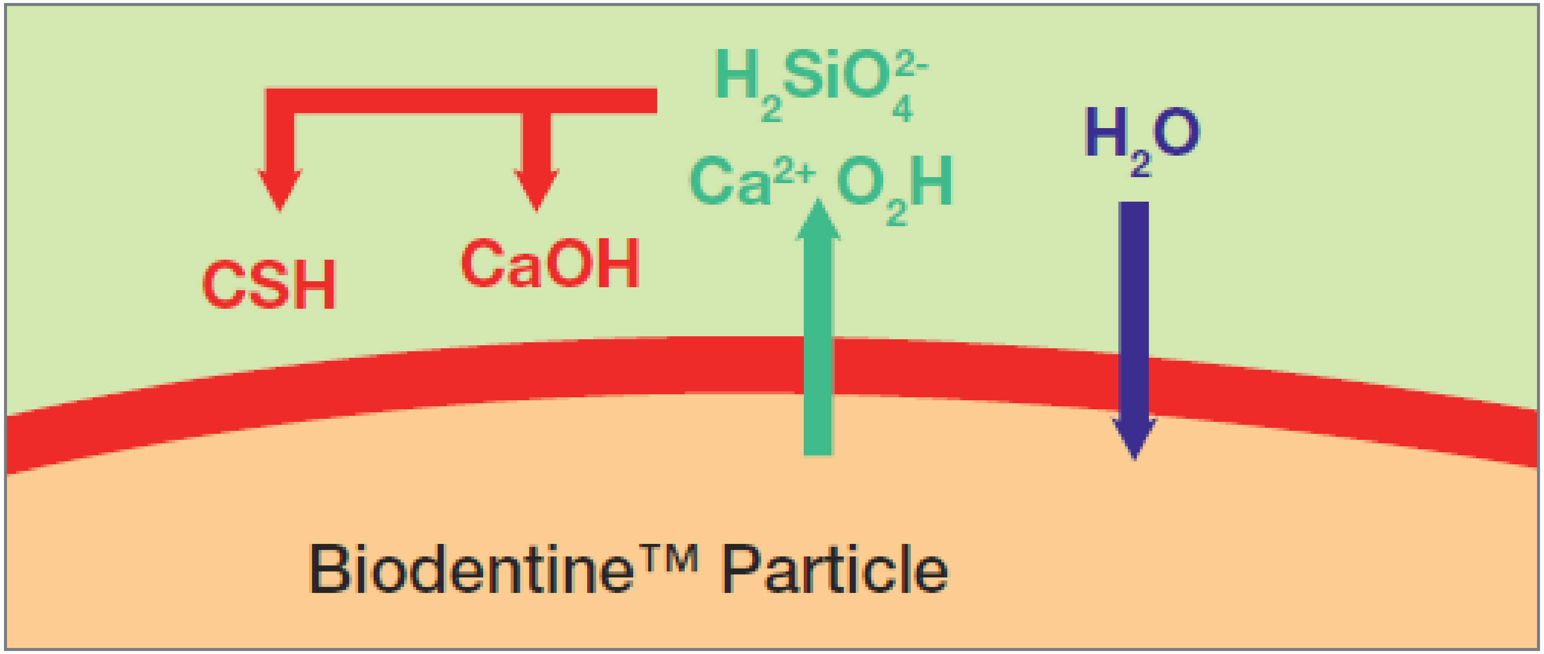
1.1 - Setting reaction

The calcium silicate has the ability to interact with water leading to the setting and hardening of the cement. This is a hydration of the tricalcium silicate (3CaO.SiO2 = C3S) which produces a hydrated calcium silicate gel (CSH gel) and calcium hydroxide (Ca (OH)2).

$$\underbrace{2(3CaO.SiO_2)}_{\mathbf{C_3S}} + 6H_2O \rightarrow \underbrace{3CaO.2SiO_2.3H_2O}_{\mathbf{CSH}} + 3Ca(OH)_2$$

This dissolution process occurs at the surface of each grain of calcium silicate. The hydrated calcium silicate gel and the excess of calcium hydroxide tend to precipitate at the surface of the particles and in the pores of the powder, due to saturation of the medium. This precipitation process is reinforced in systems with low water content.

Biodentine



The unreacted tricalcium silicate grains are surrounded by layers of calcium silicate hydrated gel, which are relatively impermeable to water, thereby slowing down the effects of further reactions. The C-S-H gel formation is due to the permanent hydration of the tricalcium silicate, which gradually fills in the spaces between the tricalcium silicate grains. The hardening process results from of the formation of crystals that are deposited in a supersaturated solution.

Biodentine

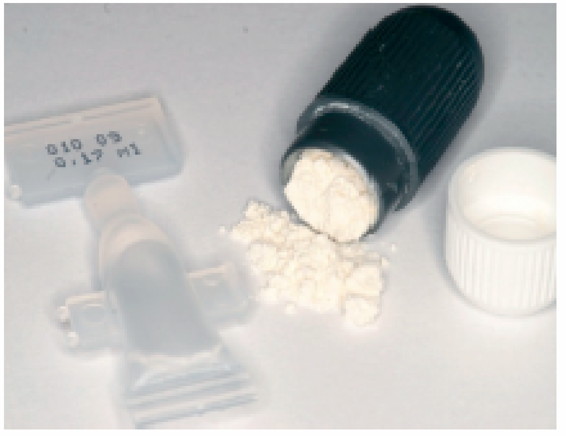
1.2 - Formulation of Biodentine™

In order to reach a formulation with a short setting time (12 minutes) and high mechanical properties in the range of natural dentine, calcium silicates could not be used alone.

Usually calcium silicate cements have setting times in the range of several hours, which is too long in most of the protocols in clinical practice.

Increasing the setting time was achieved by a combination of different effects. First, particle size greatly influences the setting time, since the higher the specific surface, the shorter the setting. Also, adding calcium chloride to the liquid component accelerates the system. Finally, the decrease of the liquid content in the system decreases the setting time to harden within 9 to 12 minutes.

Powder	
Tri-calcium Silicate (C3S)	Main core material
Di-calcium Silicate (C2S)	Second core material
Calcium Carbonate and Oxide	Filler
Iron Oxide	Shade
Zirconium Oxide	Radiopacifier
Liquid	
Calcium chloride	Accelerator
Hydrosoluble polymer	Water reducing agent



Biodentine

Reaching high mechanical strength is also quite difficult for these systems. The first cause of low mechanical properties of Portland cements are the aluminate components, which make the product fragile. Septodont controls the purity of the calcium silicate through the Active Biosilicate Technology™ which consists in eliminating aluminates and other impurities.

The second axis of formulation was to adjust the particle size distribution in order to reach an optimal powder density. The additional charge system selected was calcium carbonate, for both its biocompatibility and calcium content.

The paradox of calcium silicate systems is also that water, which is essential for the hardening of the product, can also affect the strength of the material. On the hand, excess water in the system will create some remaining porosity, significantly degrading the macroscopic mechanical resistance, but on the other hand decreasing the water content leads to reducing the possibility of a homogenous mix. The addition of hydrosoluble polymer systems described as "water reducing agents" or super plasticizers, helps in maintaining the balance between low water content and consistency of the mixture.

Radiopacity is obtained by adding zirconium oxide to the final product.

Bioglass

- In 1969 L. L. Hench and others discovered that various kinds of glasses and ceramics could bond to living bone. Hench was inspired with the idea on his way to a conference on materials. He was seated next to a colonel who had just returned from the Vietnam War. The colonel shared that after an injury the bodies of soldiers would often reject the implant. Hench was intrigued and began to investigate materials that would be biocompatible. The final product was a new material which he called Bioglass. This work inspired a new field called bioceramics. With the discovery of bioglass interest in bioceramics grew rapidly.

Bioglass

- **Bioglass** is a commercially available family of bioactive glasses, composed of SiO_2, Na_2O, CaO and P_2O_5 in specific proportions. L. L. Hench 1969 (**not** Ca-Si)
- **Glass** means it is not crystalline
- **Bio**: a thin layer of apatite forms on the glass-tissue interface
- High pH in surrounding tissue: **antibacterial effect**

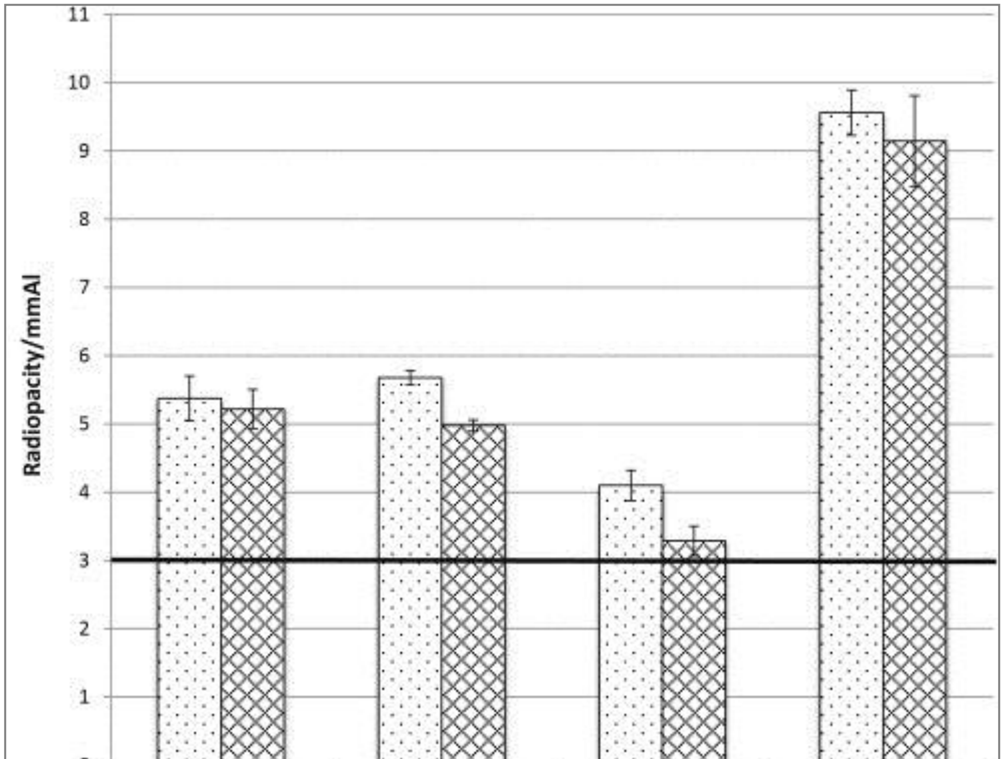
Conclusions

- Ceramic root fillings have stimulated more research
- They have played on the impressive properties of MTA
- Their clinical performance has hardly been tested
- None have documented superior performance


Thank you!

Investigation of the physical properties of tricalcium silicate cement-based root-end filling materials, L. Grech, B. Mallia, J. Camilleri

Dental Materials Volume 29, Issue 2, February 2013, Pages e20–e28

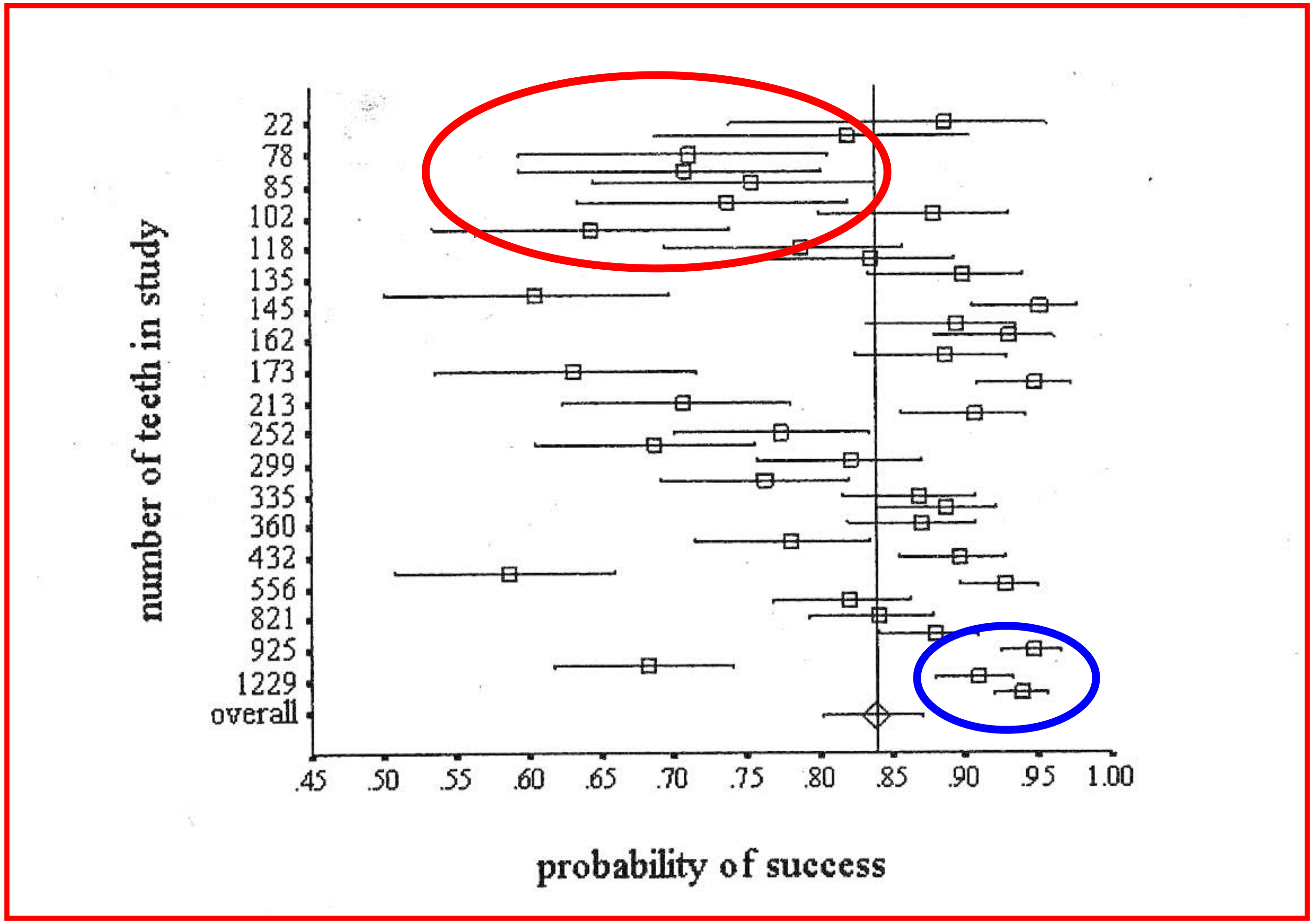


	TCS-Zr	Bioaggregate	Biodentine	IRM
1 Day	5.4	5.7	4.1	9.6
28 Days	5.2	5.0	3.3	9.1

Level	*Therapy/Prevention, Aetiology*
1a	Systematic Review (with homogeneity) of Randomized Clinical Trials
1b	Individual Randomized Clinical Trials (with narrow Confidence Interval)
6 THROUGHOUT HISTORY – ALL FLAWED	
2a	Systematic Review (with homogeneity) of cohort studies
2b	Individual cohort study (including low quality RCT; e.g., <80% follow-up)
26 – MOSTLY FLAWED	earch; Ecological studies
3a	Systematic Review (with homogeneity) of case-control studies
3b	Individual Case-Control Study (few cases, matching controls)
4	Case-series (and poor quality cohort and case-control studies)
HUNDREDS	
5	Expert opinion without explicit critical appraisal, or based on physiology, bench research or "first principles" (logical deduction)

Torabinejad M, Kutsenko D, Machnick TK, Ismail A, Newton CW.Related Articles, Links Levels of evidence for the outcome of nonsurgical endodontic treatment. J Endod. 2005 Sep;31(9):637-46.

Number of observations: effect on measures of spread



Lewsey JD, Gilthorpe MS, Gulabivala K. An introduction to meta-analysis within the framework of multilevel modelling using the probability of success of root canal treatment as an illustration. Community Dent Health. 2001 Sep;18(3):131-7.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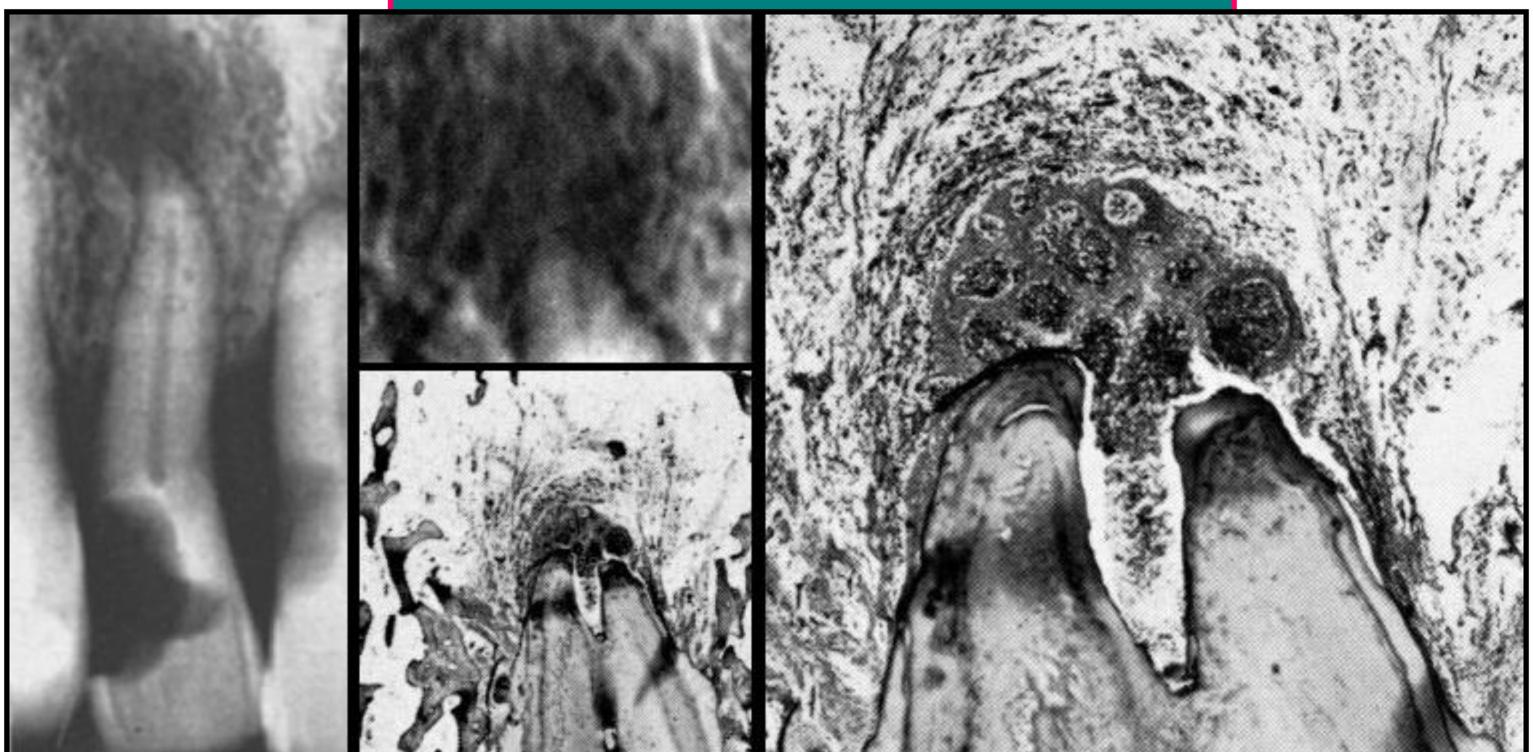
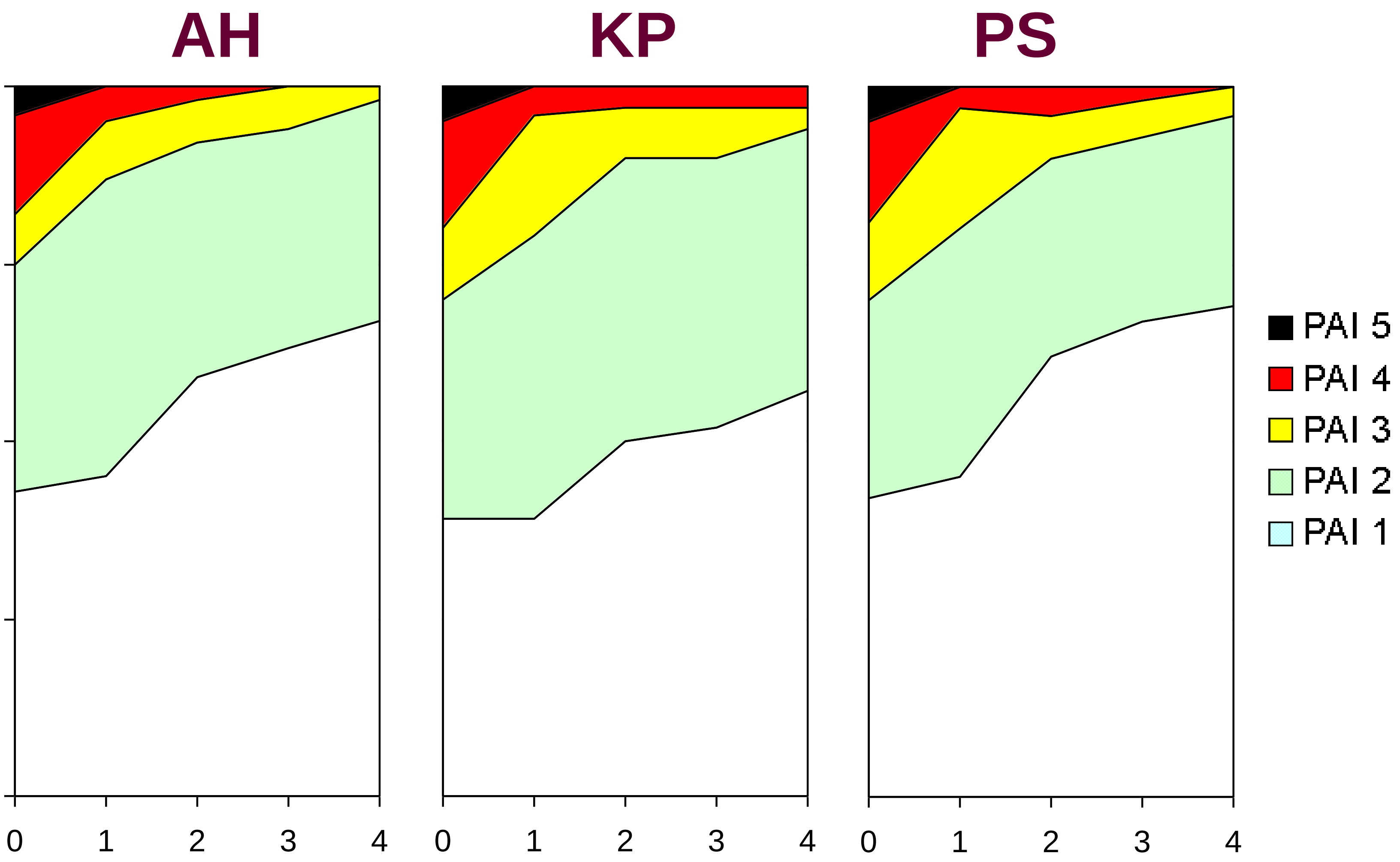


Cumulative PAI Scores



TIME: 0 to 4 years

Ørstavik et al., 1986

Clinical and radiographic evaluation of a resin-based root canal sealer.

Zmener O, Pameijer CH. Am J Dent. 2004 Feb;17(1):19-22.

…a total of **295 root canals were treated with** laterally condensed gutta-percha cones in conjunction with a methacrylate-based endodontic sealer (**EndoRez**). … The results were assessed clinically and **radiographically 14-24 months postoperatively** and a comparison to baseline radiographs was made. 145 patient records were available for a follow-up examination. Success of root canal treatment was based on absence of clinical symptoms, a normal or slightly widened periodontal ligament and reduction of periapical radiolucencies with an absence of pain in patients that had pre-existing lesions associated with pain. RESULTS: **The overall success rate was 91.3%.**

4	Case-series (and poor quality cohort and case-control studies)

Clinical Outcome of Teeth Treated Endodontically with a Nonstandardized Protocol and Root Filled with Resilon

Deborah A. Conner DDS, MS, Daniel J. Caplan DDS, PhD[†], Fabricio B. Teixeira DDS, MS, PhD[‡] and Martin Trope DMD[§]

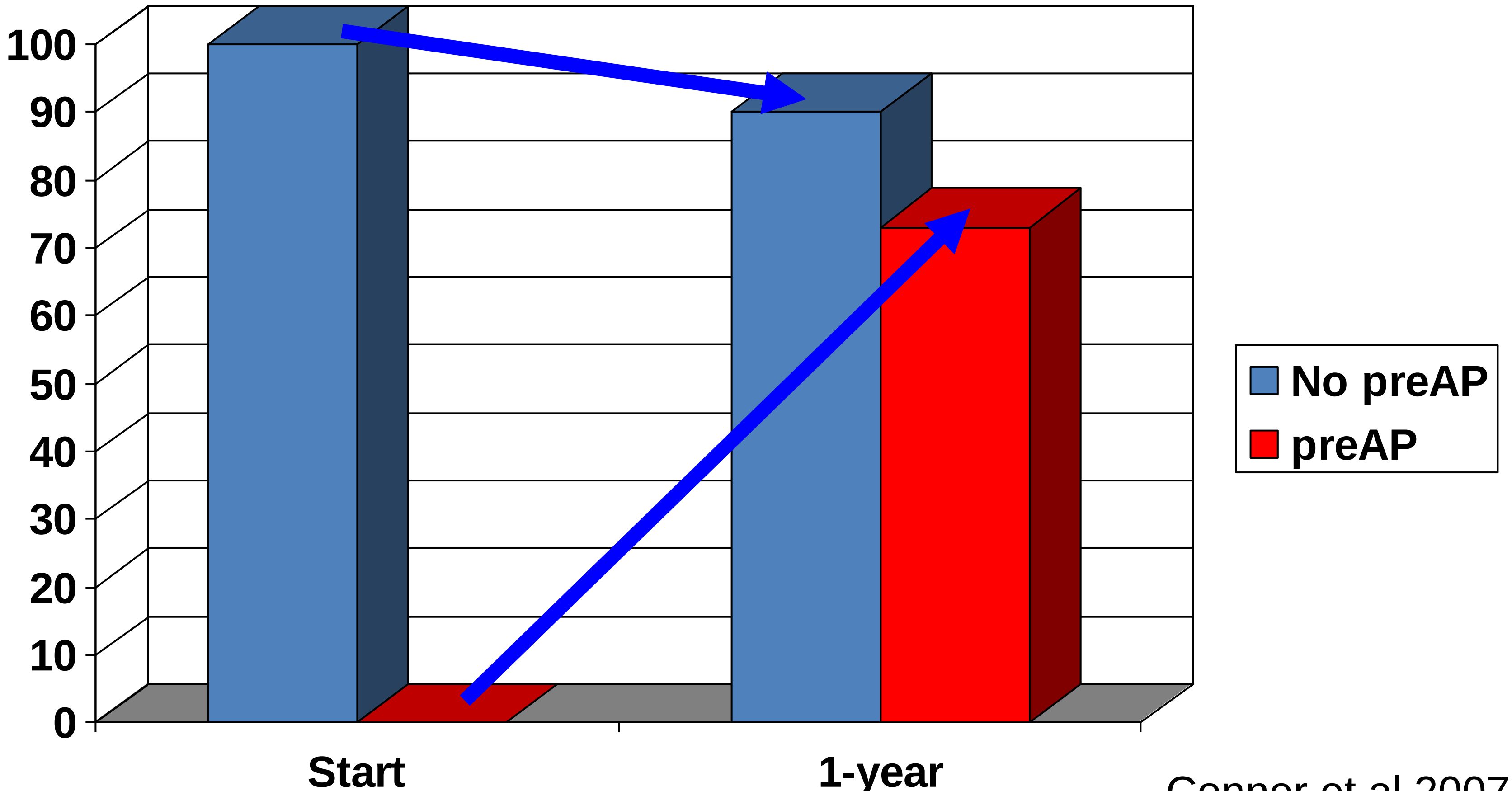
Post-Operative PAI Score

Pre-operative PAI Score	1	2	3	4	5
1	31	8	2	1	0
2	6	2	2	0	0
3	0	2	2	0	0
4	4	5	3	2	0
5	2	2	3	1	3

Each cell represents # clinical cases (N=82)

N:	Interpretation:
39	Not worse, still healthy
8	Worse, but still healthy
15	Better and healthy
5	Worse and now unhealthy
7	Not better and still unhealthy
7	Better, but still unhealthy

Clinical Outcome of Teeth Treated Endodontically with a Nonstandardized Protocol and Root Filled with Resilon



Conner et al 2007

Case-series (and poor quality cohort and case-control studies)