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MDCCCXI


Norway
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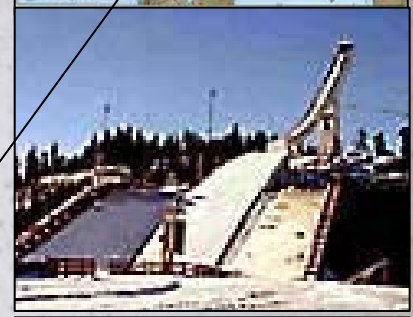


Relevance and importance of clinical endodontic research, with emphasis on outcome studies

Dag Ørstavik, Oslo, Norway

Brussels Dec 13, 2008

Research techniques

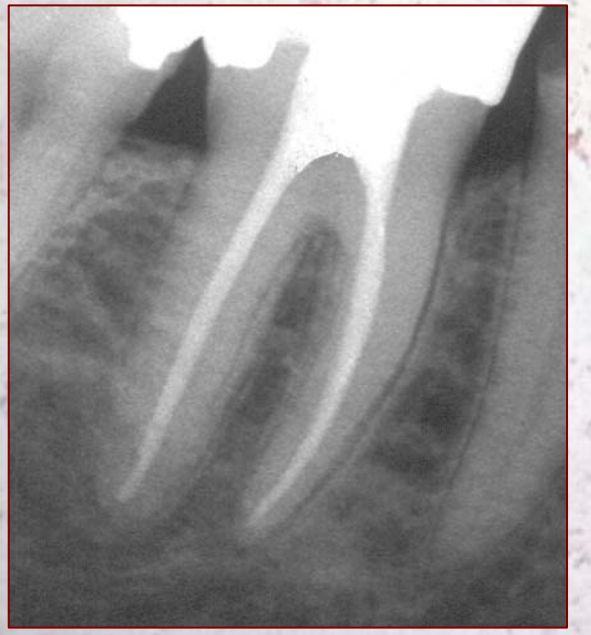
Epidemiological	⇒	True
Clinical	⇒	Probable
In vivo: animal	⇒	Likely
Ex vivo	⇒	Doable
In vitro	⇒	Possible
Laboratory	⇒	Technically possible
Literature	⇒	Basic or done before

Overview

- What is clinical research?
- Relevance: Legal aspects, manufacturers' claims
- Importance: Necessary for improvement
- The relative irrelevance of experience
- Use of microbial markers
- The need for scepticism along side with enthusiasm

Research

- Research is scientific or critical investigation aimed at discovering and interpreting facts.
- Research may use the scientific method, but need not do so.



Modern methodology

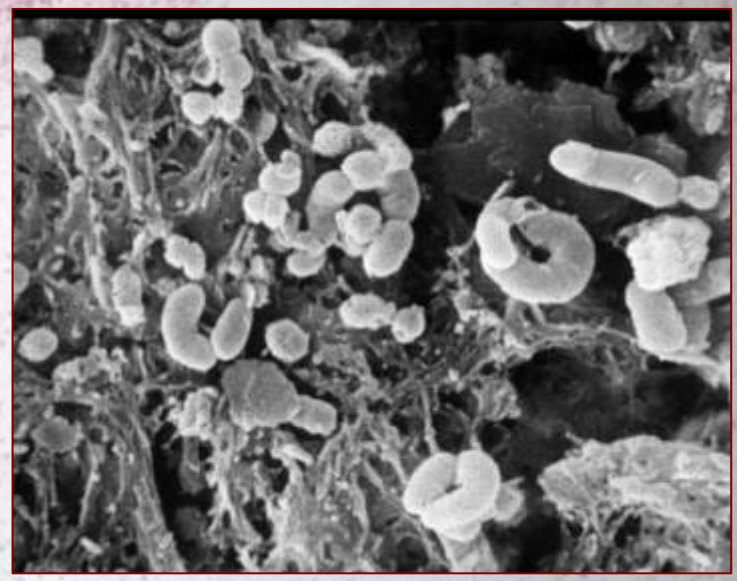
- Topic of interest
- Question
- Hypothesis
- Design
- Qualitative/quantitative answers

Examples by title

- 1965: Histologic study of 155 impacted teeth.
  - Langeland K, Langeland LK. Odontol Tidskr. 1965 Oct 30;73(5):527-49.
- 1985: A comparison of antimicrobial effects of calcium hydroxide and iodine-potassium iodide.
  - Safavi KE, Dowden WE, Introcaso JH, Langeland K. J Endod. 1985 Oct;11(10):454-6.
- 2008: Clinical and radiographic comparison of primary molars after formocresol and electrosurgical pulpotomy: a randomized clinical trial.
  - Bahrololoomi Z, Moeintaghavi A, Emtiazi M, Hosseini G. Indian J Dent Res. 2008 Jul-Sep;19(3):219-23.
- 2008: Periapical radiographs overestimate root canal wall thickness during post space preparation.
  - Souza EM, Bretas RT, Cenci MS, Maia-Filho EM, Bonetti-Filho I. Int Endod J. 2008 Aug;41(8):658-63.

Clinical studies: done at chairside

- Diagnosis
  - Xrays, pain
- Treatment
  - Prophylaxis, medicaments, materials, techniques
- Disease
  - Monitoring, criteria
- Tooth survival

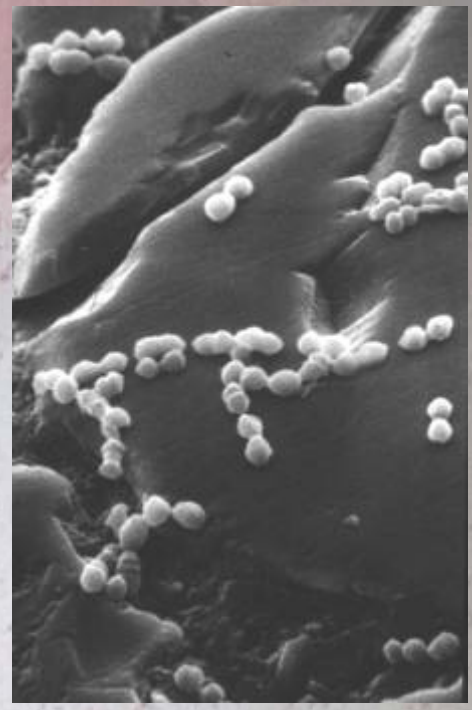


JOE clinical section: Used to be any study which applied clinical techniques

Ex vivo

- From Wikipedia, the free encyclopedia
- ***Ex vivo*** (Latin: out of the living) means that which takes place outside an organism. In science, ex vivo refers to experimentation or measurements done in or on living tissue in an artificial environment outside the organism with the minimum alteration of the natural conditions.

In vitro

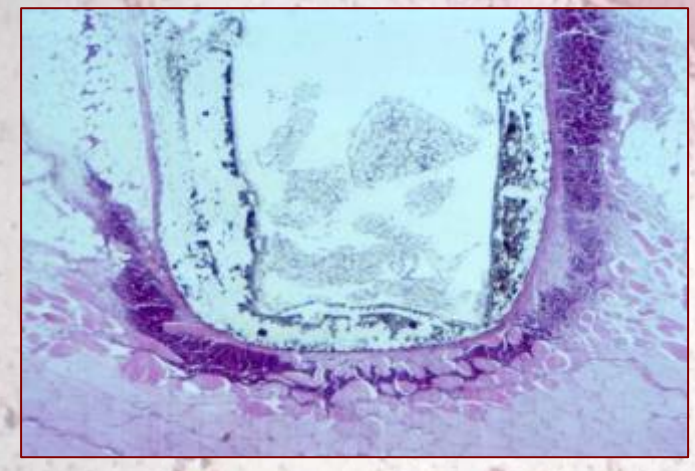


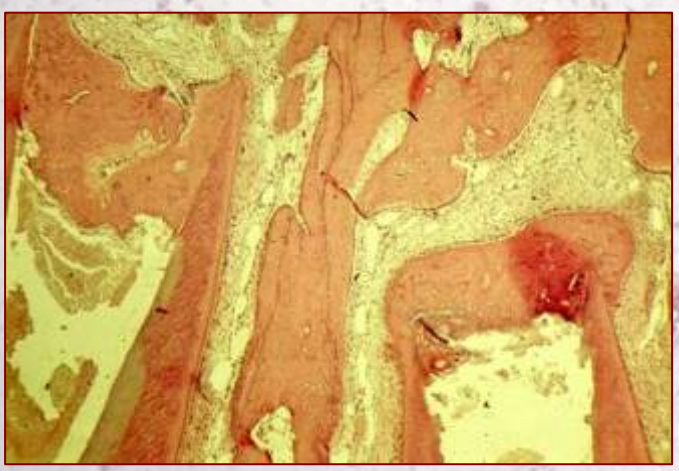
- From Wikipedia, the free encyclopedia
- ***In vitro*** (Latin for within the glass) refers to the technique of performing a given experiment in a controlled environment outside of a living organism; for example in a test tube. In vitro fertilization is a well-known example of this.

Technological experiments

- Physical testing:
  - Materials, techniques
- Chemical testing:
  - Composition, reactions
- Manipulative and functional tests:
  - Bench-top usage tests: working time, setting time, leakage (like ex vivo, but the process is lab defined)

Animal experiments





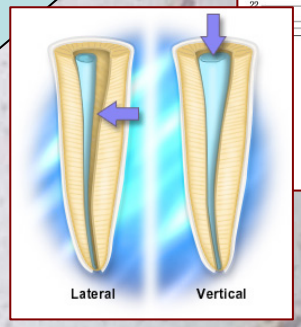
- Biological tests
  - Toxicity, allergenicity, inflammatory potential
- Usage tests
  - Medicaments and devices applied as suggested for human use

TREATMENT MODALITY

TREATMENT TECHNIQUE

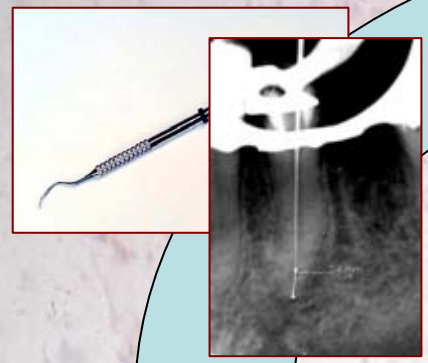
MEDICATION

DIAGNOSIS



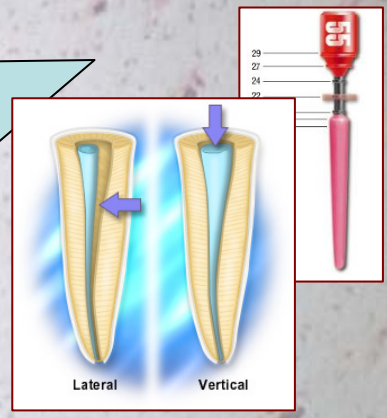
FILLING TECHNIQUE, MATERIAL

TREATMENT MODALITY



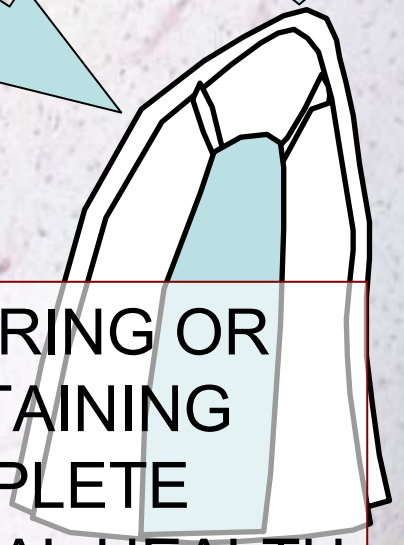
TREATMENT TECHNIQUE

MEDICATION



FILLING TECHNIQUE, MATERIAL

DIAGNOSIS



RESTORING OR MAINTAINING COMPLETE PERIAPICAL HEALTH

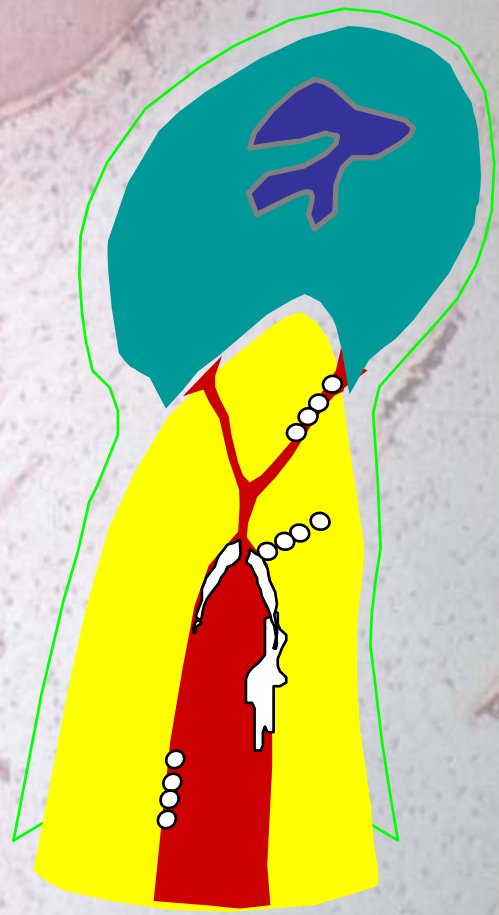
Endodontics is:

Prevention or treatment of apical periodontitis

which in practice means

Protection against or elimination of root canal infection

Diagnostics, choice of treatment method, irrigation, medication and root filling are all means towards this end



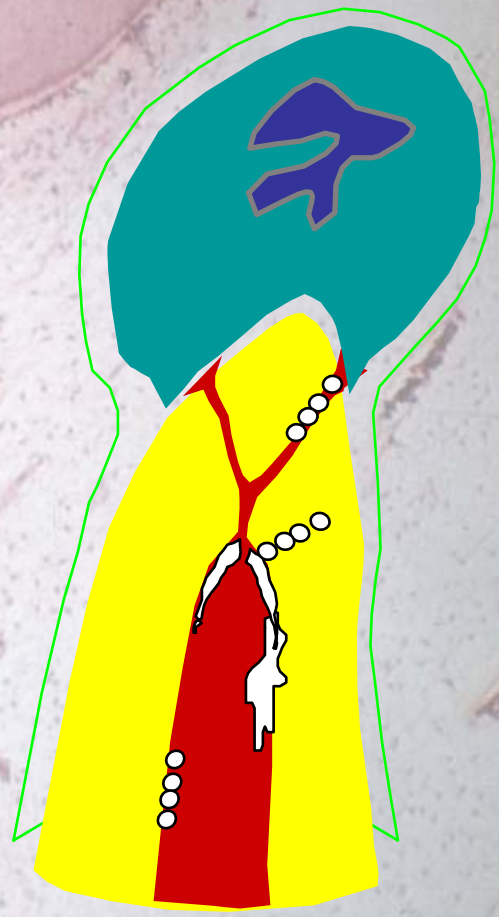
Ørstavik 1988

Choosing the relevant test

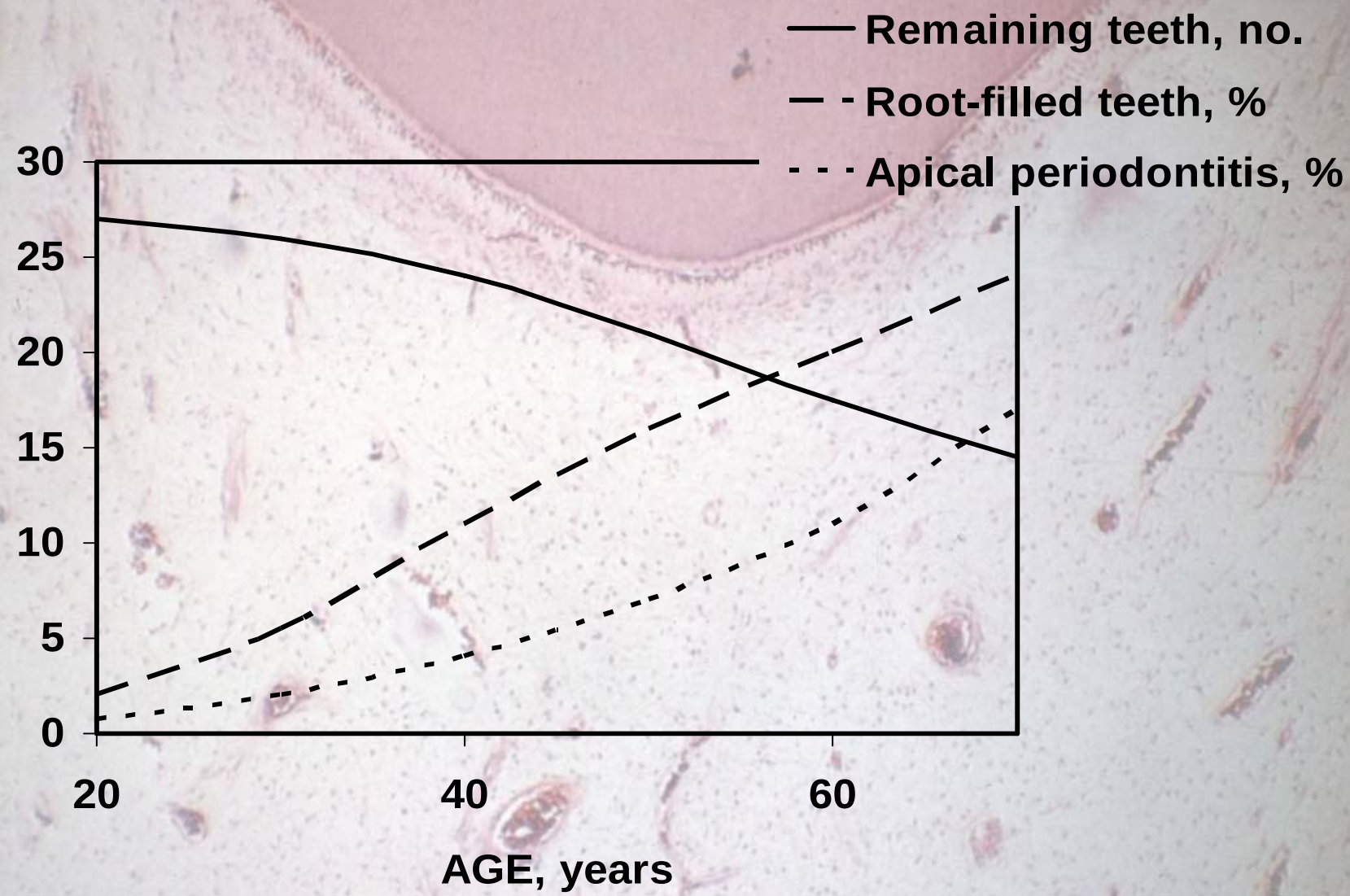
Study target	Clinical	Laboratory	Litterature
Genotoxicity	-	+	++++
Biocompatibility	+/-	++	++++
Antibacterial	++++	++	++++
Debris removal	+	++++	++
Leakage	+++	++++	+/-
Disease	++++	-	+/-
Tooth survival	++++	++	+/-

Endodontics is:

Prevention or treatment of apical periodontitis



Ørstavik 1988



Eriksen 1998

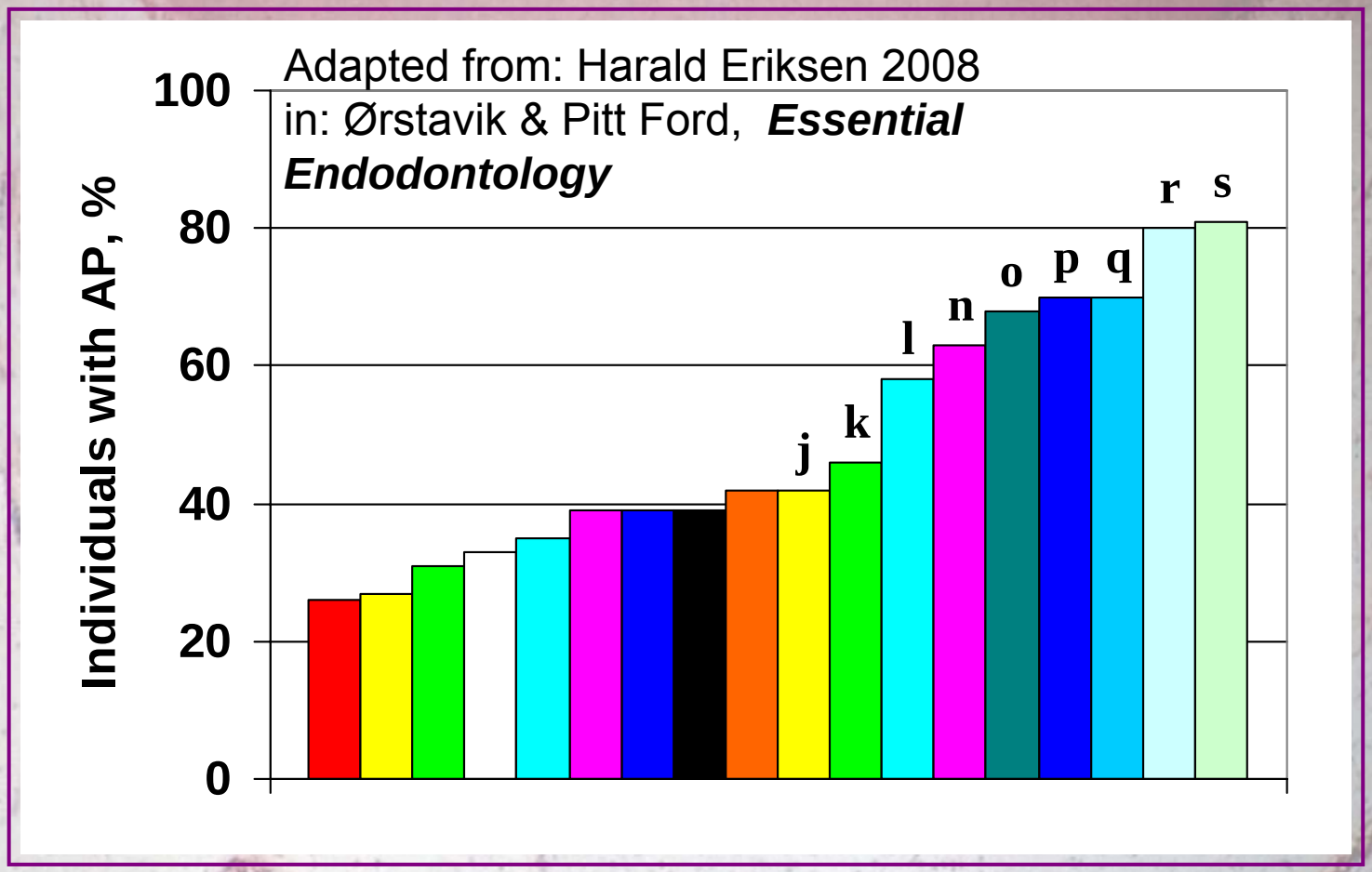


Fig. 6. The prevalence of apical periodontitis in different populations.

a, Dugas et al 2003; b, Marques et al 1998; c, Frisk & Hakeberg 2005; d, Loftus et al 2005; e, Buckley & Spangberg 1995; f, DeCleen et al 1993; g, Eriksen et al 1991; h, Dugas et al 2003; i, Kirkevang et al 1991; j, Frisk & Hakeberg 2005; k, Chen et al 2007; l, Jiménez-Pinzón et al 2004; n, De Moor et al 2000; o, Saunders et al 1997; p, Sidaravicius et al 1999; q, Tsuneishi et al 2005; r, Kabak & Abbott 2005; s, Segura-Egea et al 2005.

Results of endodontic treatment based on the presence of apical periodontitis associated with root-filled teeth evaluated from radiographs.

Reference	Avg age	Succ	Fail
Eriksen and Bjertness 1991 (Norway)	50	64	36
Ödesjö *et al.* 1990 (Sweden)	45	75	25
Imfeld 1991 (Switzerland)	66	69	31
de Cleen *et al.* 1993 (the Netherlands)	38	61	39
Buckley and Spångberg 1995 (USA)	45	69	31
Ray and Trope 1995 (USA)		61	39
Saunders *et al.* 1997 (Scotland)	(20-60+)	42	58
Weiger *et al.* 1997 (Germany)		39	61
Marques MD *et al.* 1998 (Portugal)	35	78	22
Georgopoulou MK *et al.* 2005 (Greece)	48	40	60
Mean value	**45**	**63**	**37**
”Success range”:		39-78 %	

From: Harald Eriksen 2008 In: Ørstavik & Pitt Ford, ***Essential Endodontology***

Factors known to affect the prognosis of ”endodontic treatment”

- Cotton TP, Schindler WG, Schwartz SA, Watson WR, Hargreaves KM.

  A retrospective study comparing clinical outcomes after obturation with Resilon/Epiphany or Gutta-Percha/Kerr sealer.
  (endodontist, recalled at 2–25 months)

  J Endod. 2008 Jul;34(7):789-97. Epub 2008 May 12.

Factors known to affect the prognosis of ”endodontic treatment”

• Gender	.06†	Males worse
• Appointments	.06†	Multiple worse
• **Pulp diagnosis**	**.001†**	**Nonvital worse**
• **Preoperative lesion**	**.003†**	**Present worse**
• No. of canals obturated	1†	
• Recall time	.68†	
• Age	.25	
• Tooth position	.26†	
• Obturation material	1†	

Factors known to affect the prognosis of ”endodontic treatment”

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	Healed	Nonhealed	Total	p Value
Obturation material, n (%)				**1†**
Resilon	**42 (79.2)**	**11 (20.8)**	**43 (100)**	
Gutta-percha	**39 (78.0)**	**11 (22.0)**	**50 (100)**	
Total (some w no pulp Dx)	**81**	**22**	**103**	

Factors known to affect the prognosis of ”endodontic treatment”

- Cotton TP, Schindler WG, Schwartz SA, Watson WR, Hargreaves KM. A retrospective study comparing clinical outcomes after obturation with Resilon/Epiphany or Gutta-Percha/Kerr sealer. J Endod. 2008 Jul;34(7):789-97. Epub 2008 May 12.

	Healed	Nonhealed	Total	p Value
Preoperative lesion, n (%)				**<.001†**
Yes	**43 (66.2)**	**22 (33.8)**	**65 (100)**	
No	**38 (100)**	**0 (0.0)**	**38 (100)**	
Total	**81**	**22**	**103**	

Prognosis for Pulpectomy: Prevention of Apical Periodontitis

- Strindberg 1956 94
- Kerekes & Tronstad 1979 97
- Ørstavik et al 1986(2004) 94
- Sjögren et al 1990 97
- Marquis et al 2006 93

- This is probably a reflection of an almost complete success – failures are iatrogenic, via contamination, and avoidable

Prognosis for Root Canal Infection: Treatment of Apical Periodontitis

- **Strindberg 1956** **88**
- **Kerekes & Tronstad 1979** **91**
- **Ørstavik et al 1986(2004)** **79**
- **Sjögren et al 1990** **86**
- **Marquis et al 2006** **80**
- **Zmener & Pamejer 2004** **89**

- **This is probably a reflection of persistent infection – failures are due to inadequate disinfection**

Bacteriology and the prognosis of ”endodontic treatment”

- …When no bacteria remained [in the root canal before filling], healing occurred independently of the quality of the root filling. In contrast, when bacteria remained, there was a greater correlation with non-healing in poor-quality root fillings than in technically well-performed fillings. …..

- How well do ***we*** do?

Fabricius L, Dahlén G, Sundqvist G, Happonen RP, Möller AJ. Influence of residual bacteria on periapical tissue healing after chemomechanical treatment and root filling of experimentally infected monkey teeth. Eur J Oral Sci. 2006 Aug;114(4):278-85.

The prognosis

- All teeth, the real world: **67**%
- Follow-up of vital teeth with root filling 95%
- Follow-up of infected teeth treated with root filling 85%
- Follow-up of conservative revision 70%
- 40/40/20 in your practice? ?%
- How well ***do we*** do?

The prognosis

- All teeth, the real world: **67**%
- Follow-up of vital teeth with root filling 95%
- Follow-up of infected teeth treated with root filling 85%
- Follow-up of conservative revision 70%
- 40/40/20 in your practice? 86%
- How well ***do we*** do?

Apical periodontitis				
A matter of concern..				
Pre-op Dx	Nos.	Success rates	Prop's	n
'vital'	50	'vital' s rate	0,67	34
'necrotic', no lesio	10	'vital' s rate	0,67	7
'infected', lesion	30	'necrotic' s rate	**0,67**	20
'revision, infected'	10	'necrotic' s rate	**0,67**	7
Total	100	overall s rate	***0,67***	67

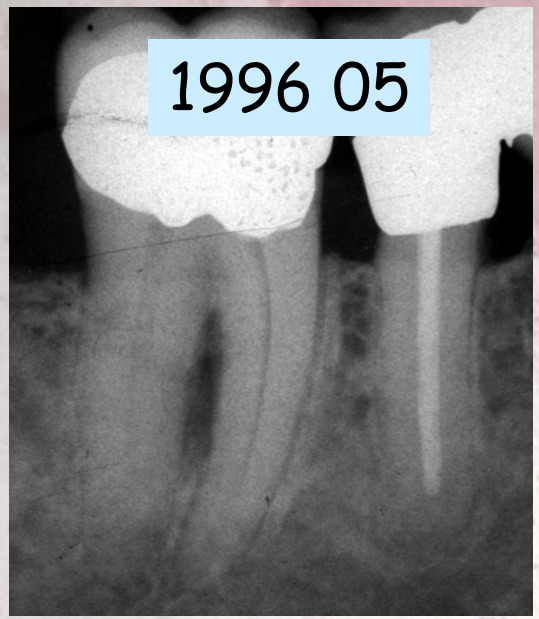
What lies behind the finding that every third root filled tooth has apical periodontitis?

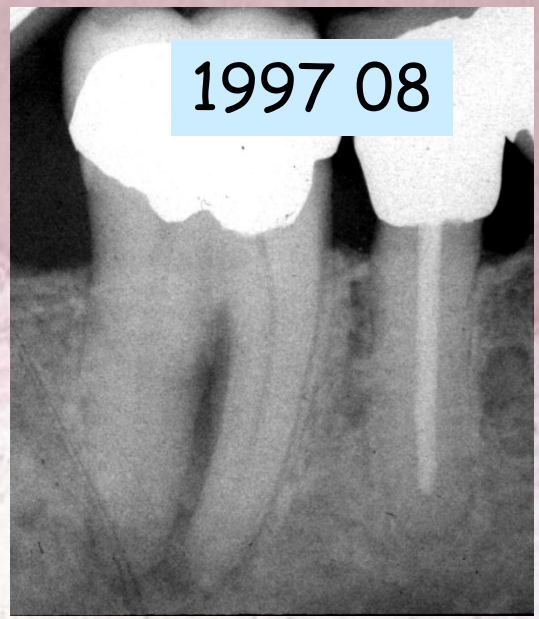
Apical periodontitis				
A matter of concern..				
Pre-op Dx	Nos.	Success rates	Prop's	n
'vital'	50	'vital' s rate	0,90	45
'necrotic', no lesio	10	'vital' s rate		9
'infected', lesion	30	'necrotic' s rate		10
'revision, infected'	10	'necrotic' s rate		3
Total	100	overall s rate		67

The incidence of healing after treatment of apical periodontitis may be alarmingly low

Radiographic evaluation and follow-up: hows and whys

- This part is a review of
  - Different methods of radiographic follow-up methods
  - The strengths and limitations of assessment of one's own cases
  - Clinical-radiographic testing of medicaments, materials and techniques


1996 05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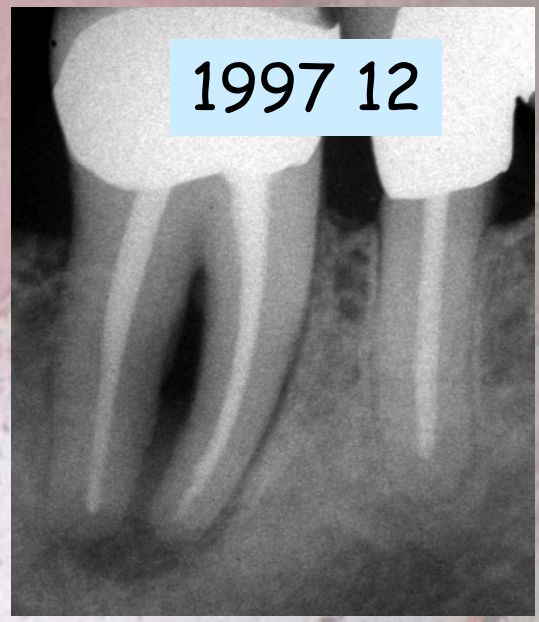
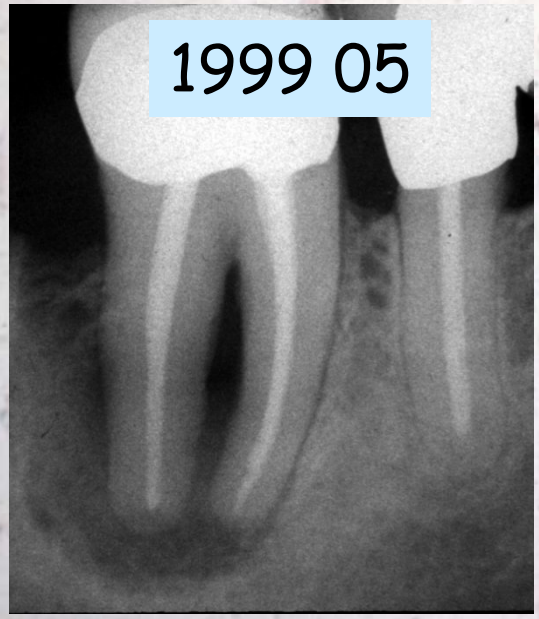

1997 12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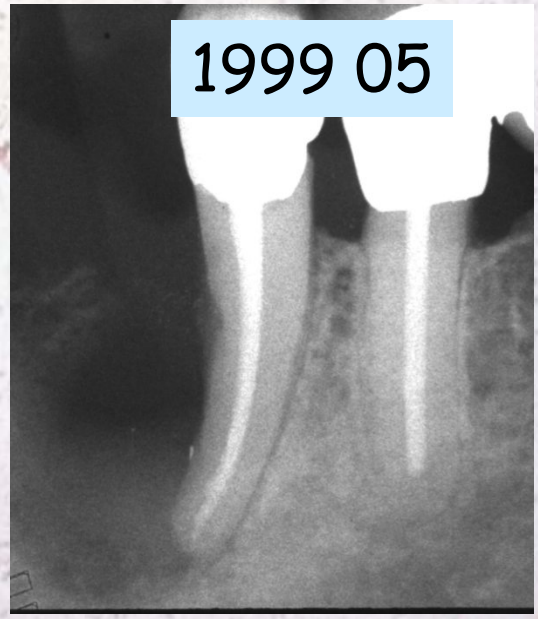
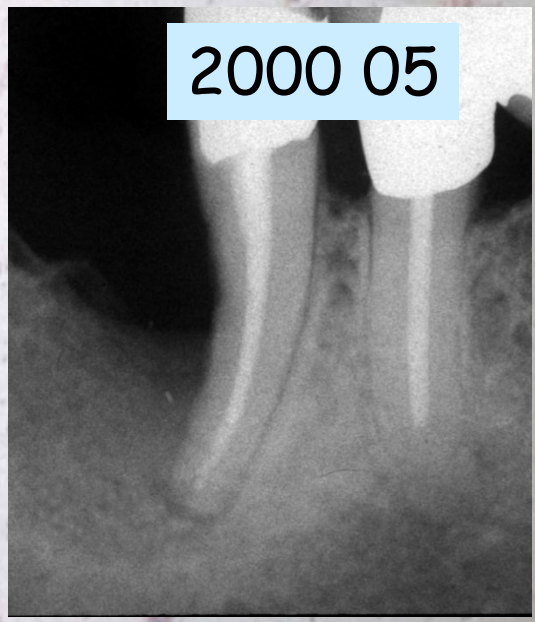

1999 05


2000 05

Pre-op Dx	Cases	Success rates	Props	n
'vital'	50	'vital' s rate	0,75	37,5
'necrotic'	10	'vital' s rate	0,75	7,5
'infected'	20	'necrotic' s rate	**0,55**	11
'revision, infected'	20	'necrotic' s rate	**0,55**	11
Total	100	overall s rate	0,67	67

Pre-op Dx	Cases	Success rates	Prop's	n
'vital'	10	'vital' s rate	0,95	9,5
'necrotic'	10	'vital' s rate	0,95	9,5
'infected'	20	'necrotic' s rate	**0,70**	14
'revision, infected'	20	'necrotic' s rate	**0,70**	14
Total	60	overall s rate	0,78	47

Elements in endodontic follow-up studies

- Outcome parameters
  success/failure, healing, survival; other
- Study design
  pro- & retro; power (β); randomization;
- Operator performance: Art, science and reality: the *possible*, *best average* and *likely* outcome

Art

The case report: See what I can do, by listening, you share the glory

From Visual Endodontics

Best average

Typically institutional or specialist practice follow-up studies; the self-assured clinician comfortably states, ”We have more than a 90 per cent success rate!”

Real average?

Cross-sectional, epidemiological approaches: the whole range; nobody wants to be associated with this.

Different situations of radio-graphic follow-up methods

- Case-by-case monitoring for healing or emergence of apical periodontitis: everyday practice
- Particular clinical situations: eg, perforations, apexification,cyst size reduction: practice and case reports
- *Feasibility* studies: case series
- Scientific clinical studies: influence of specific clinical/biological/technical variables

How do we do: the evidence ladder

- High-quality systematic reviews
- Large randomized trials with clear-cut results
- Small randomized trials with uncertain results (i.e., positive trends without statistical significance)
- Nonrandomized trials with contemporary controls
- Nonrandomized trials with historical controls
- Cohort studies: one population over time
- Case-control studies: retrospective, analysis of factors (typical follow-up)
- Dramatic results from uncontrolled studies (e.g., the treatment of infections with penicillin in the 1940s)
- Case series and other descriptive studies
- Reports of expert committees and opinions of respected authorities, based on clinical experience

Sutherland J Can Dent Assoc 2001; 67:375-8

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

2008: "Systematic Review" endodontic:
13 references, 4 including randomized trials

2005: 6 THROUGHOUT HISTORY – ALL FLAWED
2008: + 2, MINOR FLAWS

2005: 26 – MOSTLY FLAWED

2005: HUNDREDS

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.

The single case report:
A valuable contribution to the scientific literature
Gould 3xO September 2001 editorial

- ”I wish to advocate for the validity and value of the single case report. I believe that the case report with appropriate content remains an important contribution to the body of clinical and diagnostic information for oral health care providers and researchers.”

The single case report:
The demands of and insights from treatment of the tooth/individual combination

- What do you do when you have ”tried it all” and it does not work?
- You discuss with your patient and apply a treatment suggested or untried, but doing no inherent harm

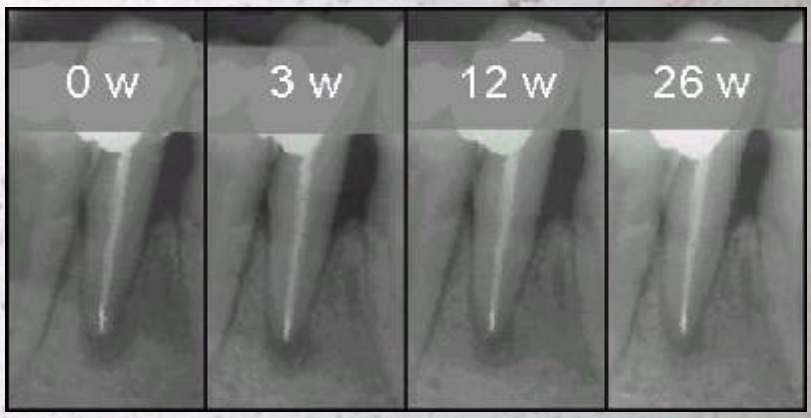
- Dentistry is seldom life-threatening

Different methods of radiographic follow-up methods

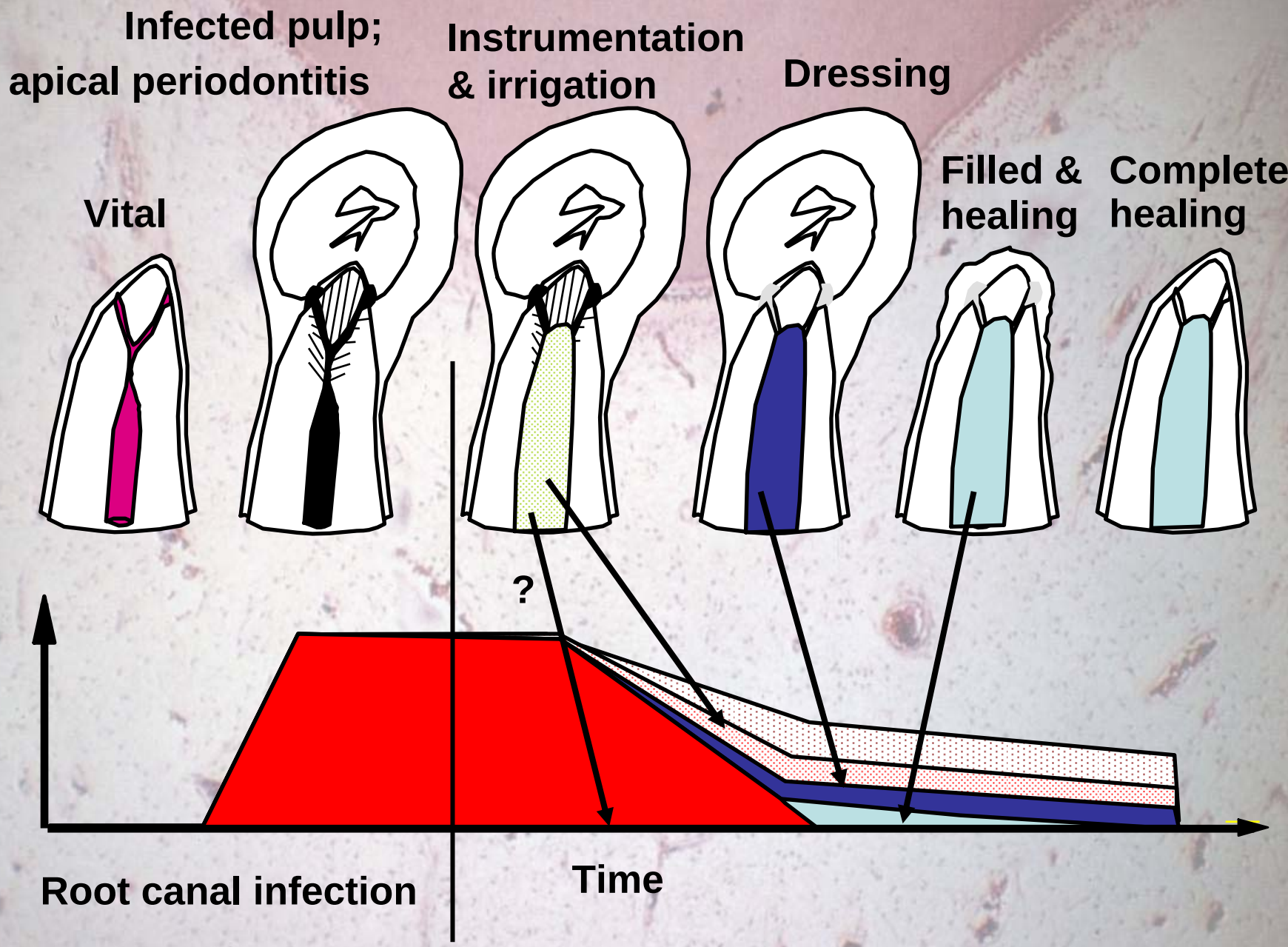
- Success-failure analysis
- Probability assessments
- Lesion size monitoring
- The PAI scoring system
- Quantitative methods
- New radiographic techniques

Case monitoring for healing or retreatment

- Simple ”success/failure”-analysis in practice
  - AP development
  - AP resolution



- Yes or no with time & subject variation


Infected pulp;
apical periodontitis
Instrumentation
& irrigation
Dressing
Filled &
healing
Complete
healing
Vital
?
Root canal infection
Time

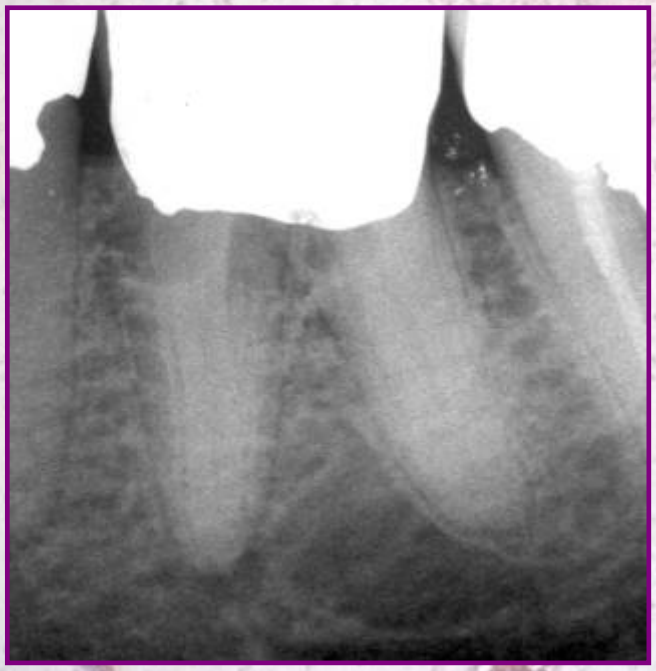
- success when
  - a, the contours, width and structure of the periodontal margin were *normal*
  - b, the periodontal contours were widened *mainly* around the excess filling
- failure when there was
  - a) a *decrease* in the periradicular rarefaction
  - b) an unchanged periradicular rarefaction
  - c) an appearance of new rarefaction or an increase in the initial
- uncertain when
  - a) there were ambiguous or technically unsatisfactory control radiographs which could not for some reason be repeated
  - b) the tooth was extracted prior to the 3-year follow-up owing to the unsuccessful treatment of another root of the tooth

Success/failure criteria
(Strindberg 1956)

Probability assessments

- Definitively no disease 1
- Probably no disease 2
- Uncertain 3
- Probably disease 4
- Definitively disease 5

Probability assessments



Advantages: numerical, reflects subjective variation in diagnosis

Probability assessments

	Observers				
Score	#1	#2	#3	#4	#5
1	16	5	1	7	6
2	5	11	16	11	9
3	1	1	5	2	0
4	1	9	7	6	7
5	24	21	18	21	25

Ørstavik et al 1986

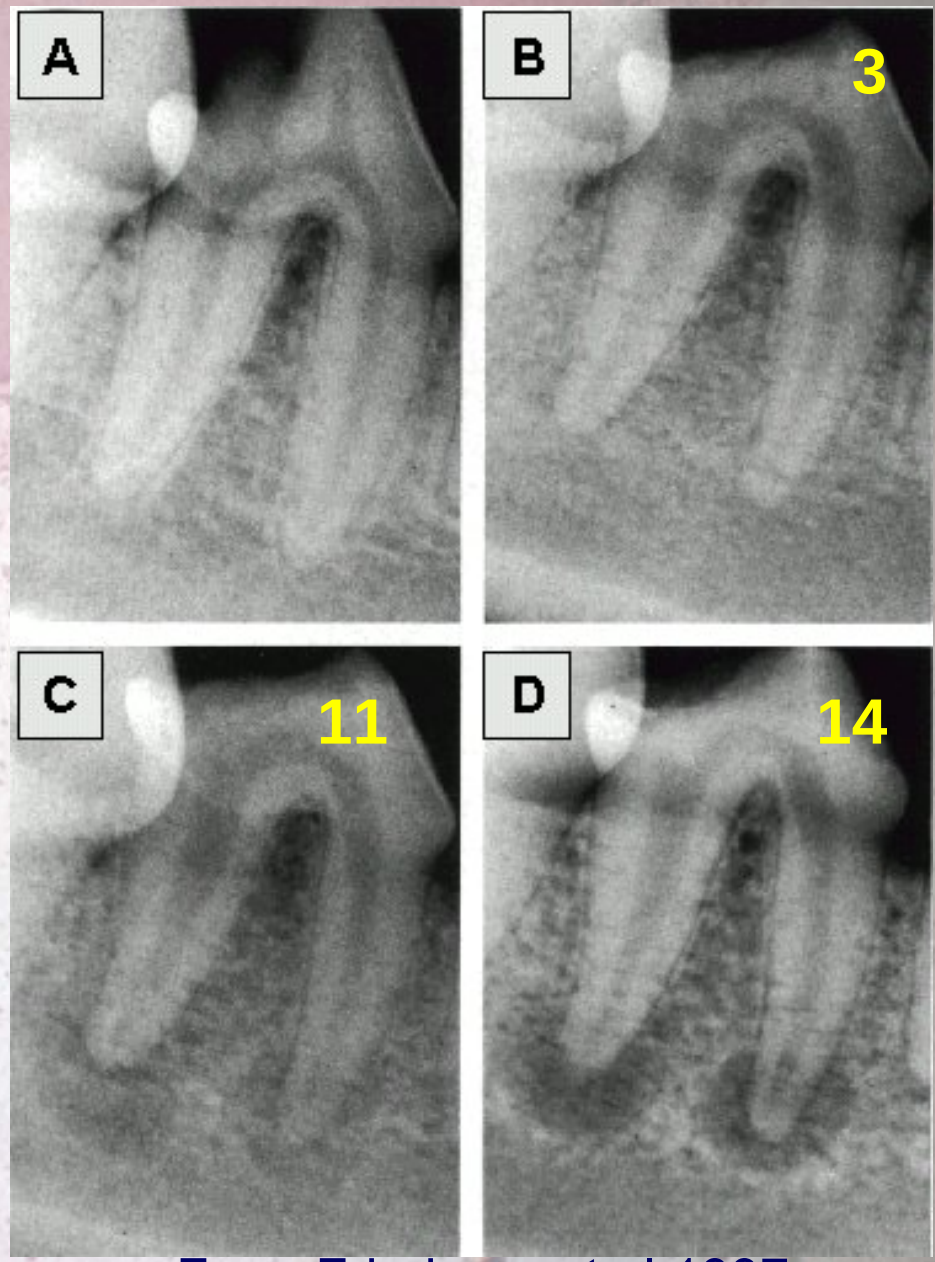
Lesion size monitoring

- Quantitative
- Numerical, continuous scale
- Reflecting the biological process?

Lesion size monitoring

Lesions may not develop as ballons growing or heal by apposition from within the shell of the bony lesion.

ImageJ



From Friedman et al 1997

Scoring Systems in Clinical Dentistry

- ***Caries***

Scoring Systems in Clinical Dentistry

- ***Caries*: limited progress until DMF index was established (1938)**
  - **Epidemiology**
  - **Cohort studies**
  - **Fluoride**
  - **Local and topical agents**
  - **Public health monitoring**

Scoring Systems in Clinical Dentistry

- ***Caries*: limited progress until DMF index was established (1938)**
- ***Gingivitis & marginal periodontitis***

Scoring Systems in Clinical Dentistry

- ***Caries*: limited progress until DMF index was established (1938)**
- ***Gingivitis & marginal periodontitis*: confusion until indices were applied (1950-60)**

Scoring Systems in Clinical Dentistry

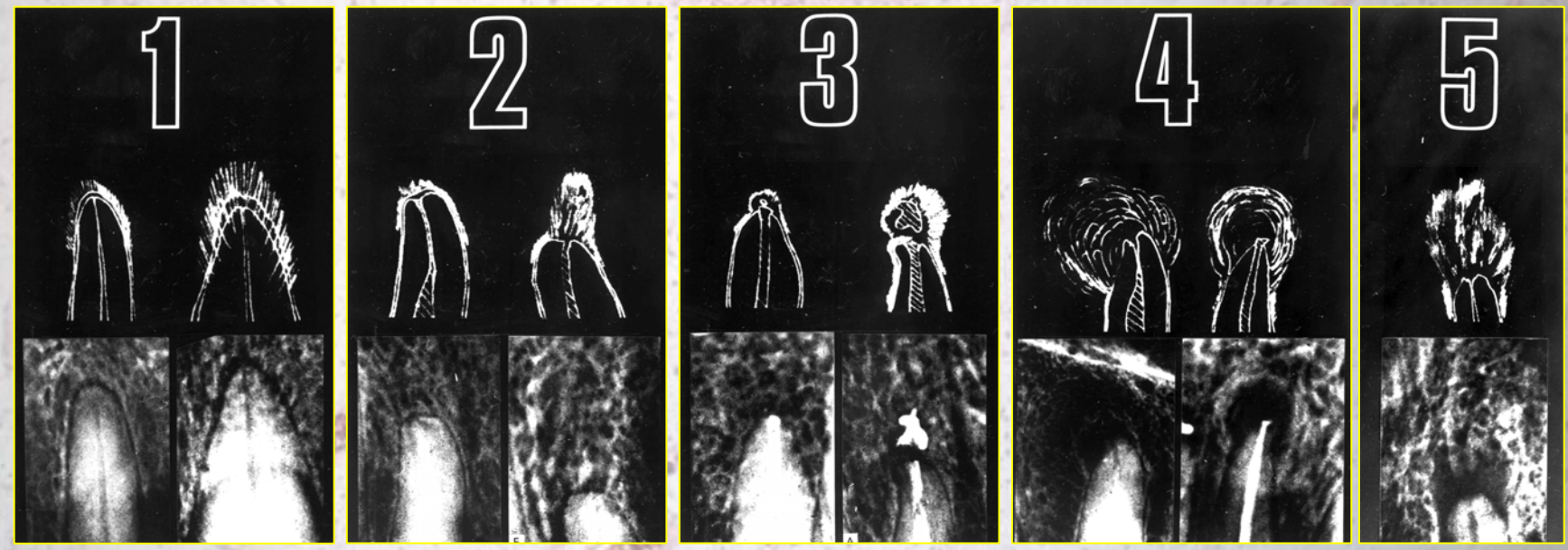
- ***Caries*: limited progress until DMF index was established (1938)**
- ***Gingivitis & marginal periodontitis*: confusion until indices were applied (1950-60)**
- ***Apical periodontitis (pulpitis)?***

Scoring Systems in Clinical Dentistry

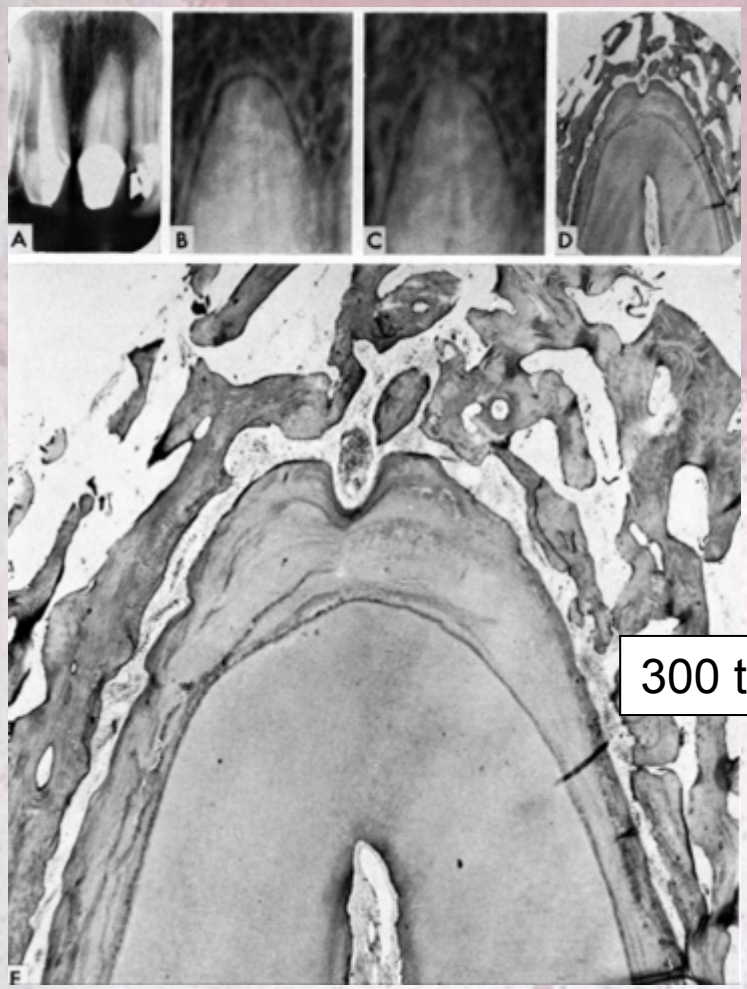
- ***Caries*: limited progress until DMF index was established (1938)**
- ***Gingivitis & marginal periodontitis*: confusion until indices were applied (1950-60)**
- ***Apical periodontitis:* Calibrated indices? X-ray digitized measurements?**

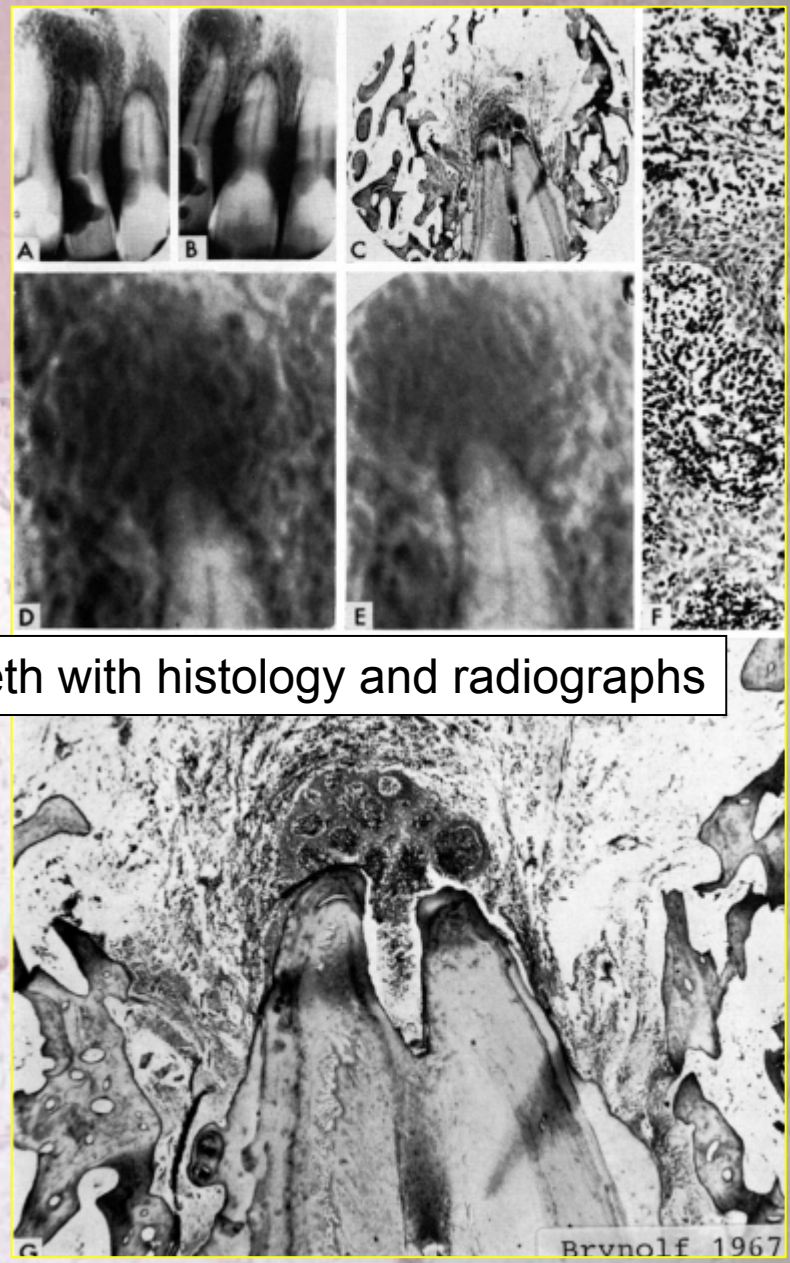
The PAI Scoring System

- ***Apical periodontitis:* A calibrated index**



Ørstavik et al. 1986: The periapical index: a scoring system for tradiographic assessment of apical periodontitis





300 teeth with histology and radiographs

Brynolf 1967: A histological and radiological study of the periapical region of human upper central incisors

Brynolf 1967:
A histological and radiological study of the periapical region of human upper central incisors

Seven histologic/radiographic groups

Ørstavik et al. 1986:
The periapical index: a scoring system for tradiographic assessment of apical periodontitis

Five radiographic categories on an ordinal scale of severity

*The PAI scoring system is a radiographic interpretation on a 5 point scale from 1-5 in order of absence to presence and increasing severity of disease.
*It uses a reference set of radiographs with corresponding line drawings and their associated score on a photographic print or computer screen.
*The scores are based on a correlation with inflammatory periapical status confirmed by histology.

Nine radiographs from Brynolf's selection were taken as representatives of the five categories, *verbally* described as:

1 - Normal apical periodontium
2 - Structural changes in periapical bone
3 - Structural changes with mineral loss
4 - Overt radiolucency
5 - Structural changes peripheral to radiolucency

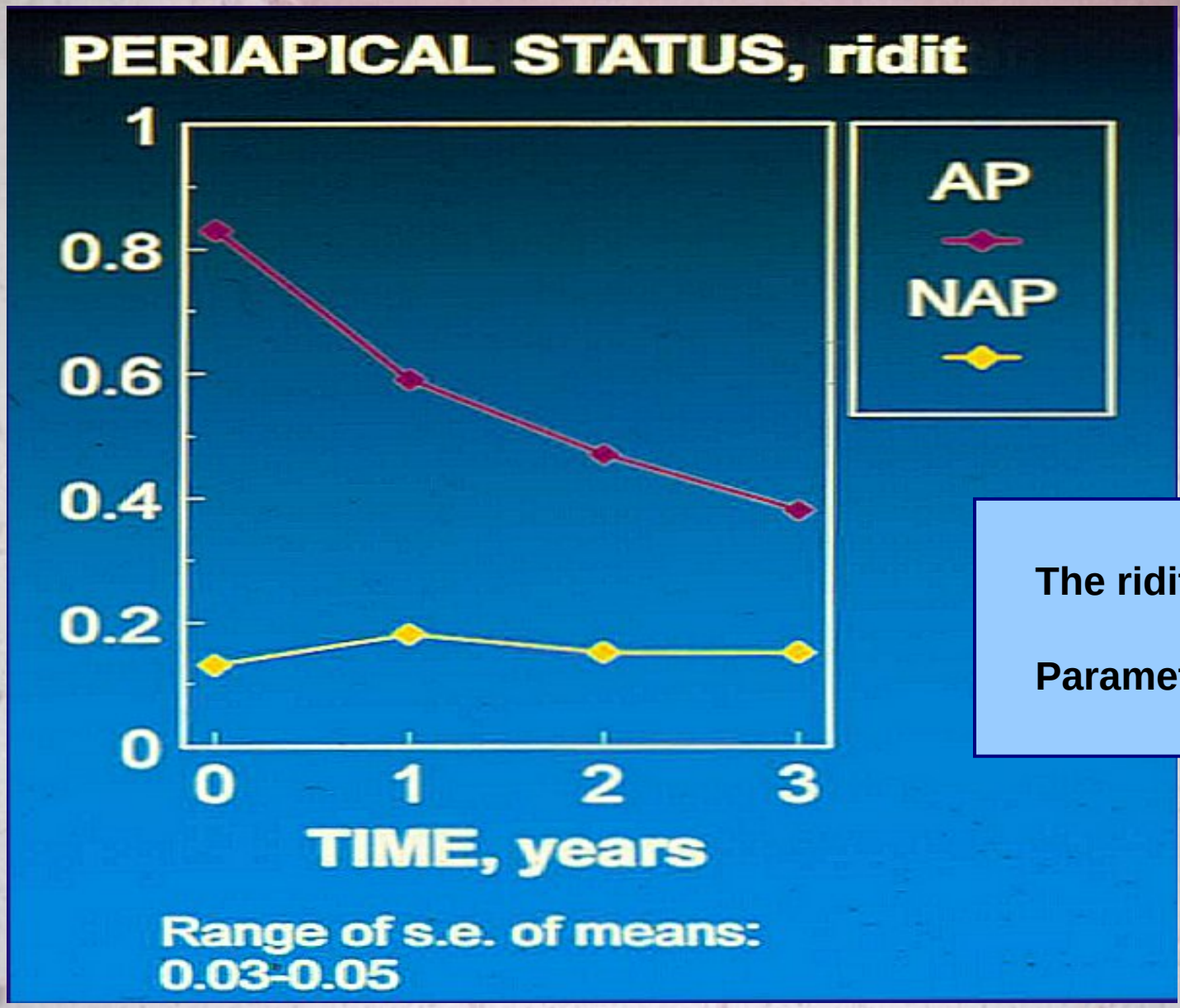
- ***Find the reference radiograph where the periapical area most closely resembles the periapical area you are studying.*** **Assign the corresponding score to the observed root.**
- **When in doubt, assign a higher score.**
- **For multirooted teeth, use the highest of the scores given to the individual roots.**
- **All teeth must be given a score.**

Calibration

- **Material**:
- Reference scale
- Set of written instructions for scoring
- Set of 100 radiographs, one tooth in each is scored. The ’true scores’ have been determined by consensus of two endodontists involved with the development of the system.
- Excel file for computation of essential statistical parameters.

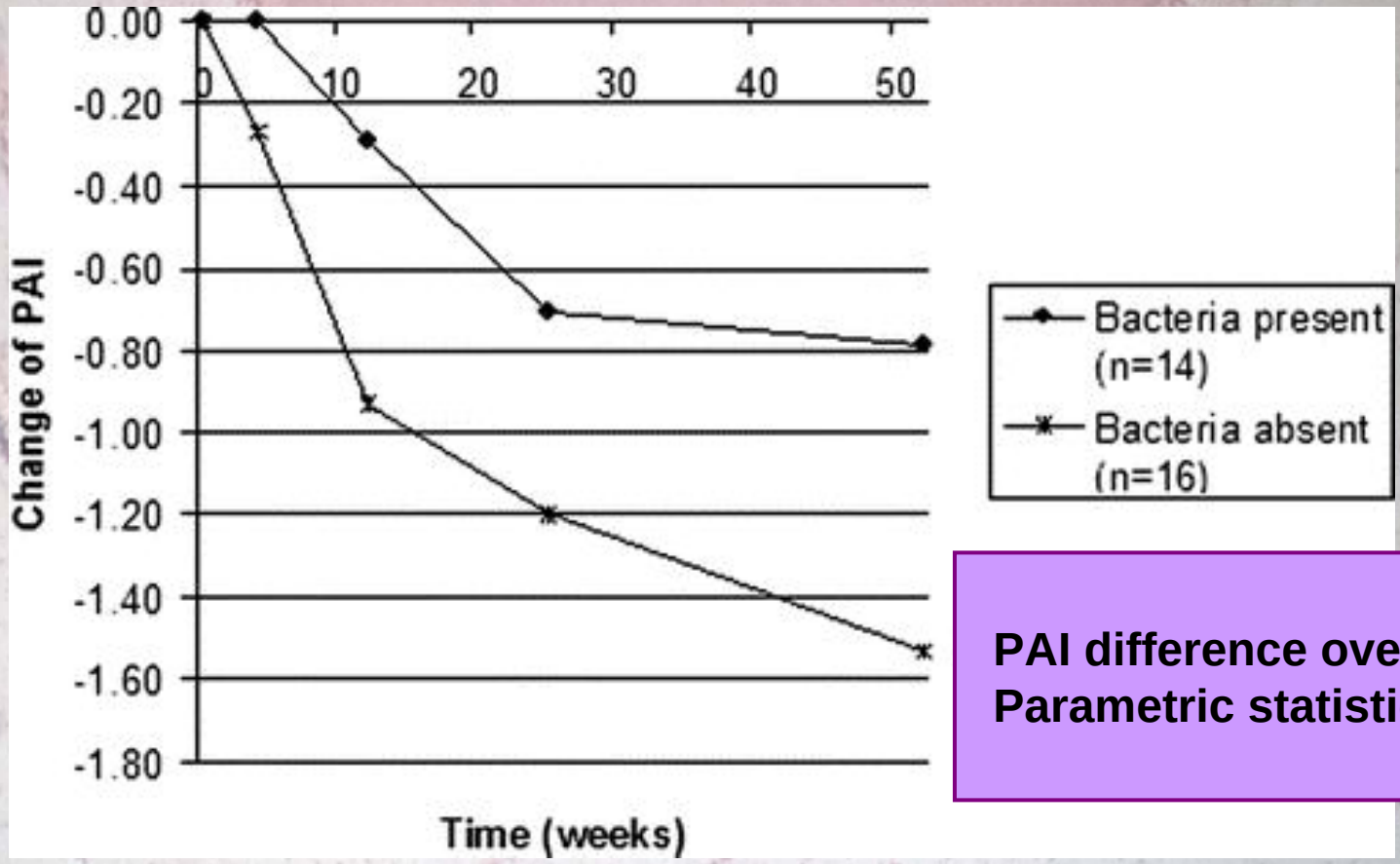
Calibration

- **Procedure**:
- Day 1: Scoring of the 100 X-rays producing scoring set 1. Discussion of results in comparison with ’true scores’. Emphasis is placed on scores deviating more than 1 unit from the ’true scores’.
- Day 2. Repetition of day 1 with production of scoring set 2.
- Day 5. Repetition of day 1 with production of scoring set 3.
- Calculation of kappa. K > 0.61 and higher is acceptable. An observer with kappa values for inter- and intra-observer reproducibility of >0.61 is ’authorised' to produce valid experimental scores.
- 20+ observers world-wide calibrated; i.e., they judge populations of teeth similarly/identically



The ridit statistic

Parametric statistics



PAI difference over time: Parametric statistics

Change of PAI in cases with bacteria absent or present at the second appointment. Single visit cases are not included.

From: Waltimo et al: J Endod, Volume 31(12).December 2005.863-866

Usage

- 16 countries
- 40+ publications
- Retrospective clinical follow-ups
- Epidemiological studies
- Prospective studies

Weaknesses of the PAI system

- Front tooth reference only
- Moderate specifity

Radiographic follow-up after endodontic treatment

S. Huumonen & D. Ørstavik, in prep.

- **Aim**
  - To assess radiographically the rate and pattern of healing apical periodontitis after endodontic treatment. Furthermore healing of different tooth types was analysed.

Radiographic follow-up after endodontic treatment

S. Huumonen & D. Ørstavik, in prep.

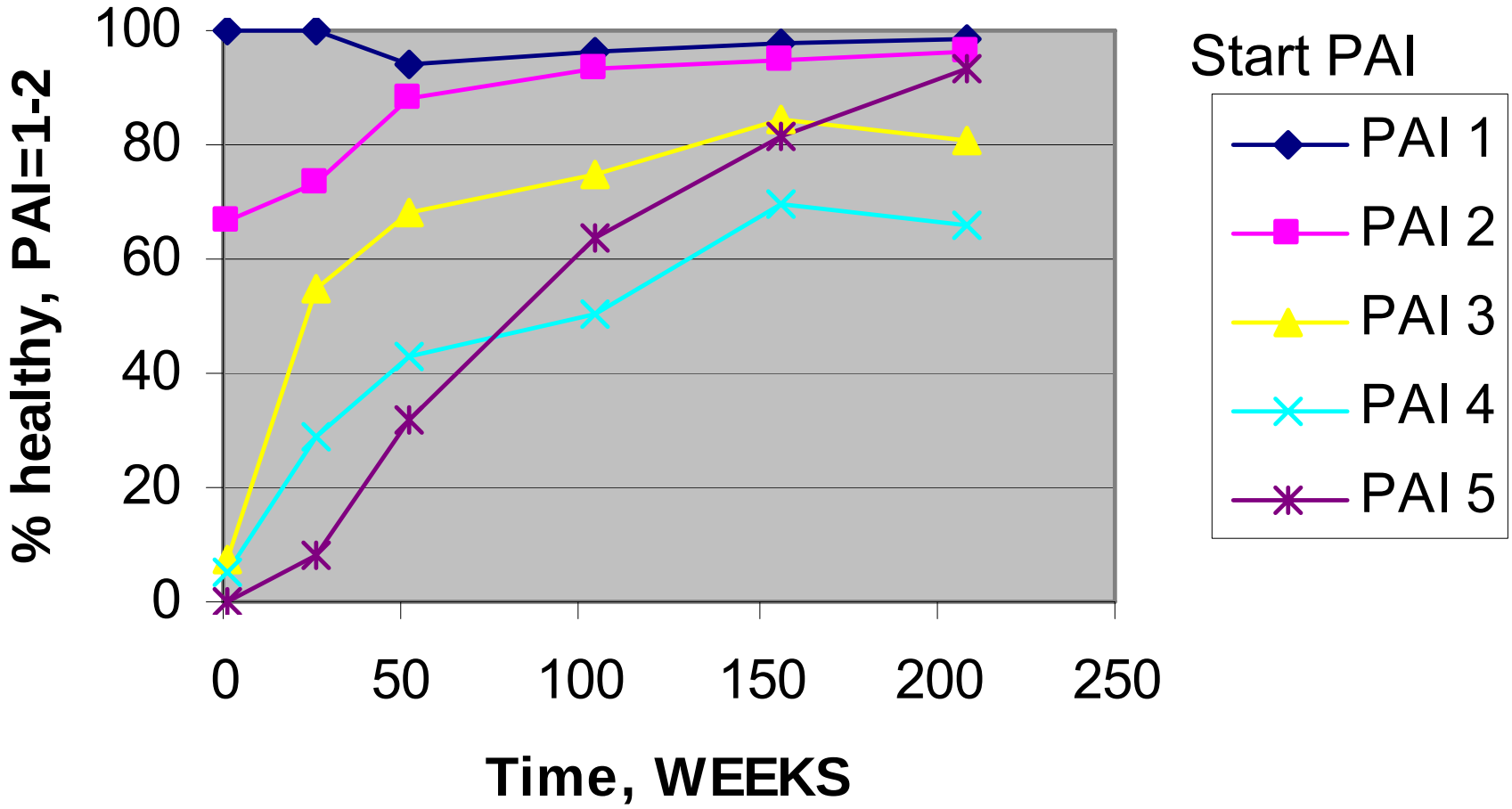
- **Methodology**
  - Radiographic data from 7 prospective clinical studies was pooled to get large material for analysis. A total of 1410 teeth were included into the analysis. The periapical status was evaluated using the Periapical Scoring System (PAI). The total follow-up period was 4 years, with intervals varying between controls from 3 months to a year.

Radiographic follow-up after endodontic treatment

S. Huumonen & D. Ørstavik, in prep.

- **Results**
  - Significant healing of apical periodontitis was evident at 3 months, and 27% of treated teeth were considered healthy at this early time point. At one year the proportion of completely healed teeth had increased to 41%. Thereafter, healing continued more slowly. Upper lateral incisors were overrepresented among teeth with apical periodontitis which did not show healing within one year postoperatively.

Periapical changes after treatment



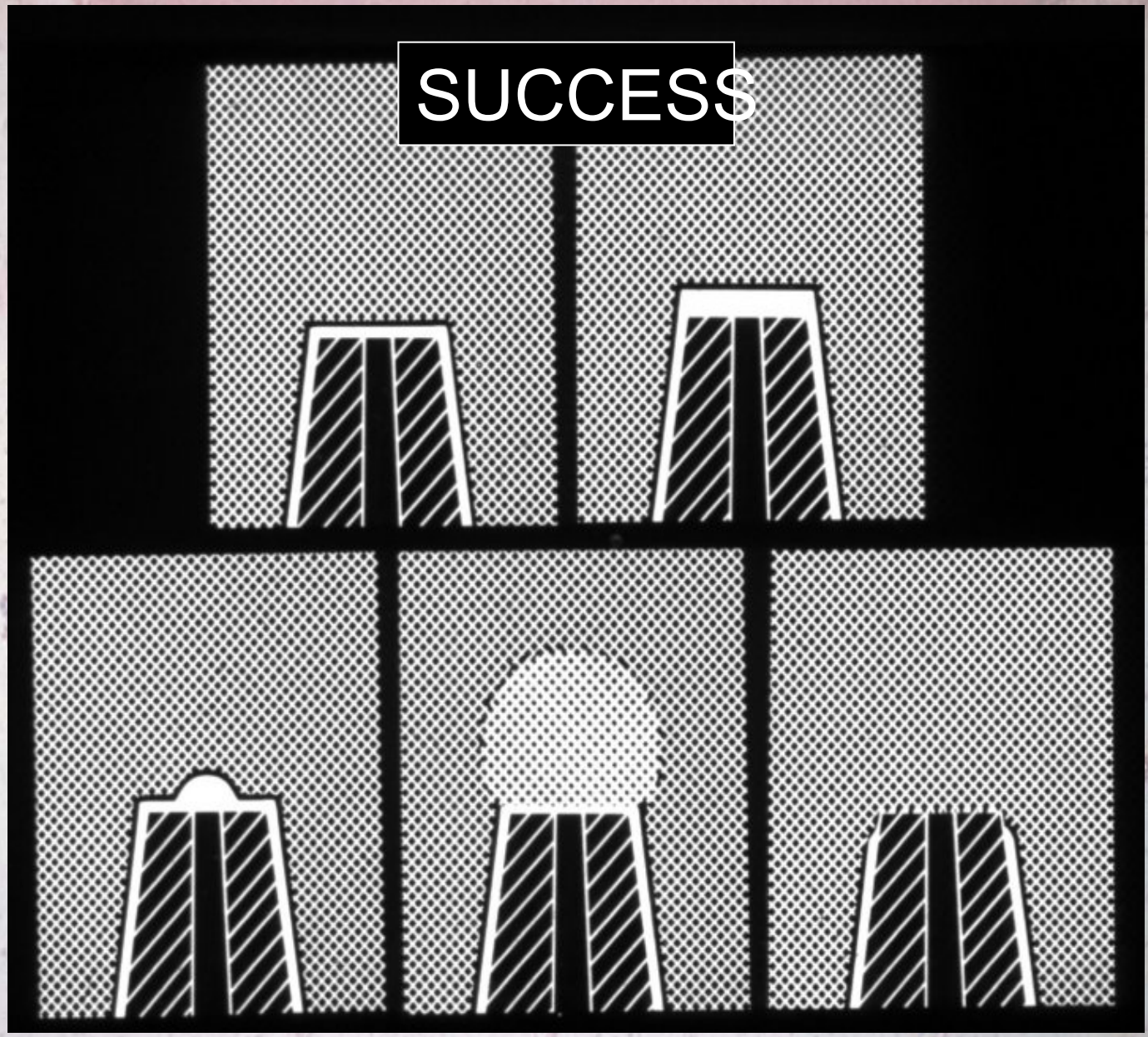
Radiographic follow-up after endodontic treatment

S. Huumonen & D. Ørstavik, in prep.

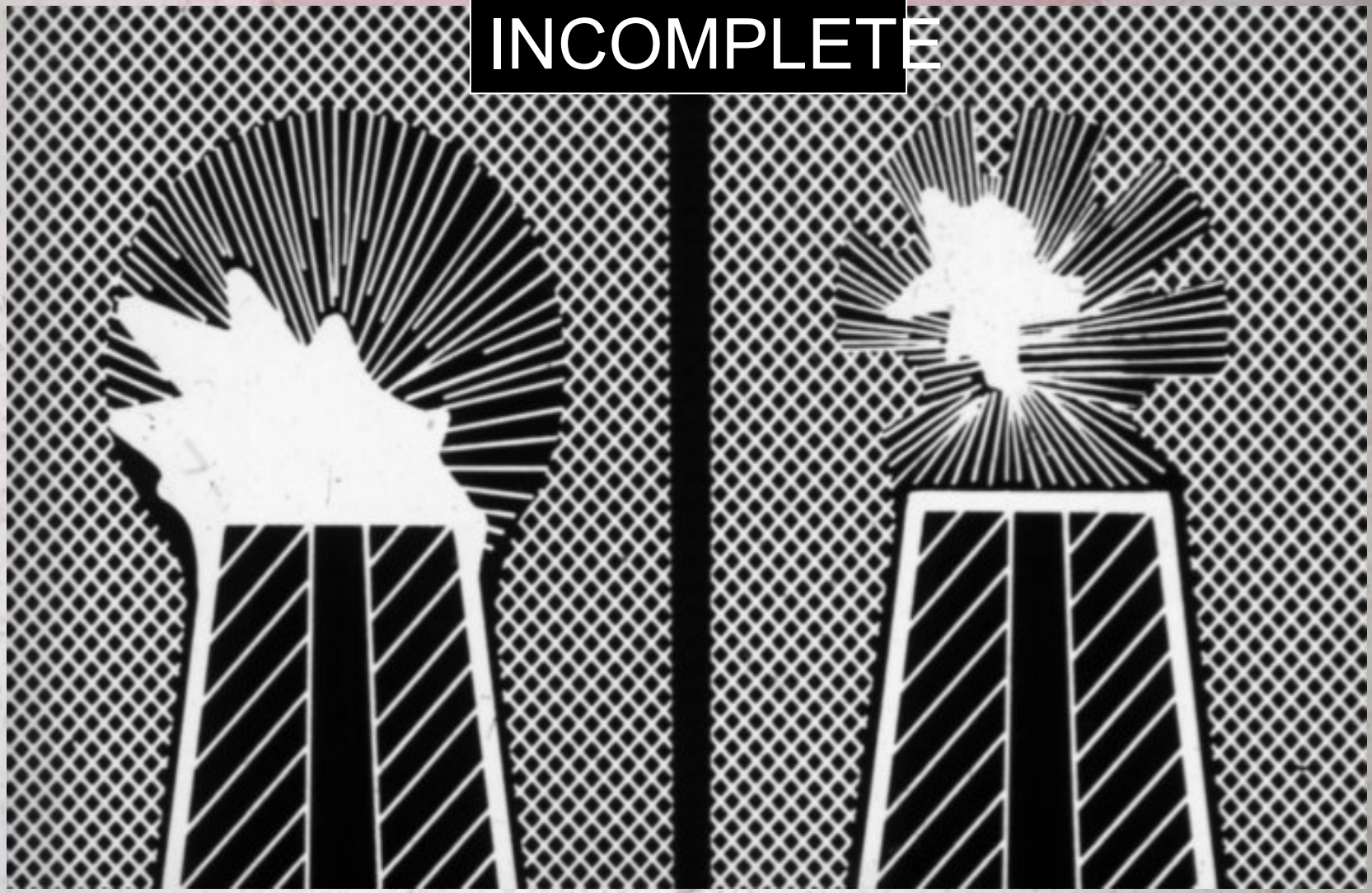
- **Conclusion**
  - Significant healing of apical periodontitis was seen at 3 months postoperatively.
  - Approximately half of teeth were healed within the first year.
  - Improvement of periapical status was slower in PAI groups 4 and 5 compared with PAI 3 during the first year.
  - After two years, improvement of periapical status continued similarly among different preoperative apical periodontitis groups of teeth.
  - Upper lateral incisors failed to heal more often than other tooth types.

Apical surgery

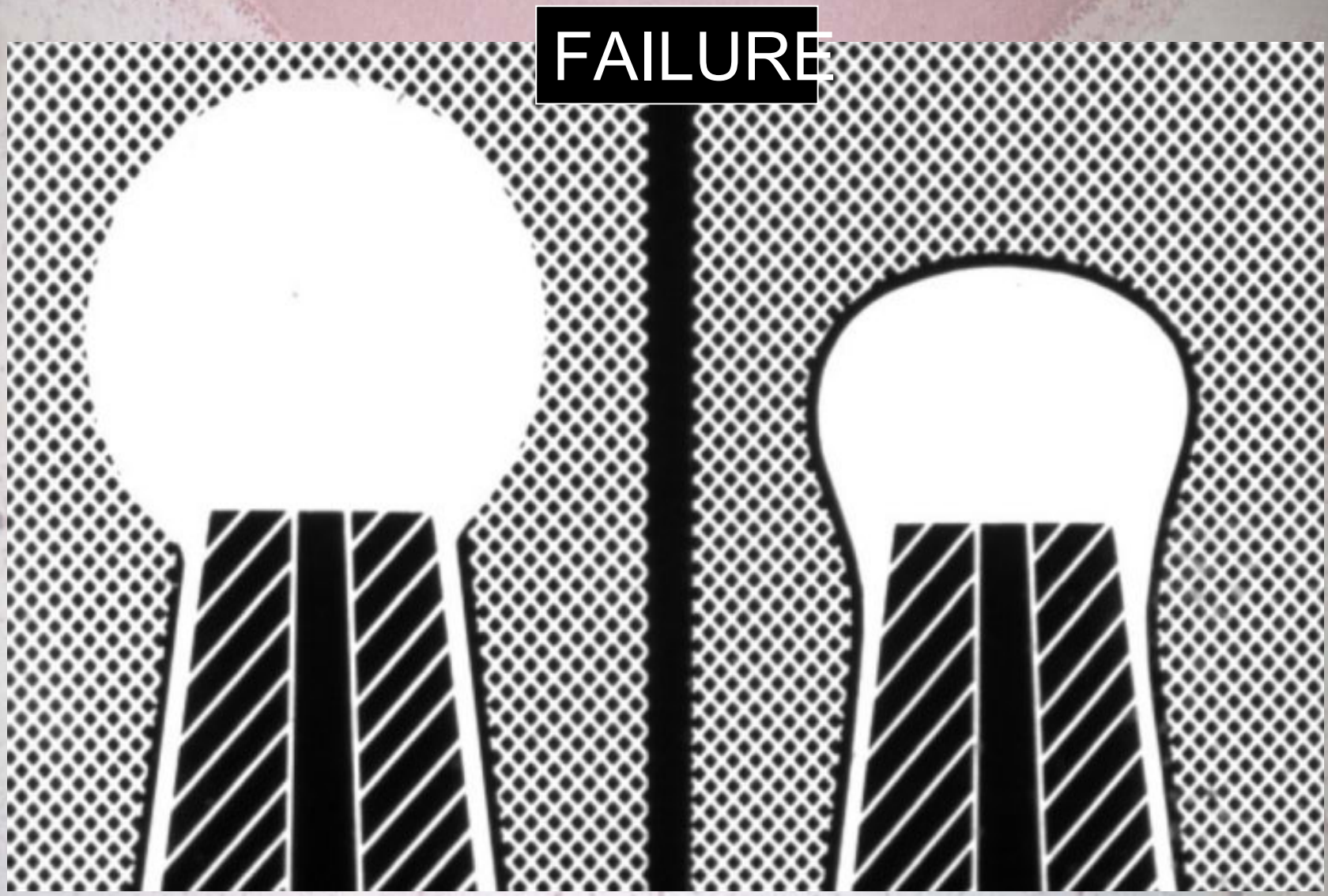
- Healing of periodontitis
- Healing of operation wound
- No histological correlate



After Molven et al. 1987: a visual, not verbal reference is used



After Molven et al. 1987

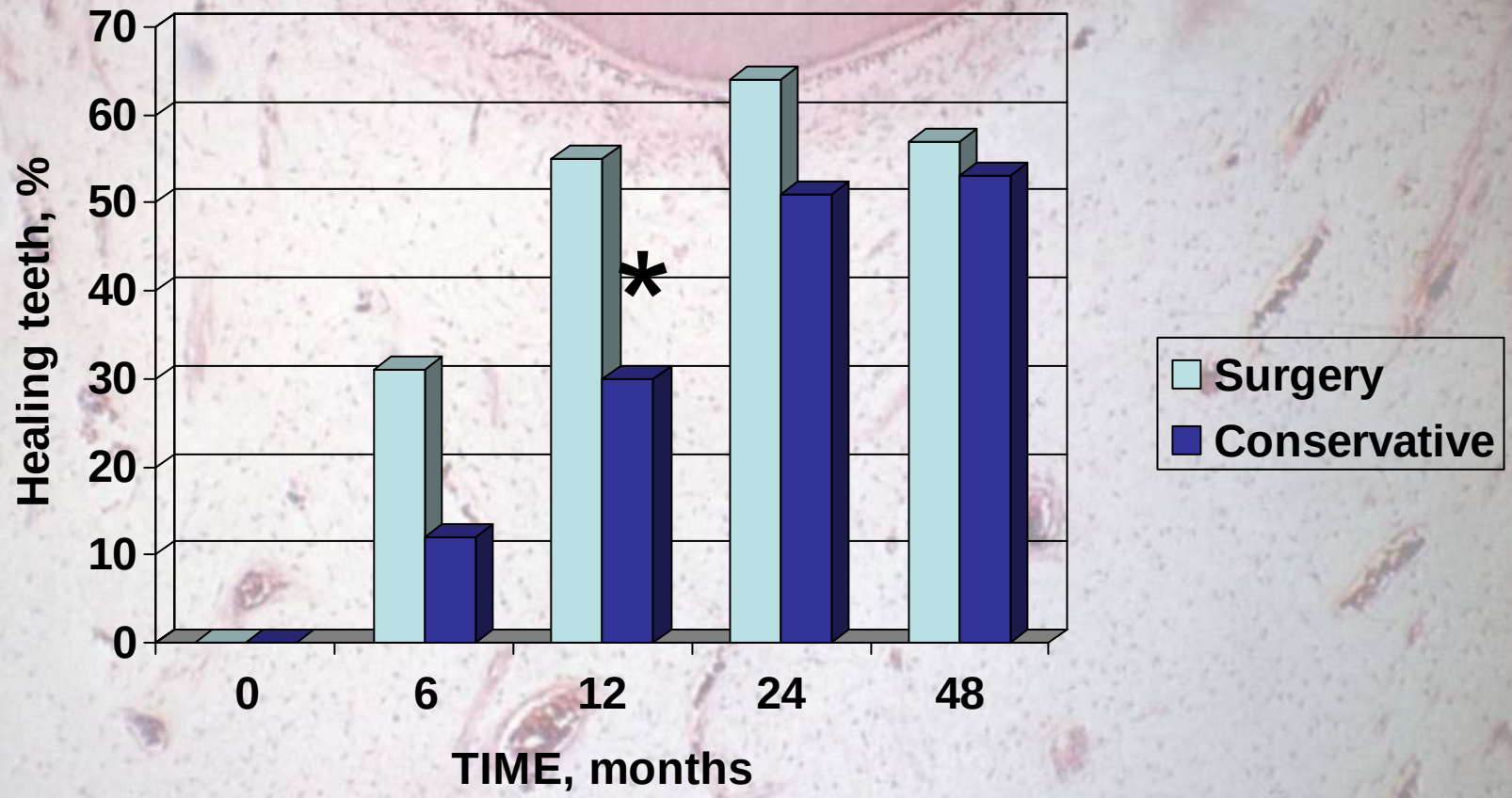


After Molven et al. 1987

Results of endodontic retreatment: a randomized clinical study comparing surgical and nonsurgical procedures.

- Kvist T, Reit C. J Endod. 1999 Dec;25(12):814-7.
- Conclusively, this study failed to show any systematic difference in the outcome of surgical and nonsurgical endodontic retreatment. Surgical retreatment seems to result in more rapid periapical bone fill, but also may imply a higher risk of "late failures." From a scientific point of view, the length of the follow-up period is very important and may strongly influence the conclusions made.

Results of endodontic retreatment: a randomized clinical study comparing surgical and nonsurgical procedures.



Endodontic surgery with and without inserts of bioactive glass PerioGlas(R)-a clinical and radiographic follow-up.

- Oral Maxillofac Surg. 2008 Nov 21.

  Pantchev A, Nohlert E, Tegelberg A.

  OBJECTIVE: This study evaluated the use of bioactive glass, PerioGlas(R), after retrograde filling with Super EBA cement in the treatment of periapical bone destruction. STUDY DESIGN: Healing outcomes were followed up after endodontic surgery in 186 teeth. Outcomes were divided into two groups according to follow-up time: short- and long-term. The EBA group (n = 110) underwent endodontic surgery and retrograde filling with EBA cement. In the EBA + PerioGlas(R) group (n = 76), PerioGlas(R) was embedded in the bone cavity after retrograde filling.

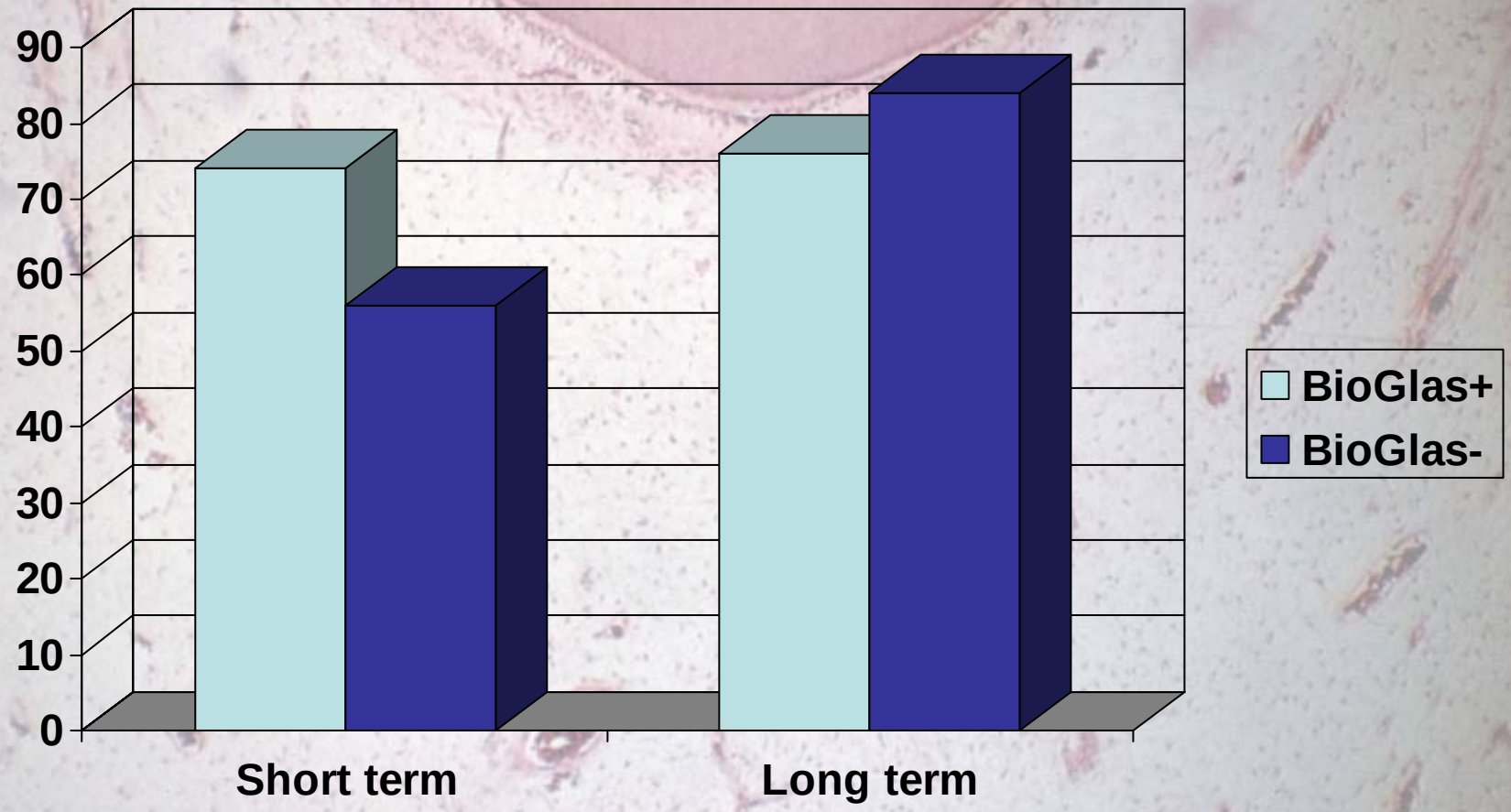
Endodontic surgery with and without inserts of bioactive glass PerioGlas(R)-a clinical and radiographic follow-up.

- Oral Maxillofac Surg. 2008 Nov 21.

  Pantchev A, **Nohlert E**, **Tegelberg A**.

  RESULTS: The success rate in the EBA + PerioGlas(R) group was 72% compared with 56% in the Super EBA group at the short-term follow-up and 74% and 84%, respectively, at the long-term follow-up. Healing of periapical bone destruction classified as uncertain at the short-term follow-up was considered successful in two out of three cases at the long-term follow-up.

Endodontic surgery with and without inserts of bioactive glass PerioGlas(R)-a clinical and radiographic follow-up.

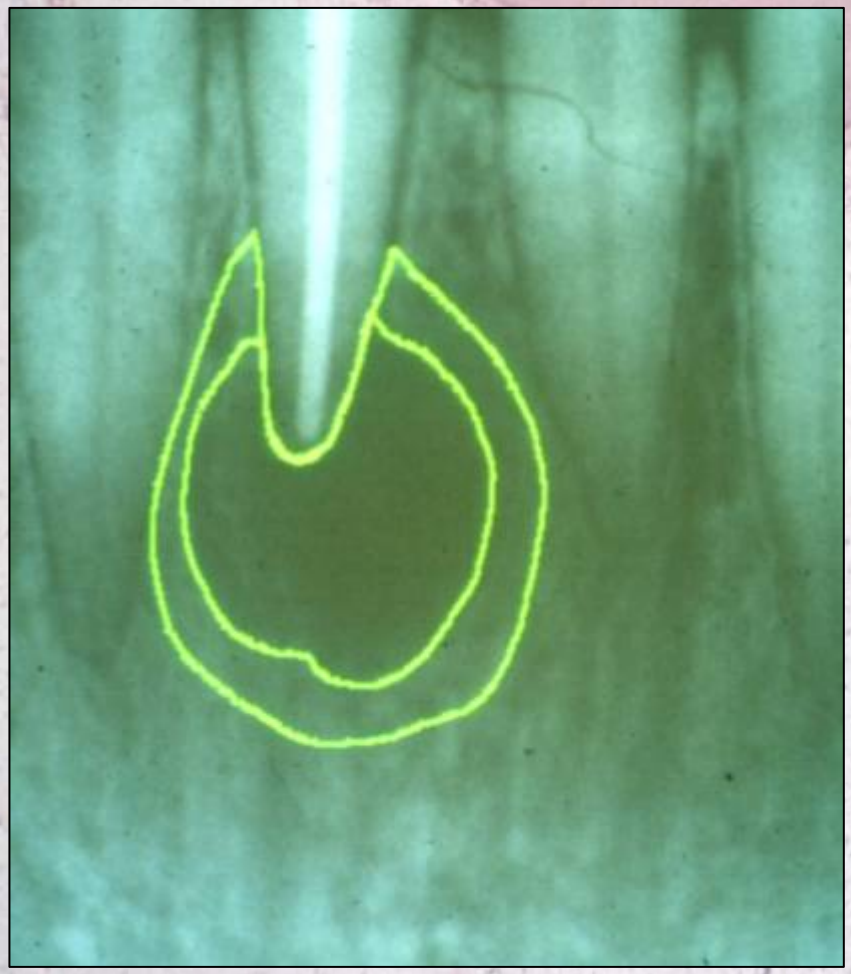


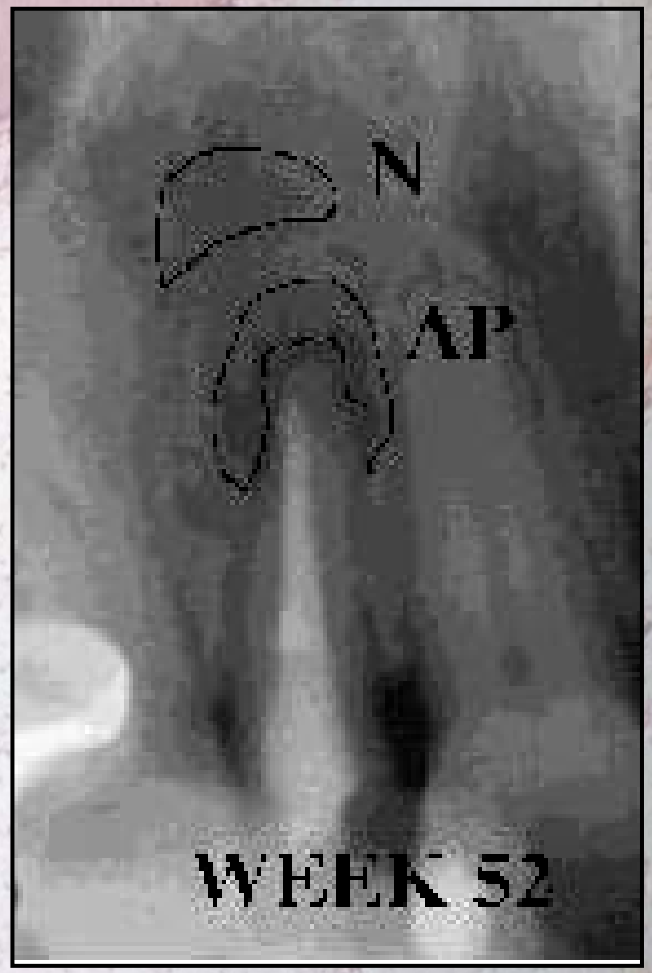
CONCLUSION: This study found that PerioGlas(R) as bone substitute did not significantly improve endodontic healing outcome

PerioGlas: PubMed

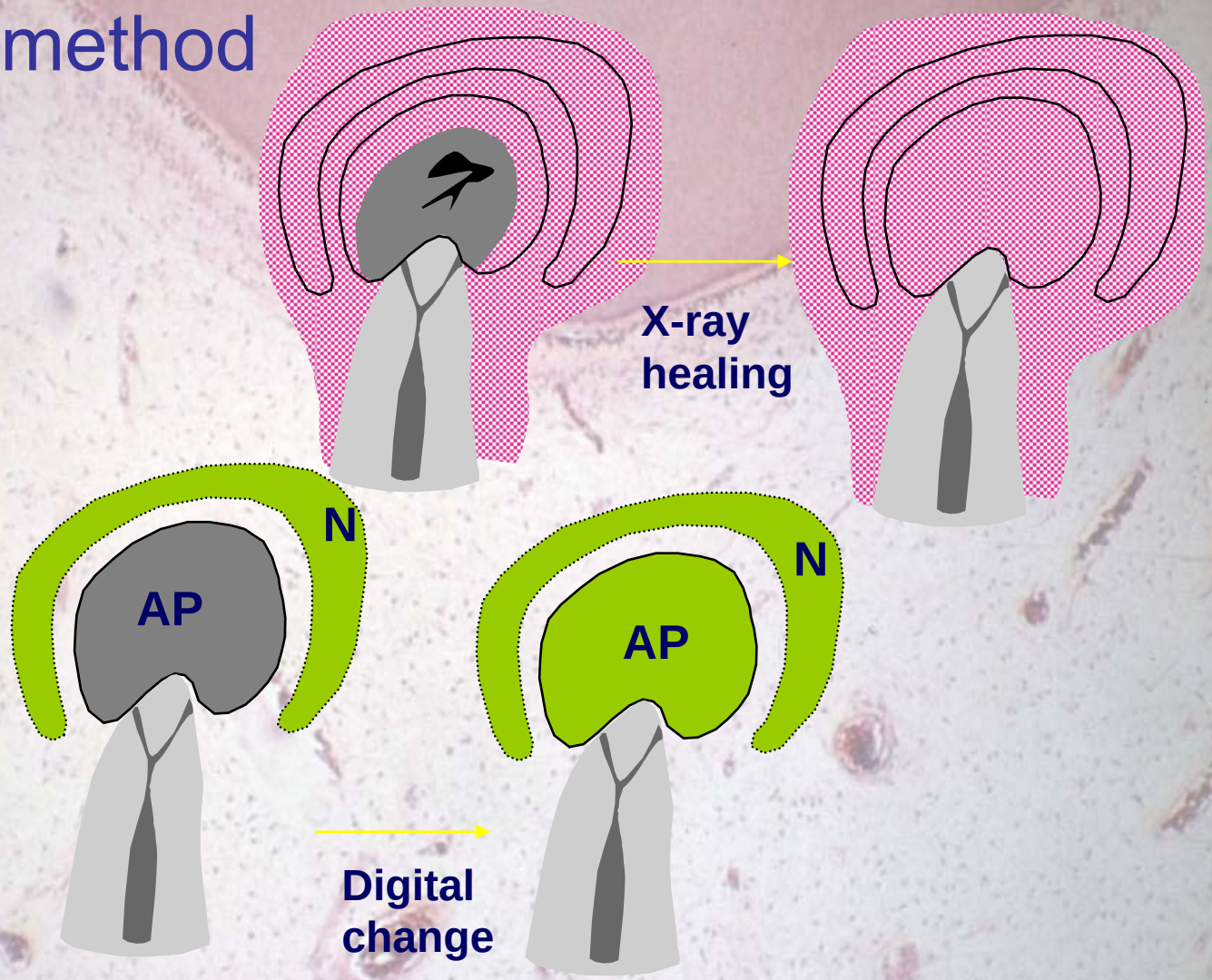
- Bioactive glass 989 articles
- PerioGlas 481 articles
- PerioGlas surgery 211 articles
- PerioGlas endodontic 4 articles

Digital manipulation

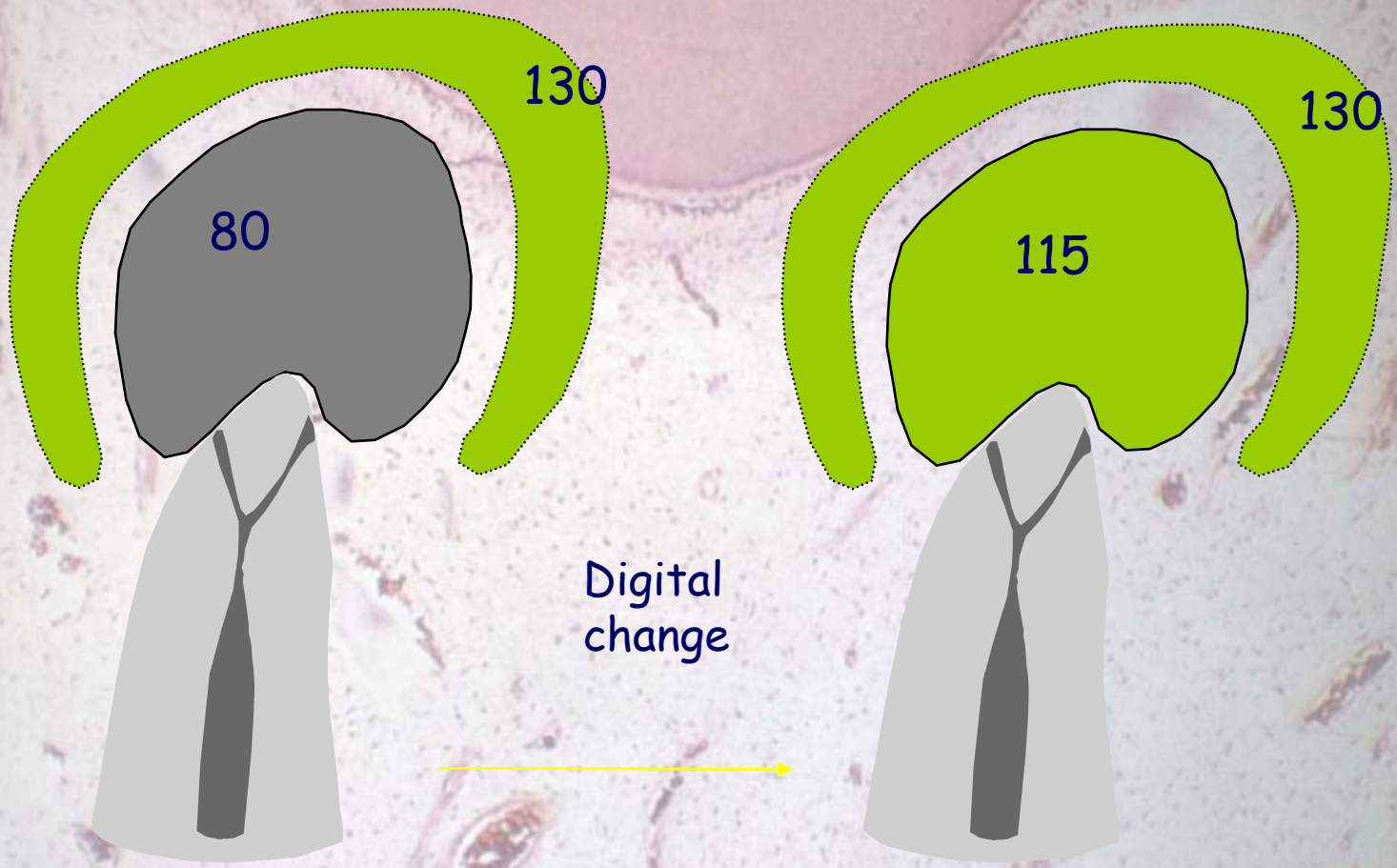




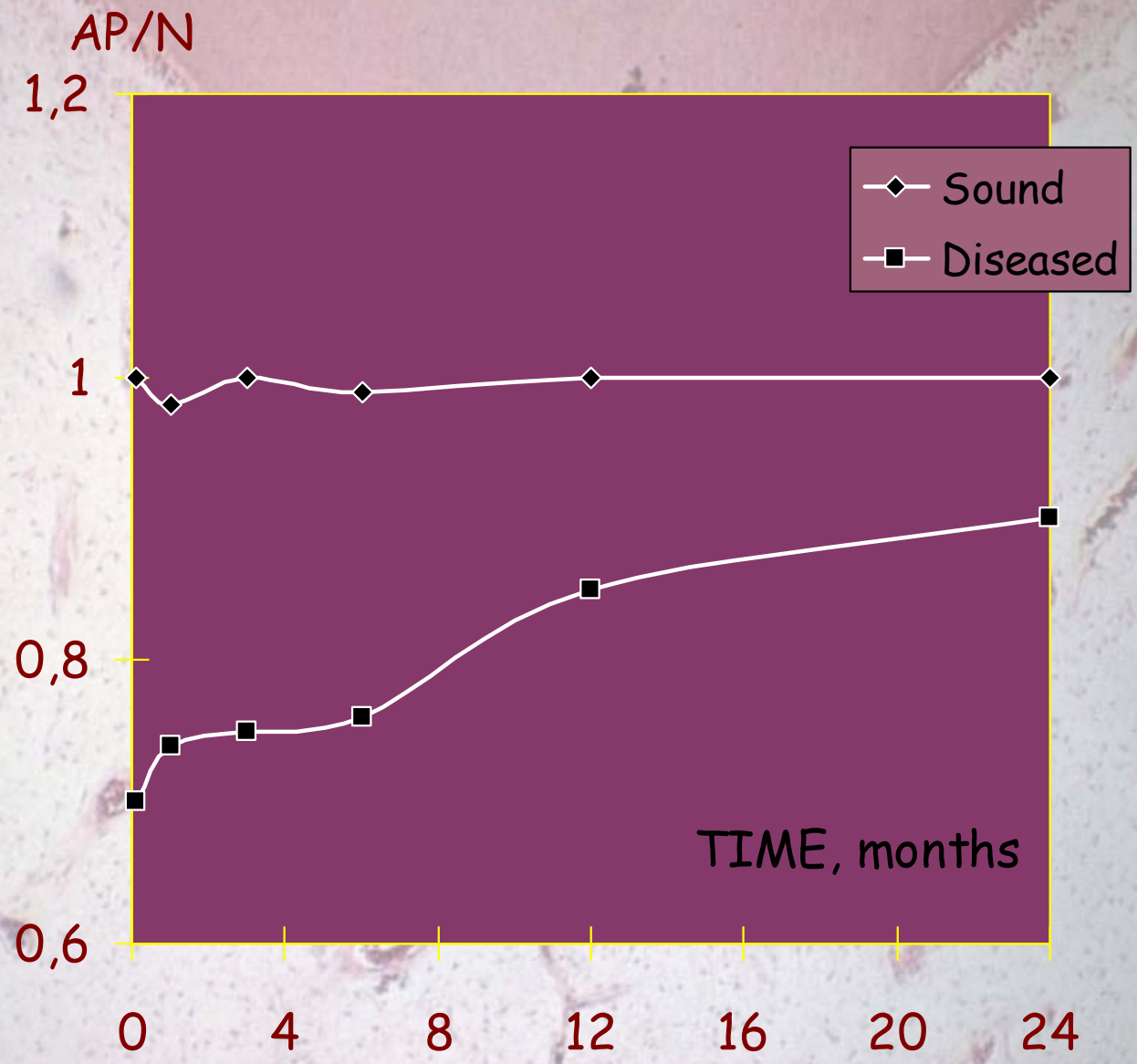
Ratio method



Numbers are average gray values in the defined areas: 255=white; 0=black



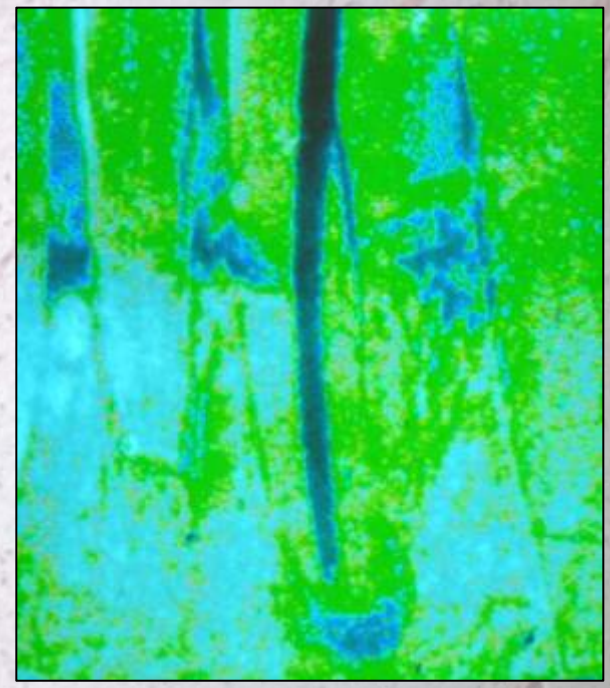
AP/N =0,62 → AP/N 0,88

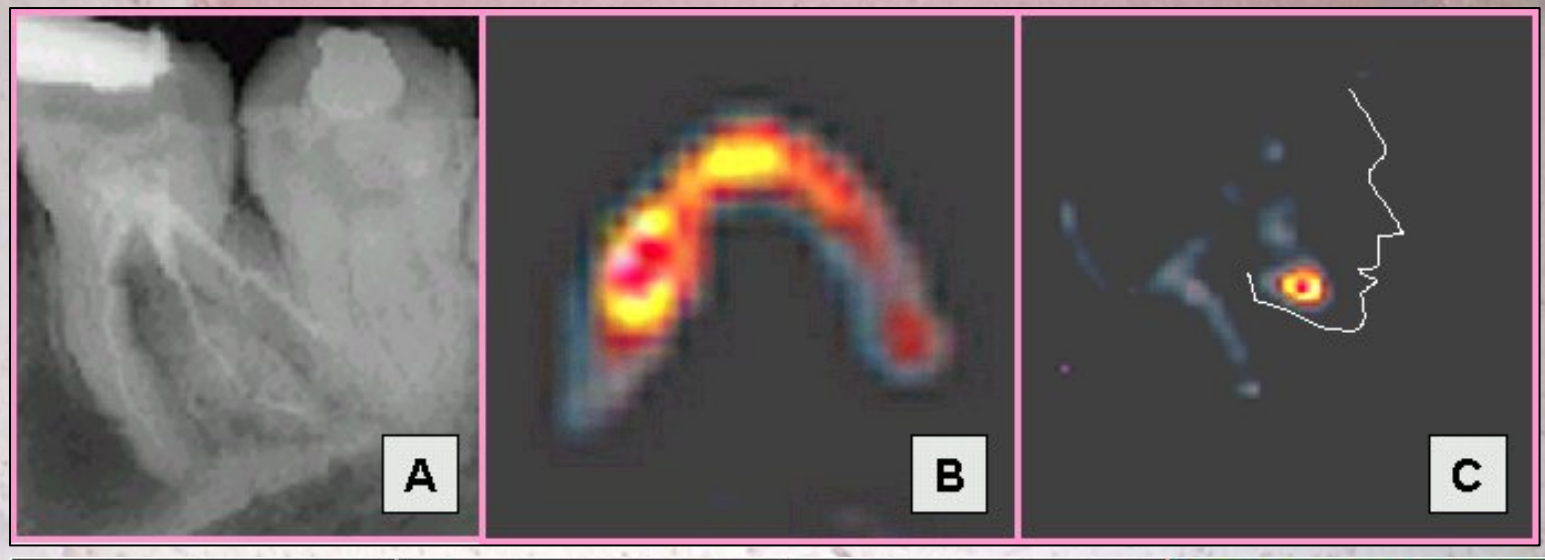

AP/N
1,2
1
0,8
0,6
Sound
Diseased
TIME, months
0
4
8
12
16
20
24

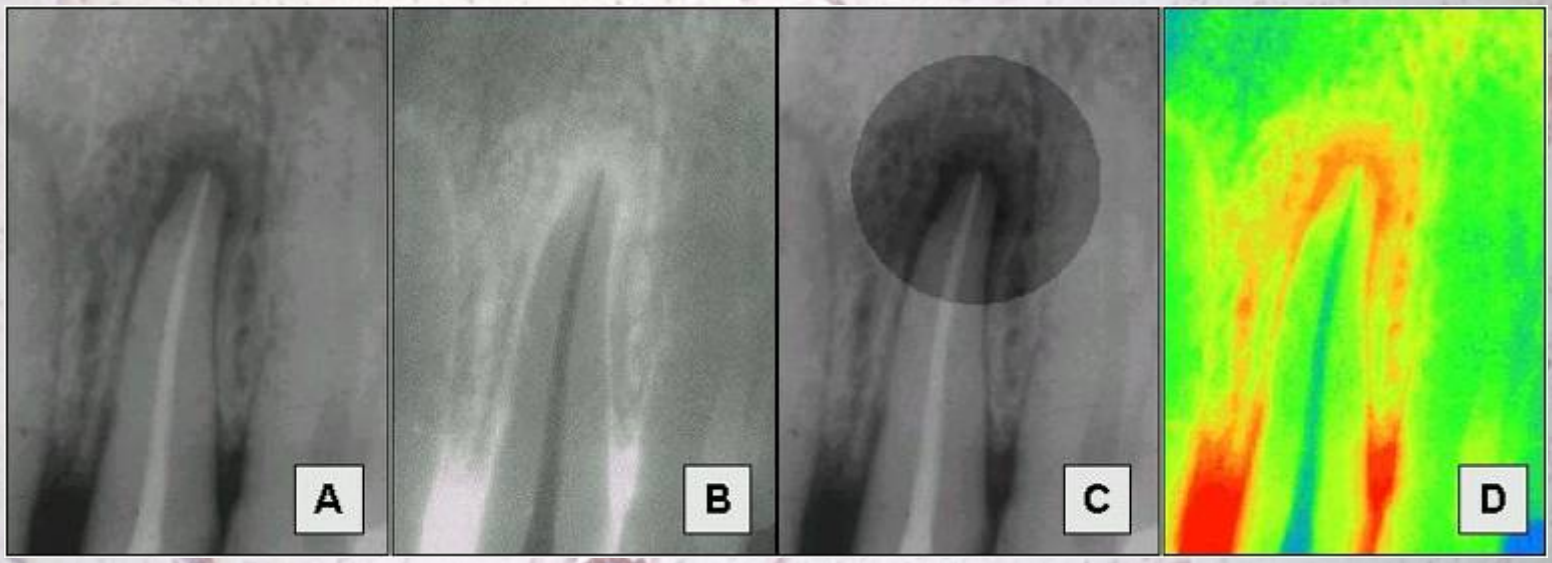
Other methods:

digital subtraction

visual enhancement

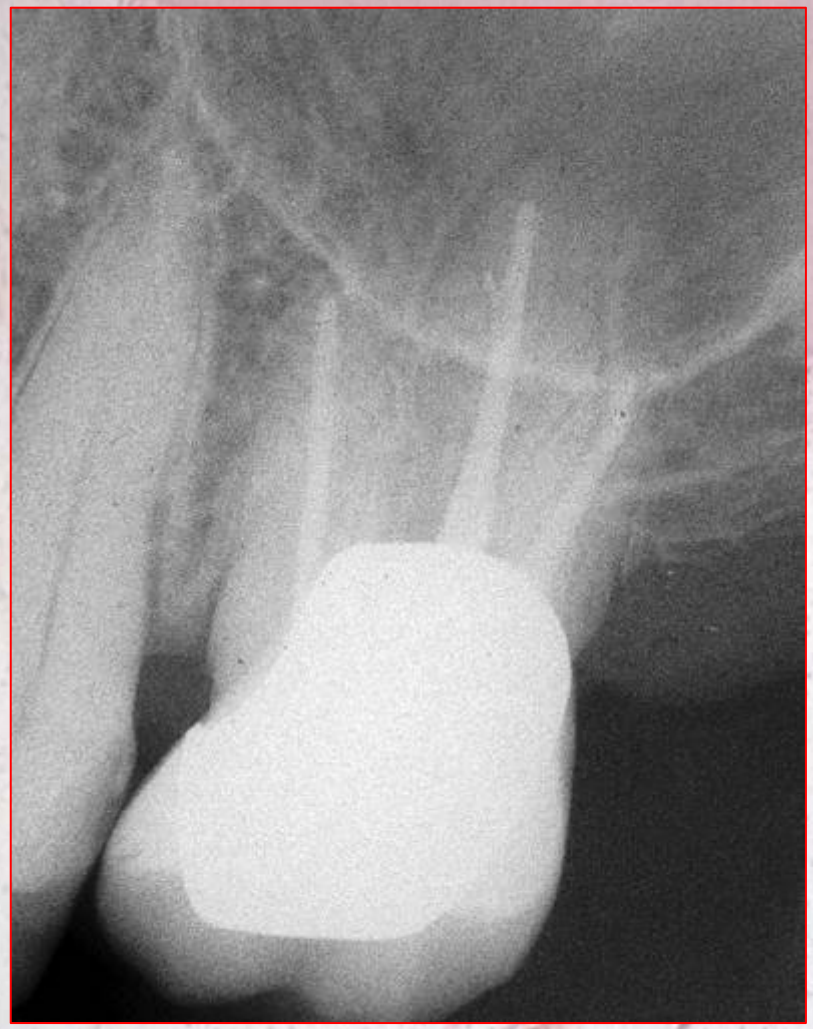






Scintigrahy and digital manipulation: Fine for visualization, so far no application in quantitative approaches

Huumonen & Orstavik 2002



CT: Fine for visualization, so far no application in quantitative approaches

Huumonen & Orstavik 2002

Feasibility studies

- These are basically case series documenting that a given technique, material or medicament may be used with a fair expectation of success (Endorez, Resilon)

Glass ionomer sealer

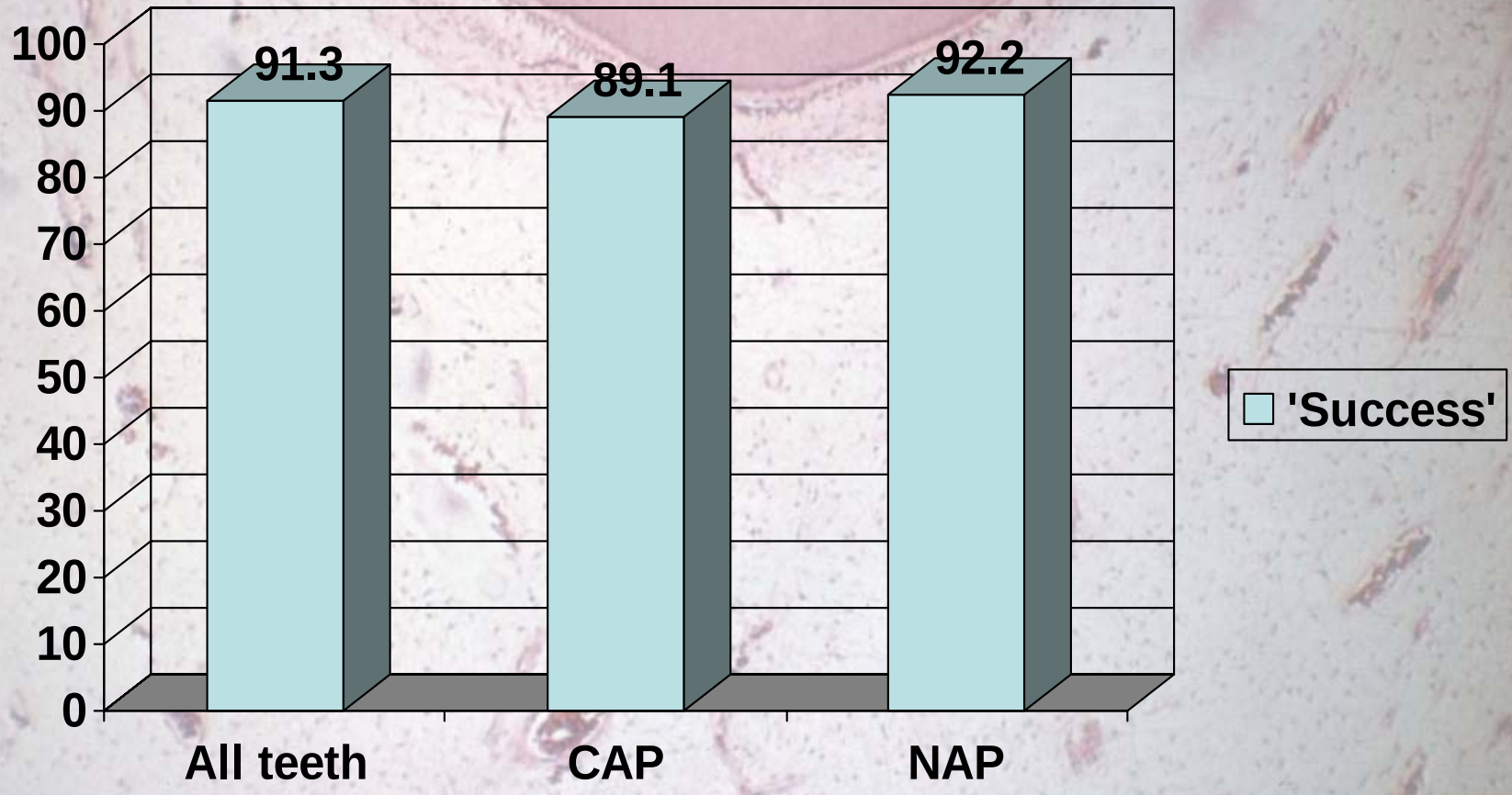
Of 378 followed-up teeth, there was 78.3% success, 15.6% incomplete healing, and 6.1% failure.

Harmonized criteria?

Reproducibility?

Friedman et al., 1995

Clinical Study – EndoRez



’Feasibility study’

Zmener O, Pameijer CH. 2004

Resilon - Epiphany

Of 38 teeth with an initial PAI score of ≥3, 58% had a PAI score ≤2 after 12 months.

Heffernan et al., 2006

Resilon - Epiphany

Of 38 teeth with an initial PAI score of ≥3, 58% had a PAI score ≤2 after 12 months.

Trope et al: ca. 75 %; Huumonen & Ørstavik: ca: 50 %

Harmonized PAI scores make all the difference

Heffernan et al., 2006

Conclusions on case series

- Valuable baseline for general acceptance of a product or method
- No comparison with other products unless Tx and analysis methods are standardized:
  - Nonrandomized trials with historical controls are then OK

Particular clinical situations

- Perforations, fractures, open apices, endo-perio, differential diagnosis may represent problems that have unique radiographic features and must be separated from follow-up analyses

Scientific clinical studies

- Defined criteria for outcome parameters including
  - Subjective symptoms
  - Objective symptoms
  - Radiographic characteristics
  - Temporal aspects
- Systematic discrimination of variables
- Retro- or prospective
- Randomized distribution and unbiased evaluation

Assessment of one's own cases

- Careful selection of cases for systematic studies:
  - Preoperative diagnosis
  - Complications
  - Technically difficult cases
  - Surgical variables, if applicable
- Limitations of one's own long-term follow-up experiences

Self-assessment

- Suppose 200 patients are seen for *control* each year,
- this gives a 95% confidence interval for success rates around *85%* of
- ***80 to 90%***
- i.e., there is ***no way*** anyone can register a real change in treatment outcome of less than some 10%!

Self-assessment: example

- For detail, suppose that of the 200 patients, perhaps 80 had CAP,
- of which at least ¼ had to be treated in 2 or more appointments anyway, leaving 60,
- ***which gives a conf int of 76 to 94%***
- i.e., there is ***no way*** anyone can register a real change in therapeutic outcome of less than some 20%

'It works in my hands':

How many cases do ***you*** really need to document a difference in performance?

Outcome	Treatment categories (groups) Old method	New method				
Success	85	94	179	0,895		
Failure	15	6	21	0,105		
	100	100	200	1		
Success %	85	94				
	89,5	89,5	179			
	10,5	10,5	21			
	0,226257	0,226257	0,452514	0,05	0,01	
	1,9285714	1,9285714	3,8571429			
Chi-square value:			*4,3096568*	3,84	6,63	
Degrees of freedom:			1			

Even 200 cases are not very discriminating: How many cases do you follow up ***systematically?***

And who controlled ***and*** randomized the variables influencing *bacteria in the canal*, or other variables affecting the final outcome?

Finally: any new method or new material is correctly applied to simple cases first, recognizing the learning curve.

When such cases are retrospectively assessed, they **should** have a better outcome than the average or complicated case

Assessment of one's own cases

- There are serious limitations just by the numbers needed, in one's own ability to assess outcome
- Base-line harmonization almost impossible and
- Case selection crucial
- But: the unusual case is still evading systematic studies, and treatment will still have to be based on hearsay: cf the plea for the case report

Conclusions from theoretical considerations

- Sharing practice experiences is an inadequate method of improving performance
- *Systematic improvements must rely on well-designed clinical studies*
- First: do we really need improvement ?

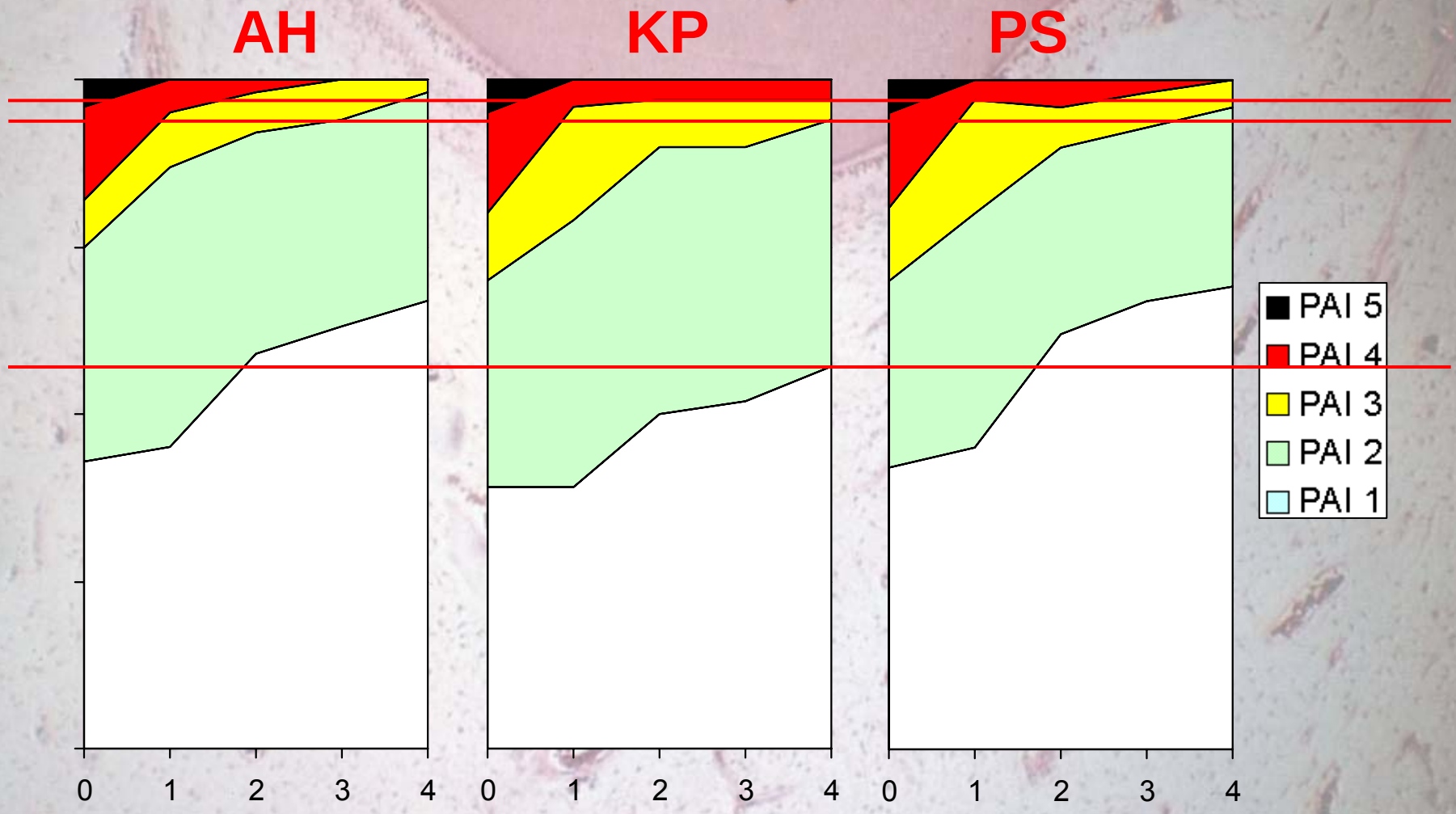
Clinical testing of medicaments, materials and techniques

- Traditional feasibiblity tests
- Analysis of retrospective testing
- Prospective studies; comparison with historical data
- Randomized, controlled clinical studies

Clinical Evaluation

- Prevention
  - failure: AP developing where none existed
  - AH26 vs ProcoSol (Grossman's sealer) vs Kloroperka: Significantly poorer results for Kloroperka in one clinical study

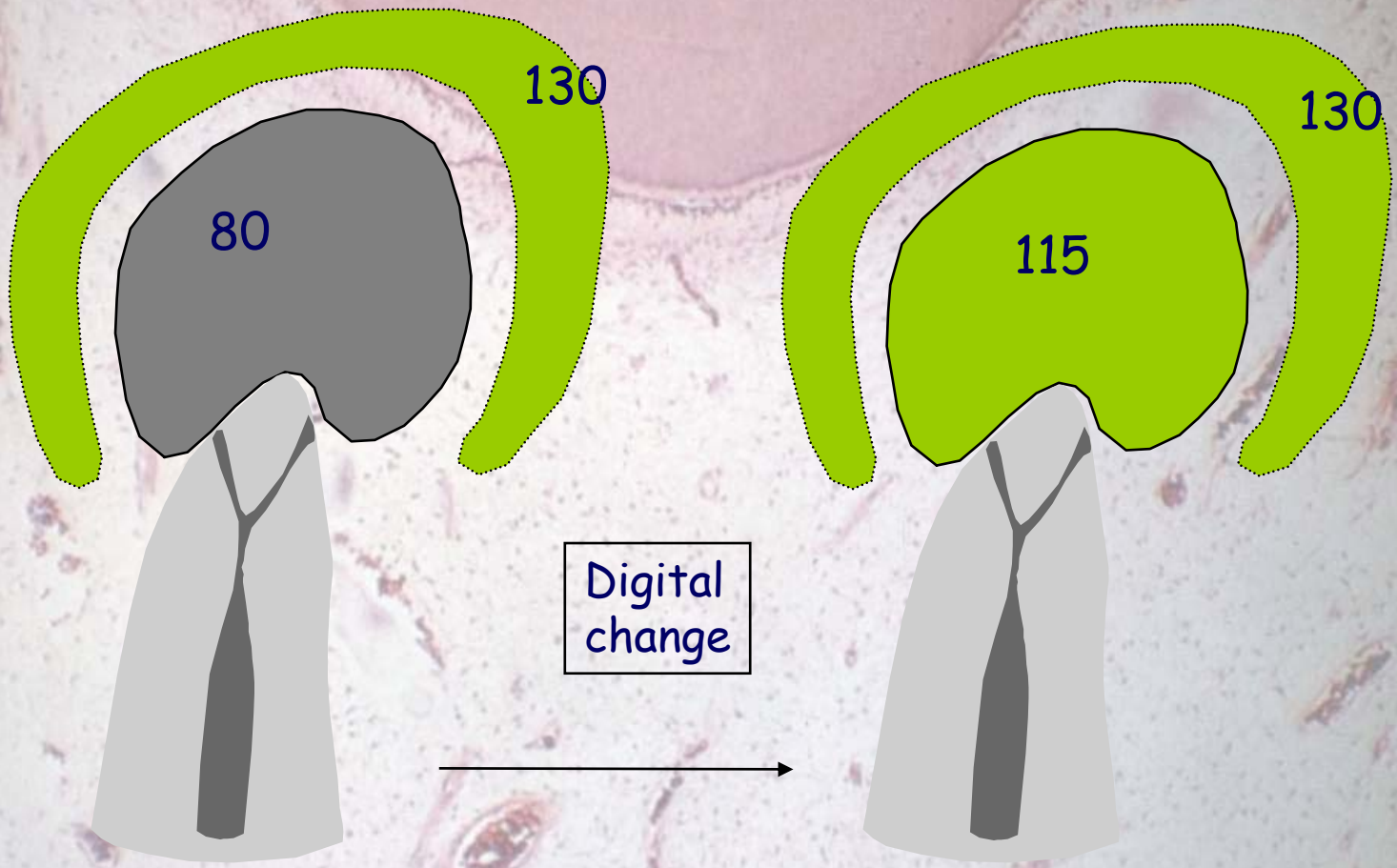
Cumulative PAI Scores



TIME: 0 to 4 years

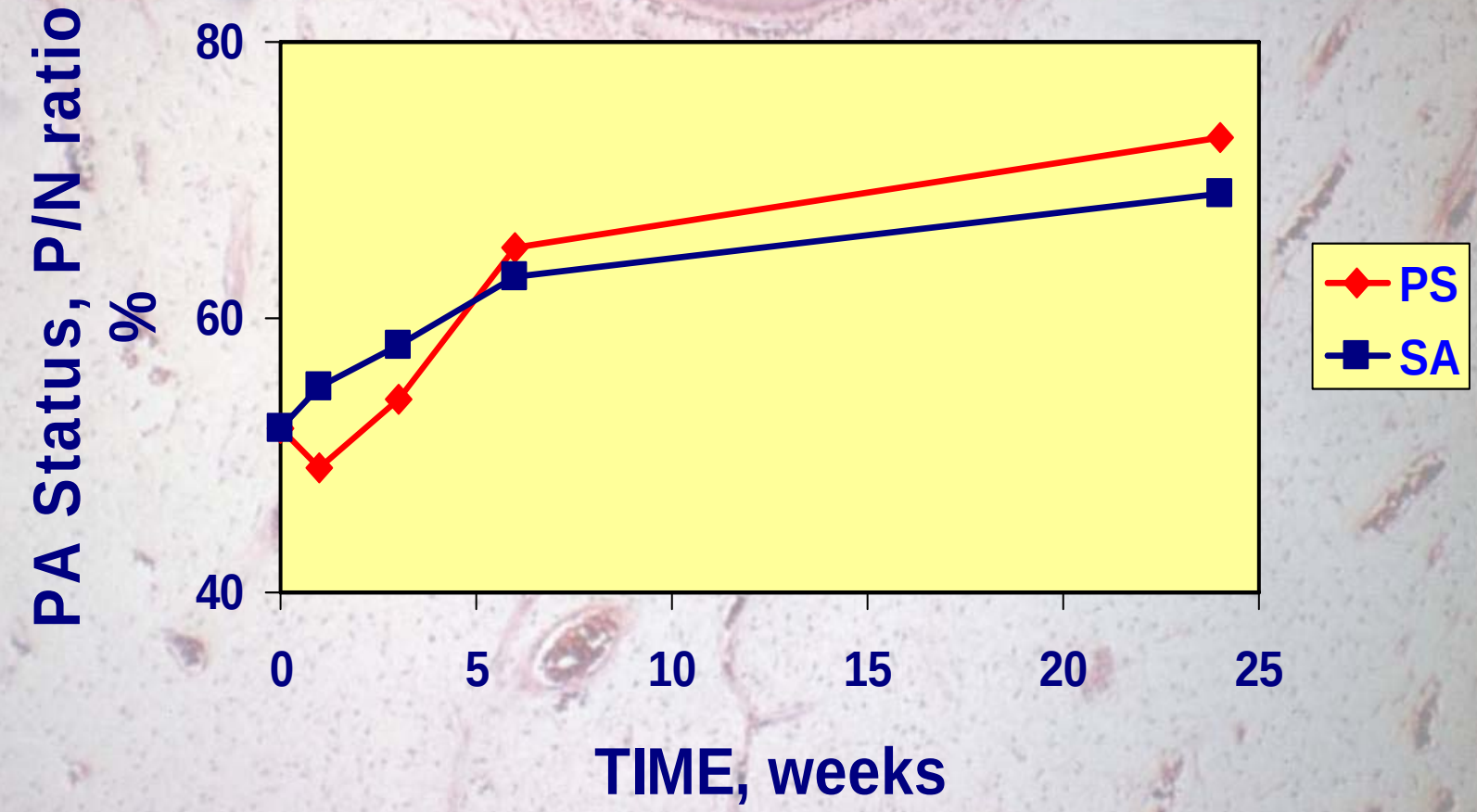
Ørstavik et al., 1986

Numbers are average gray values in the defined areas: 255=white; 0=black

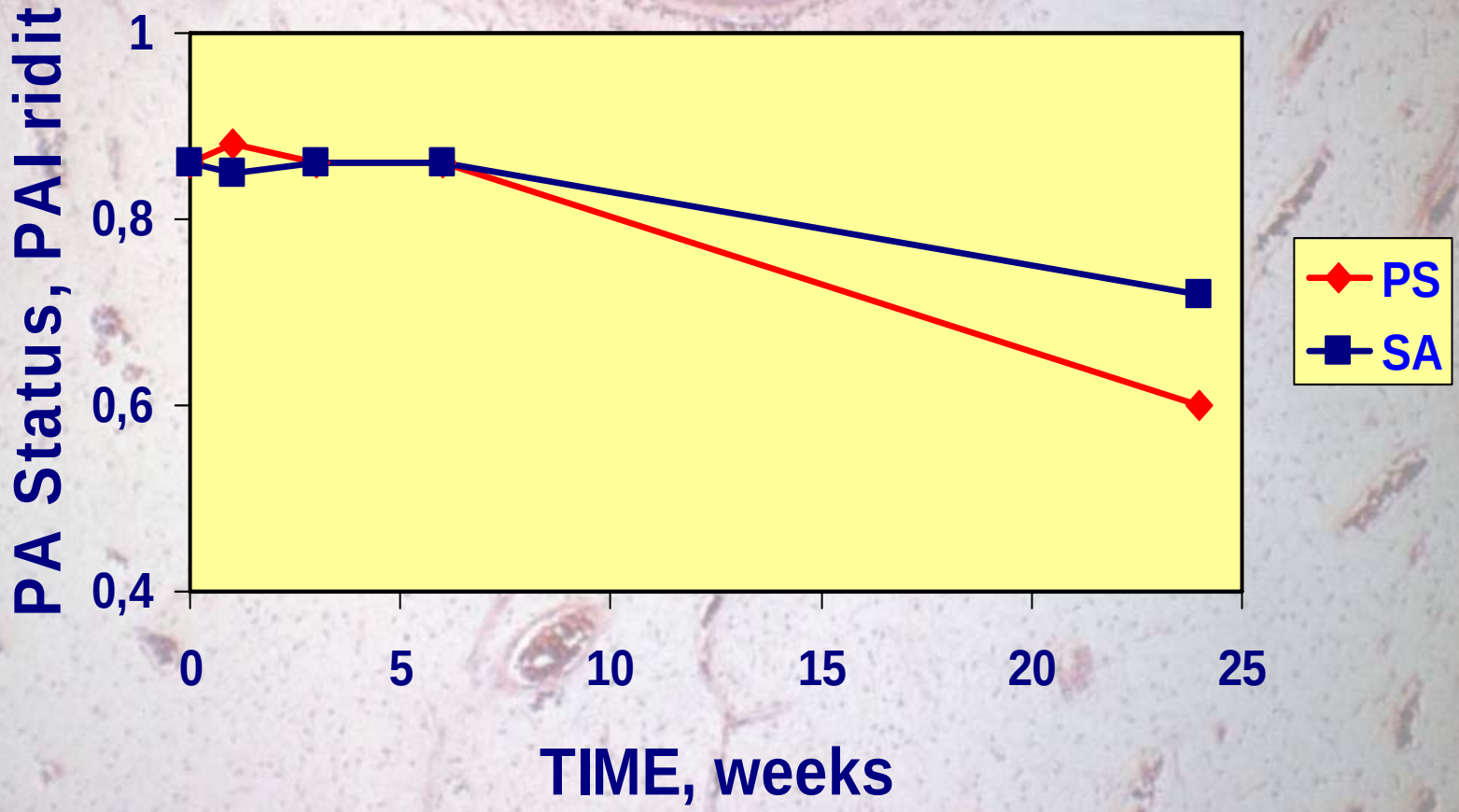


AP/N =0,62 → AP/N 0,88

Healing by AP/N Ratio



Healing by PAI Score

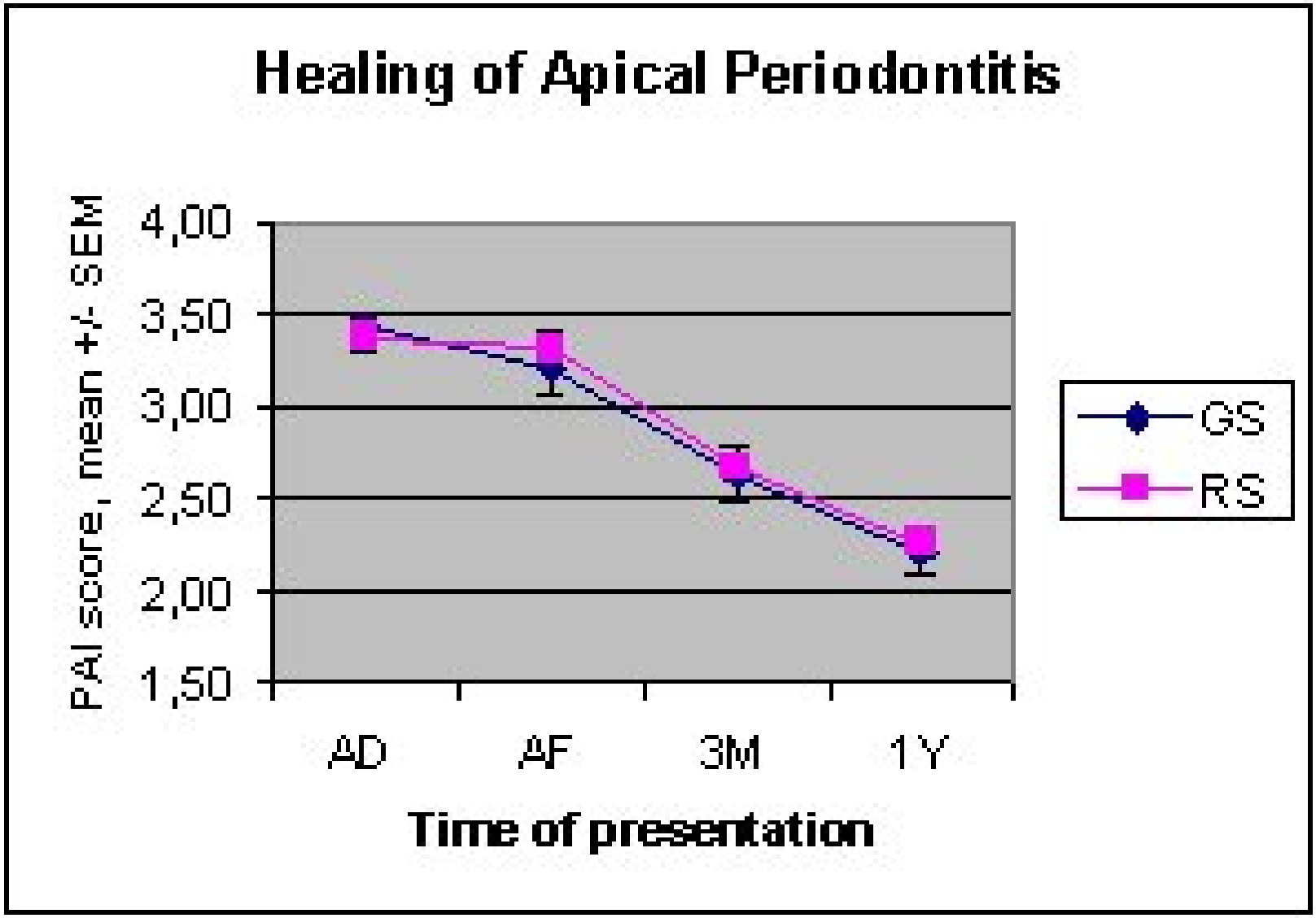


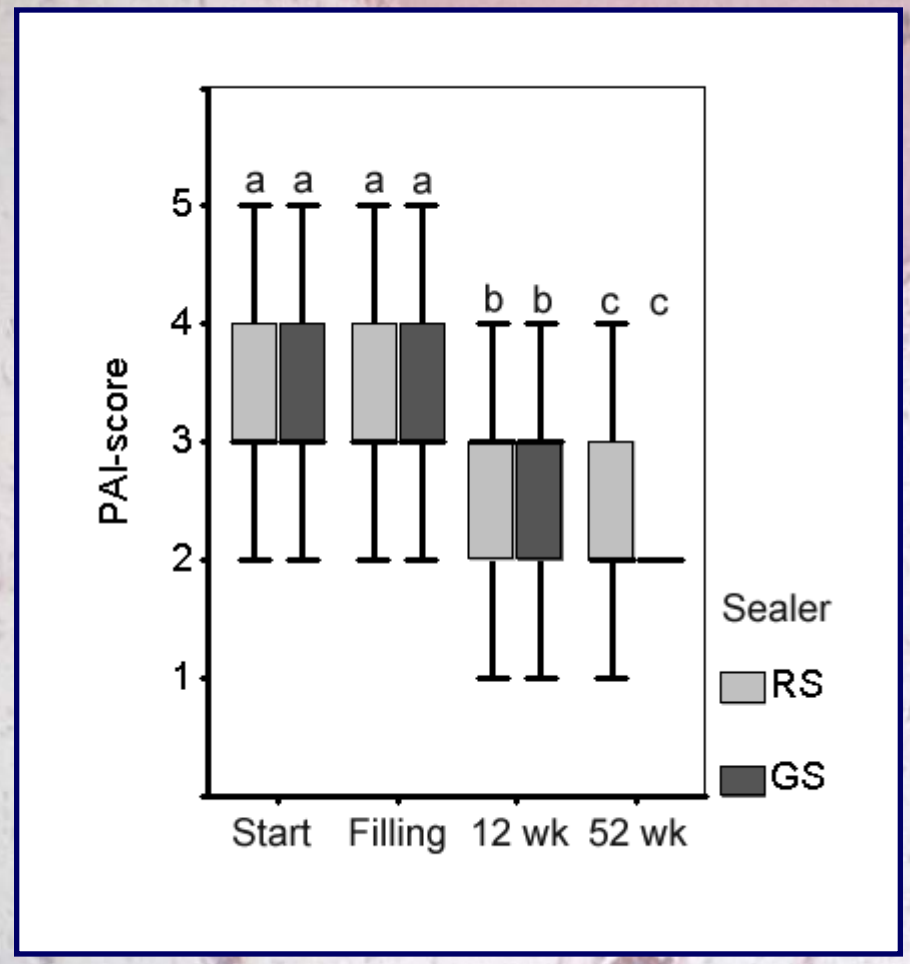
Single-visit: both PAI score and ratio method

From Trope et al., 1998

TX	N	Ratio average gray value on original image at 52 weeks
C	23	0.9897
E	21	0.9279
O	41	0.9555

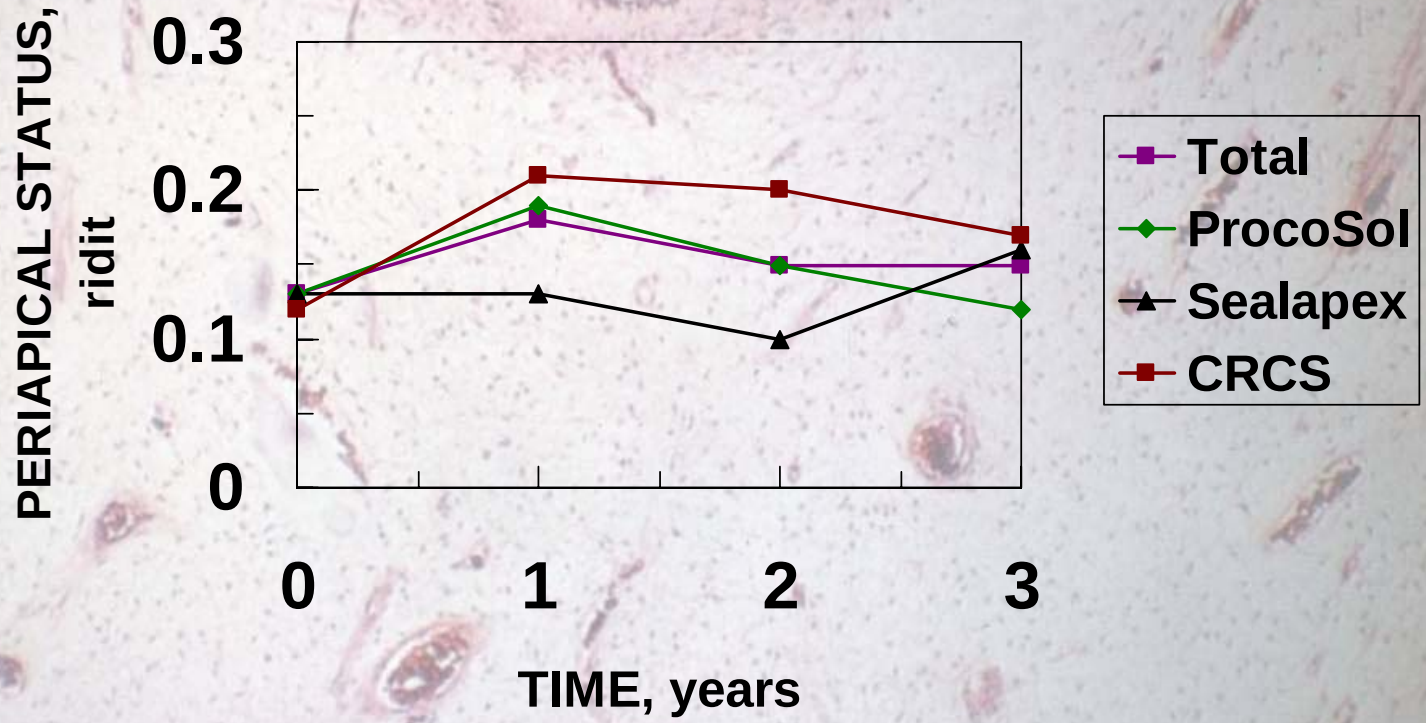
Delano et al 2001


Healing of Apical Periodontitis
PAI score, mean +/- SEM
4,00
3,50
3,00
2,50
2,00
1,50
AD
AF
3M
1Y
Time of presentation
GS
RS



The effect of the sealer used on changes in periapical status (The boxes show the 1st and 3rd quartiles with the median value in bold line. The whiskers show the minimum and maximum). Identical letters indicate no statistically significant differences ($\alpha = 0.01$).

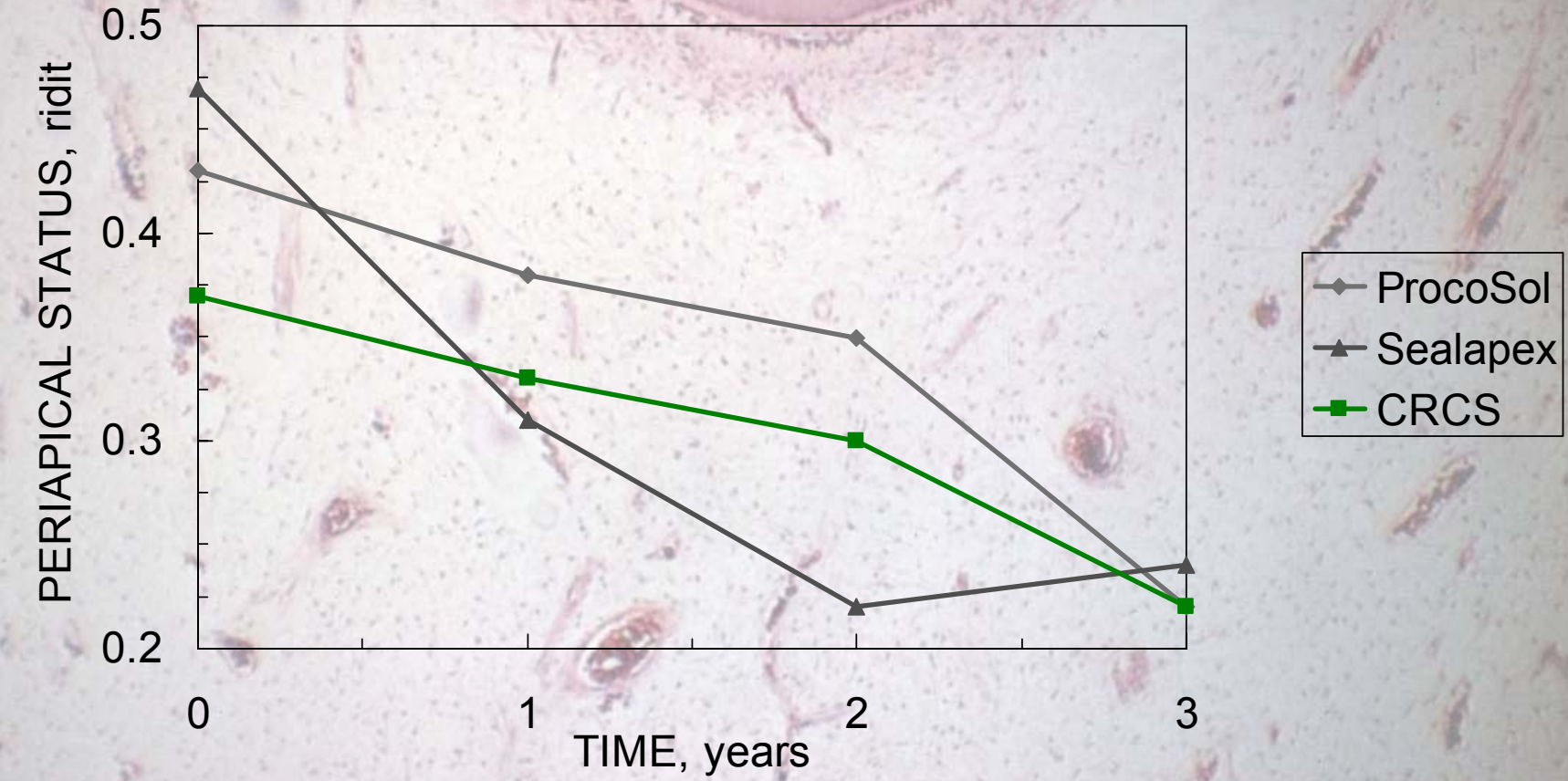
Preoperative Healthy Periodontium: Effect of Sealer



From Waltimo et al 2003

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

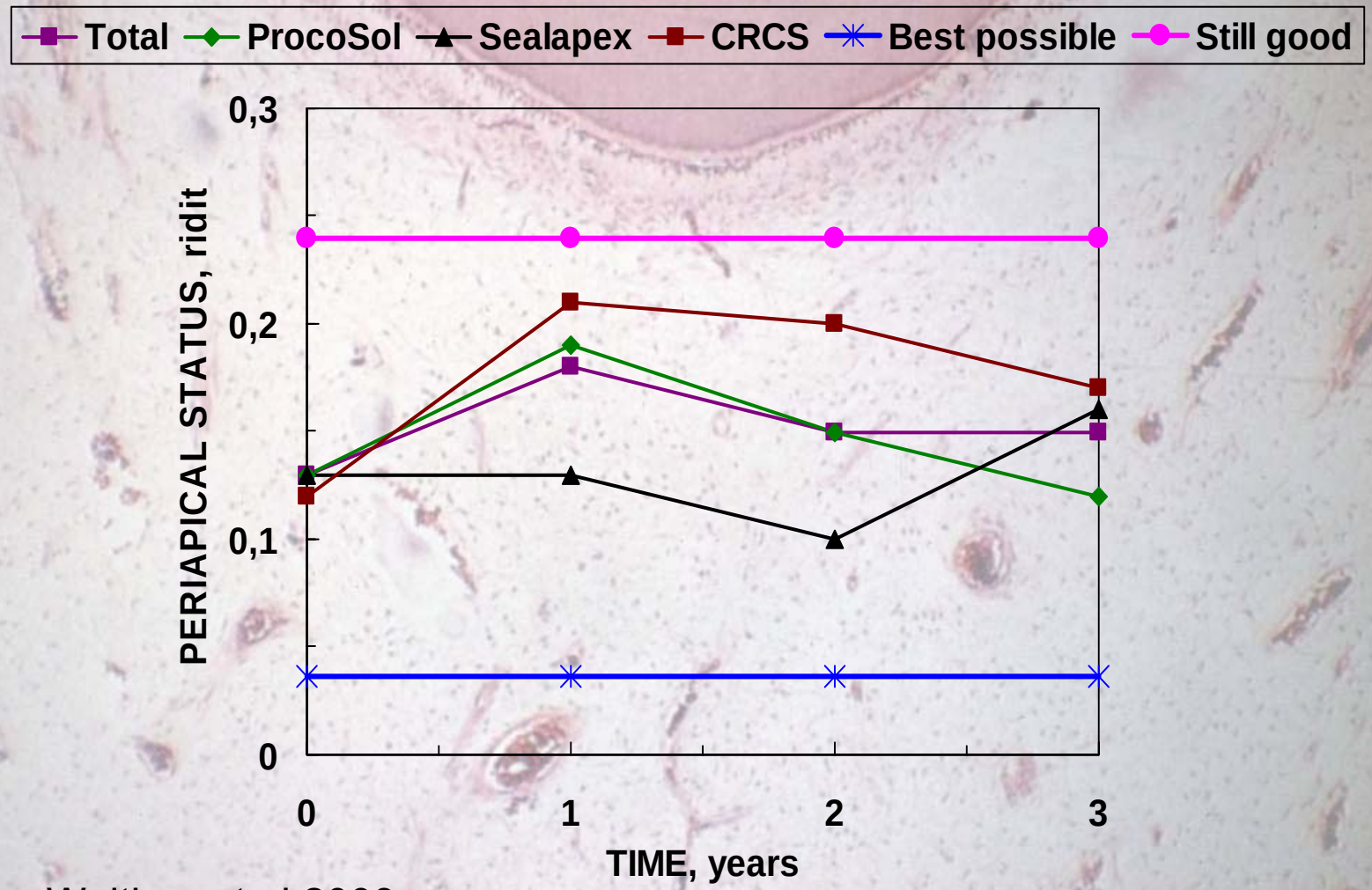
Healing of apical periodontitis following root filling with 3 different sealers



From Waltimo et al 2003

Range of s.e. of means: 0.02-0.07

Preoperative Healthy Periodontium: Effect of an Adhesive, Seal-Tight Sealer?



From Waltimo et al 2003

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

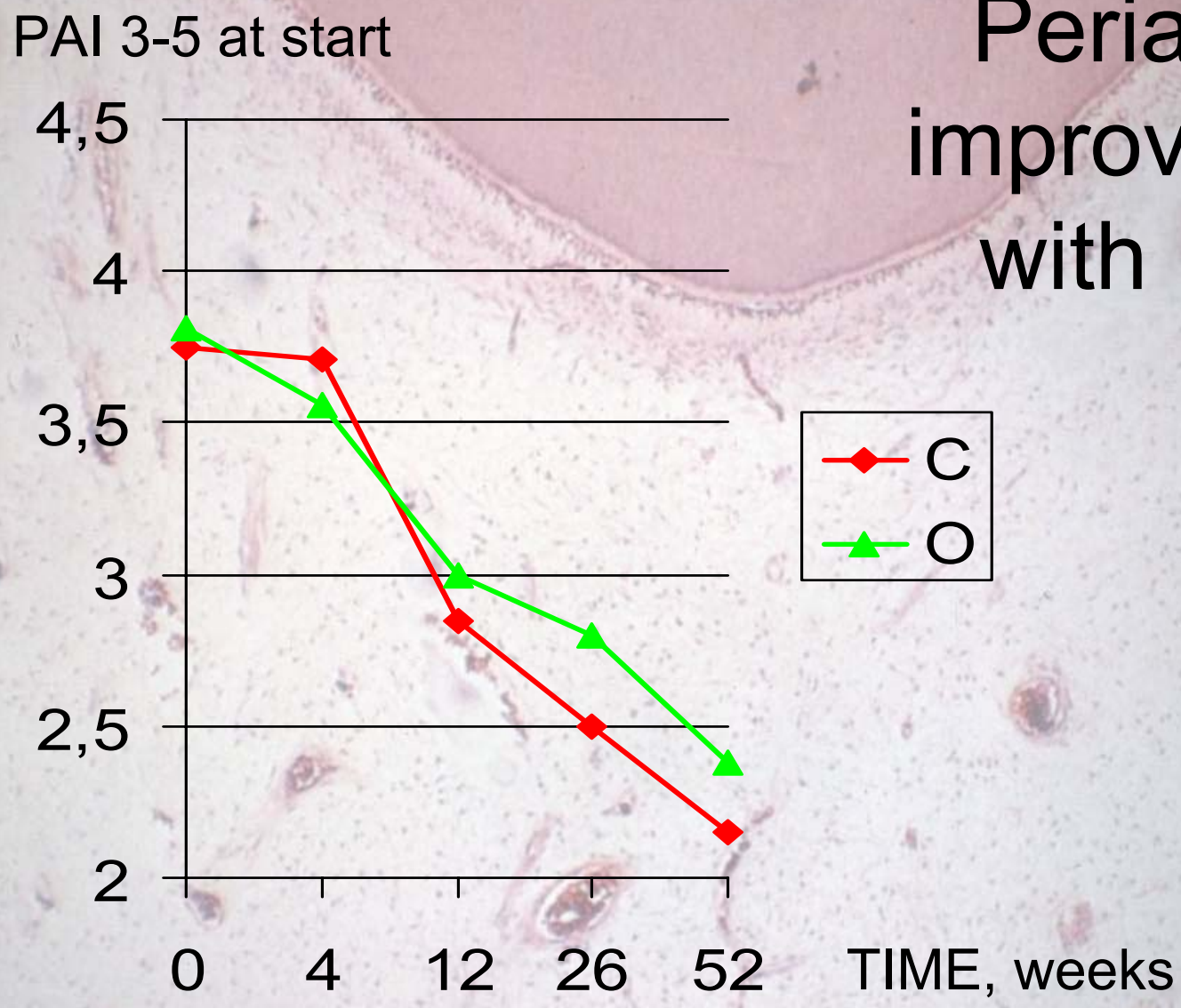
Comparative clinical testing

- ProcoSol, Grossman's sealer: reference
  - AH26: as good or better
  - Sealapex: as good or better
  - CRCS: no worse
  - RoekoSeal no worse
  - GuttaFlow no worse
  - Kloroperka poorer
  - Epiphany as good or better
- Lateral condensation reference:
  - Warm vertical as good or better

The one-step issue

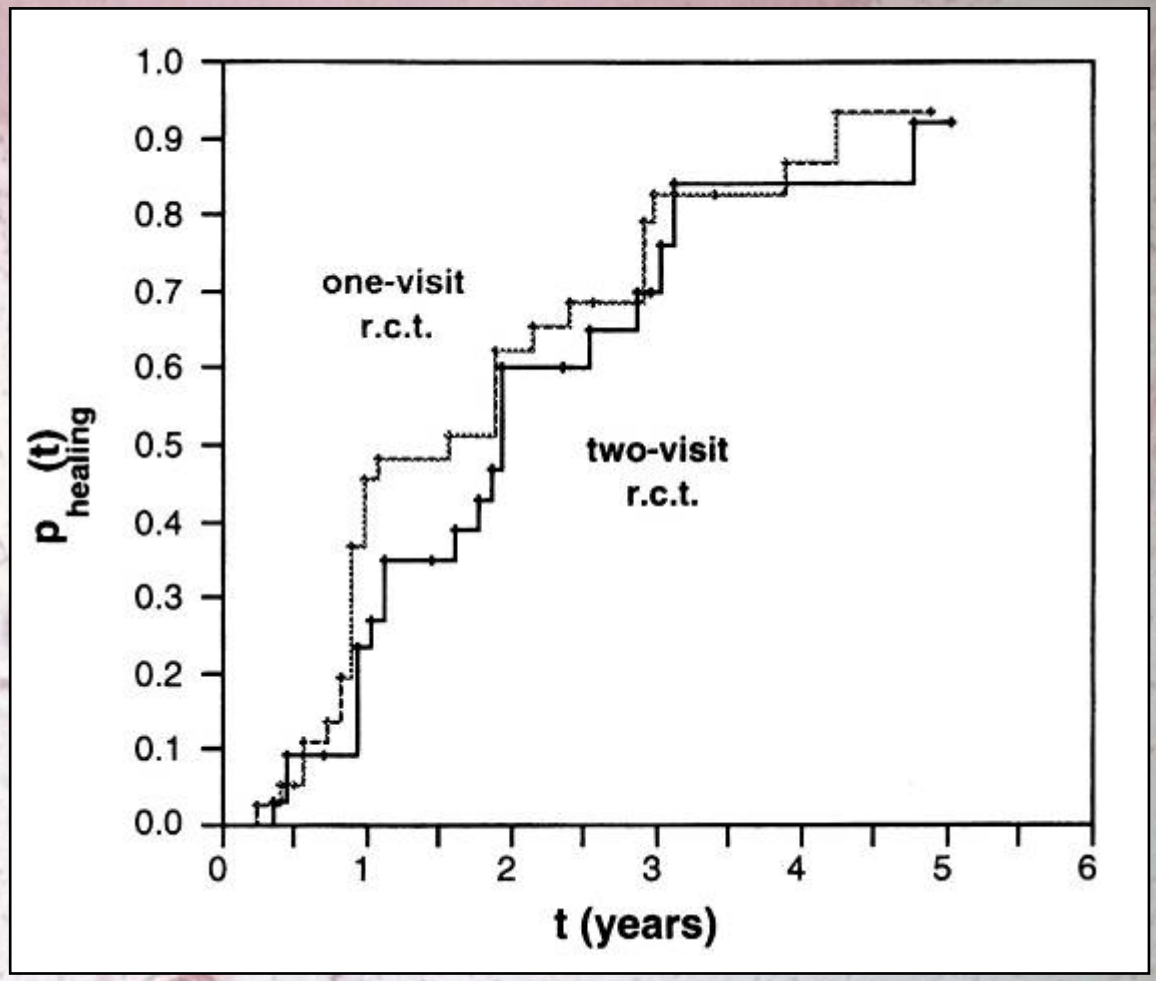
Courtesy E Elkjaer

Periapical improvement with time



Trope et al 1999

Calcium hydroxide was placed in the instrumented root canals of 31 teeth for at least one week and the treatment finished at the second visit. Thirty-six teeth were root canal treated at one visit. …. a follow-up time of 4 5 years

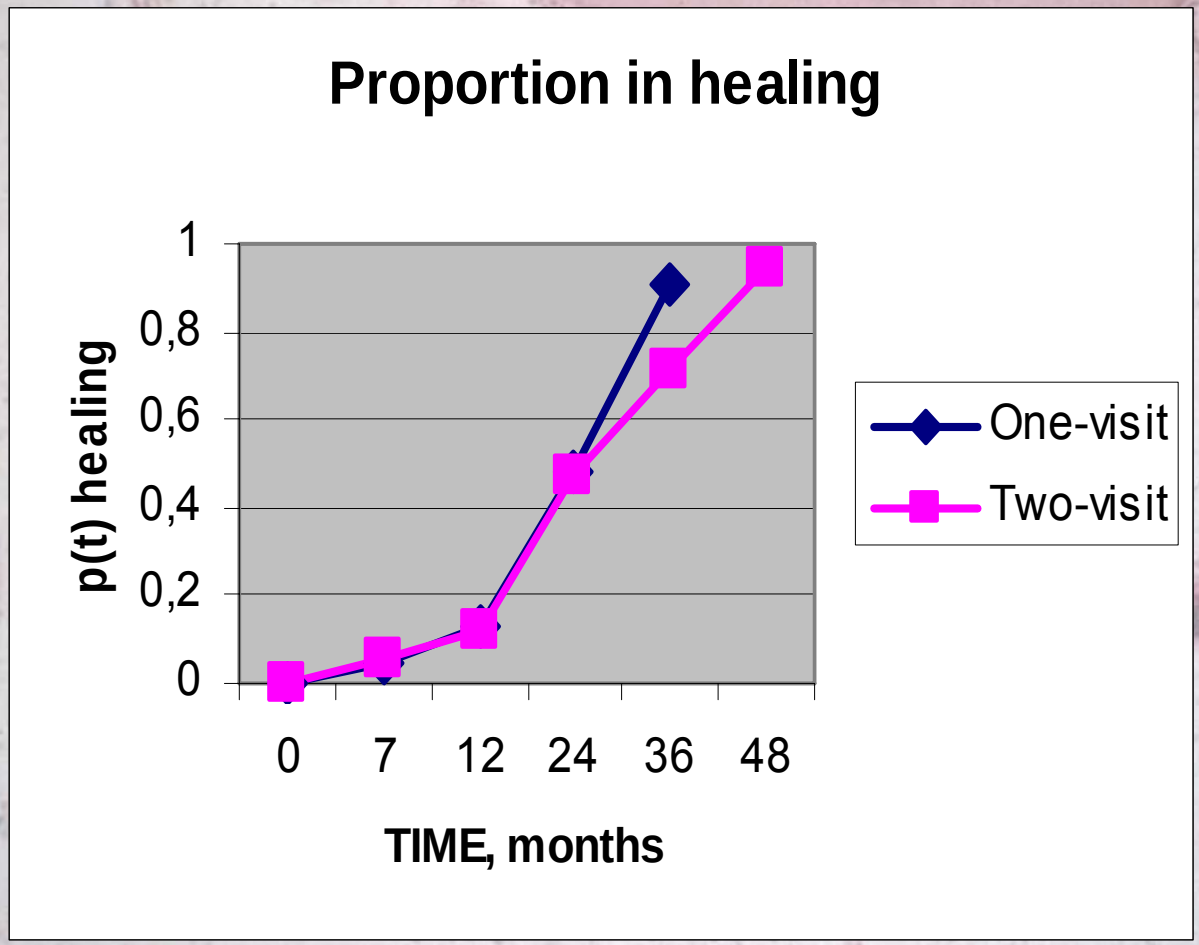


Weiger et al.,
Calcium hydroxide and prognosis of RCT.
IEJ 2000; 33:219-226

Peters & Wesselink 2002

- **Methodology** Thirty-nine patients received root-canal treatment. In the first visit, teeth were instrumented, and 18 of these teeth were filled (after microbiological sampling) with calcium hydroxide in sterile saline. The other 21 teeth were obturated with gutta-percha and AH-26 sealer after microbiological sampling. Four weeks later, the teeth with calcium hydroxide were accessed again and after microbiological sampling they were obturated with gutta-percha and AH-26 sealer. Healing of periapical radiolucency was recorded over a period up to 4.5 years.

Peters & Wesselink 2002



18 .. teeth were filled .. with calcium hydroxide ... The other 21 teeth were obturated with gutta-percha and AH-26 sealer. Four weeks later, the teeth with calcium hydroxide were … obturated with gutta-percha and AH-26 sealer.

Conclusions: Trope et al. 1999

- …. the calcium hydroxide group showed the most improvement in PAI score .. followed by the one-step group (74% vs. 64%). …… it was shown that large experimental groups on the order of hundreds of patients would be required to show significant differences.

Conclusions: Weiger et al. 2000

- …. one-visit root canal treatment created favourable environmental conditions for periapical repair similar to the two-visit therapy when calcium hydroxide was used as antimicrobial dressing. One-visit root canal treatment is an acceptable alternative to two-visit treatment for pulpless teeth associated with an endodontically induced lesion.

Conclusions: Peters & Wesselink 2002.

- … no significant differences in healing of periapical radiolucency was observed between teeth that were treated in one visit (without) and two visits with inclusion of calcium hydroxide for 4 weeks. The presence of a positive bacterial culture (CFU<10^2) at the time of filling did not influence the outcome of treatment.

Sathorn, C., Parashos, P. & Messer, H. H.
Effectiveness of single- versus multiple-visit endodontic treatment of teeth with apical periodontitis: a systematic review and meta-analysis.
International Endodontic Journal **38** (6), 347-355.

Table 5 Meta-analysis data summary

Citation	Risk difference (%)	95% CI		Weight (%)	*P*-value
		Lower	Upper		
Trope *et al.* (1999)	10	−18.2	38.3	48.25 (24.8)	0.491
Weiger *et al.* (2000)	−12.4	−32.5	7.7	95.20 (49)	0.226
Peters & Wesselink (2002)	−10.4	−37.8	17	51.14 (26.2)	0.455
Combined three studies	−6.3	−20.3	7.8	NA	0.381

Negative value indicates the difference is in favour of single-visit endodontics. NA, not applicable.

Arguments

- Disease diagnosis is the critical entity in outcome/follow-up studies
- We need improved registrations of disease, primarily in conventional, clinical-radiographic follow-up studies
- We need extended cooperation in clinical research in endodontology: to acquire the numbers needed, multicenter studies with uniform recordings are needed

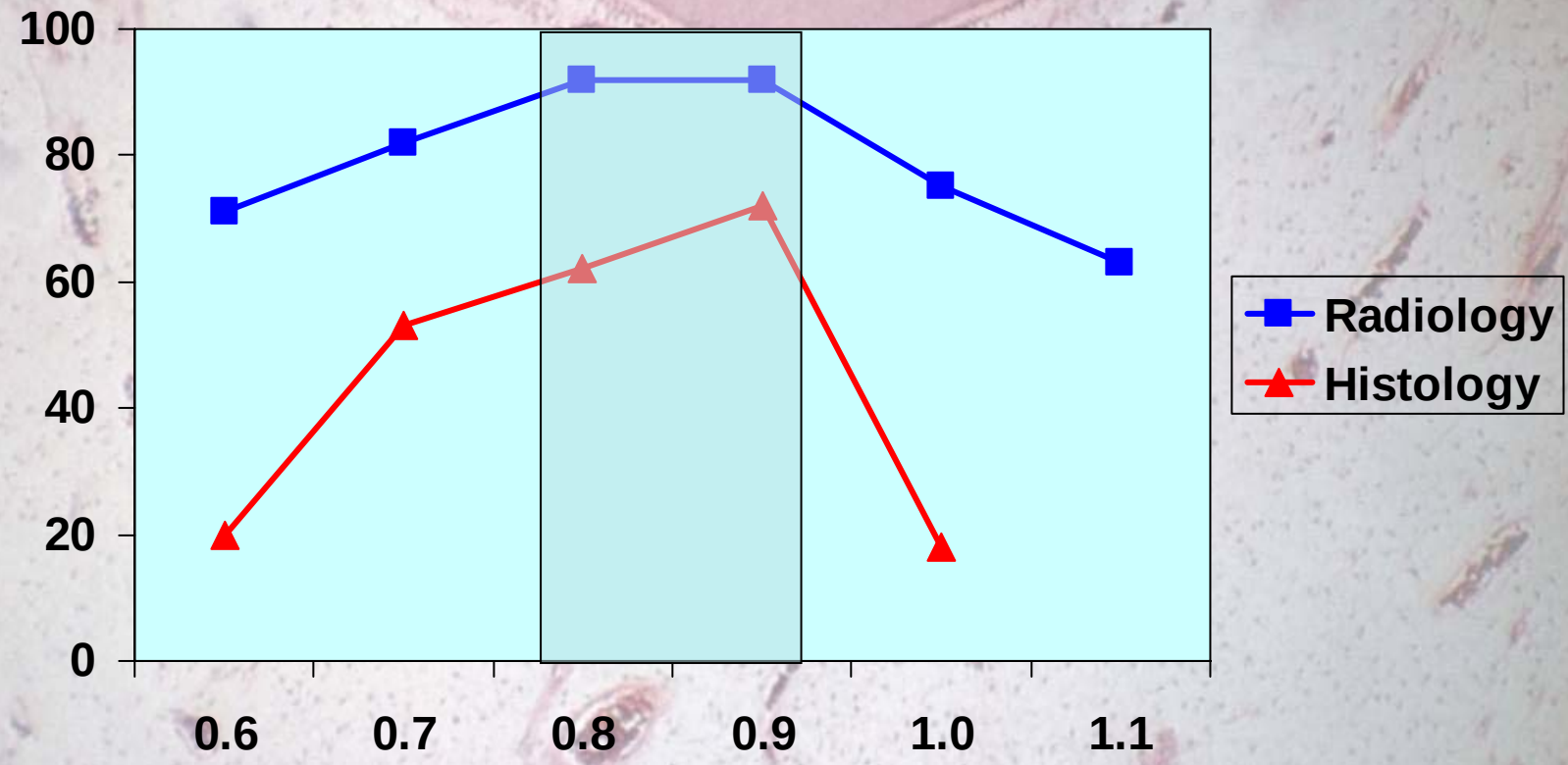
Future Improvements and Shortcuts

- Quantitative, digitital analysis – qualified success
- Computerized tomography – still limited by the dose involved
- Relationship of long-term to short-term outcome results
- Relationship to other clinical parameters
  - Serum markers
  - Microbial markers

Instrumentation

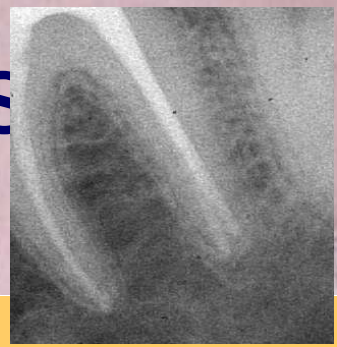
- Length: epidemiology: root filling length a measure of instrumentation length
- Shape: taper; retention of canal shape
- Width: bacteriology

End point of root filling and success



Ketterl 1965

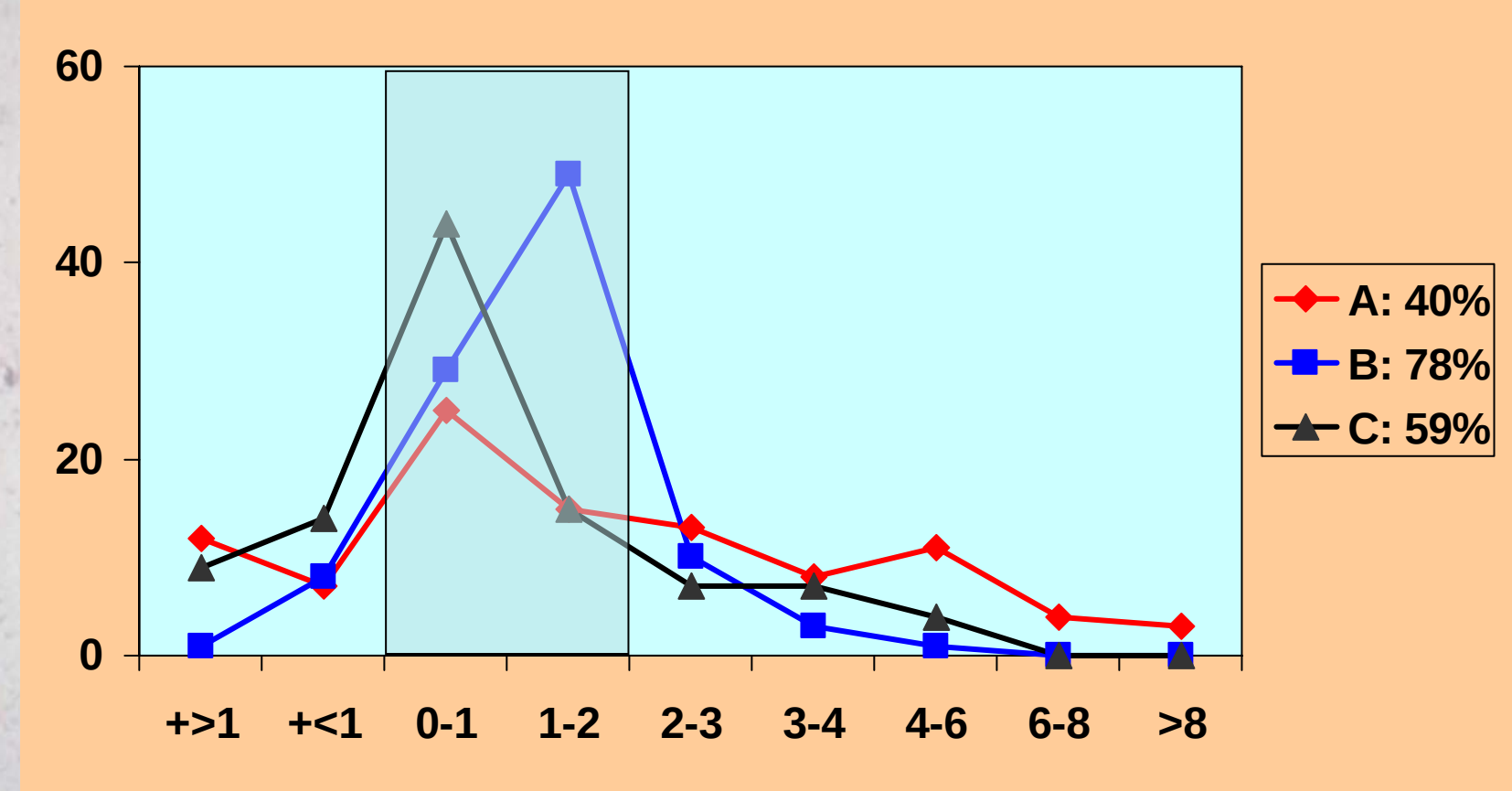
Aspects of ins ntation



No preoperative apical perio:
Instrumentation length/overfilling of little importance

Sjögren et al. 1991

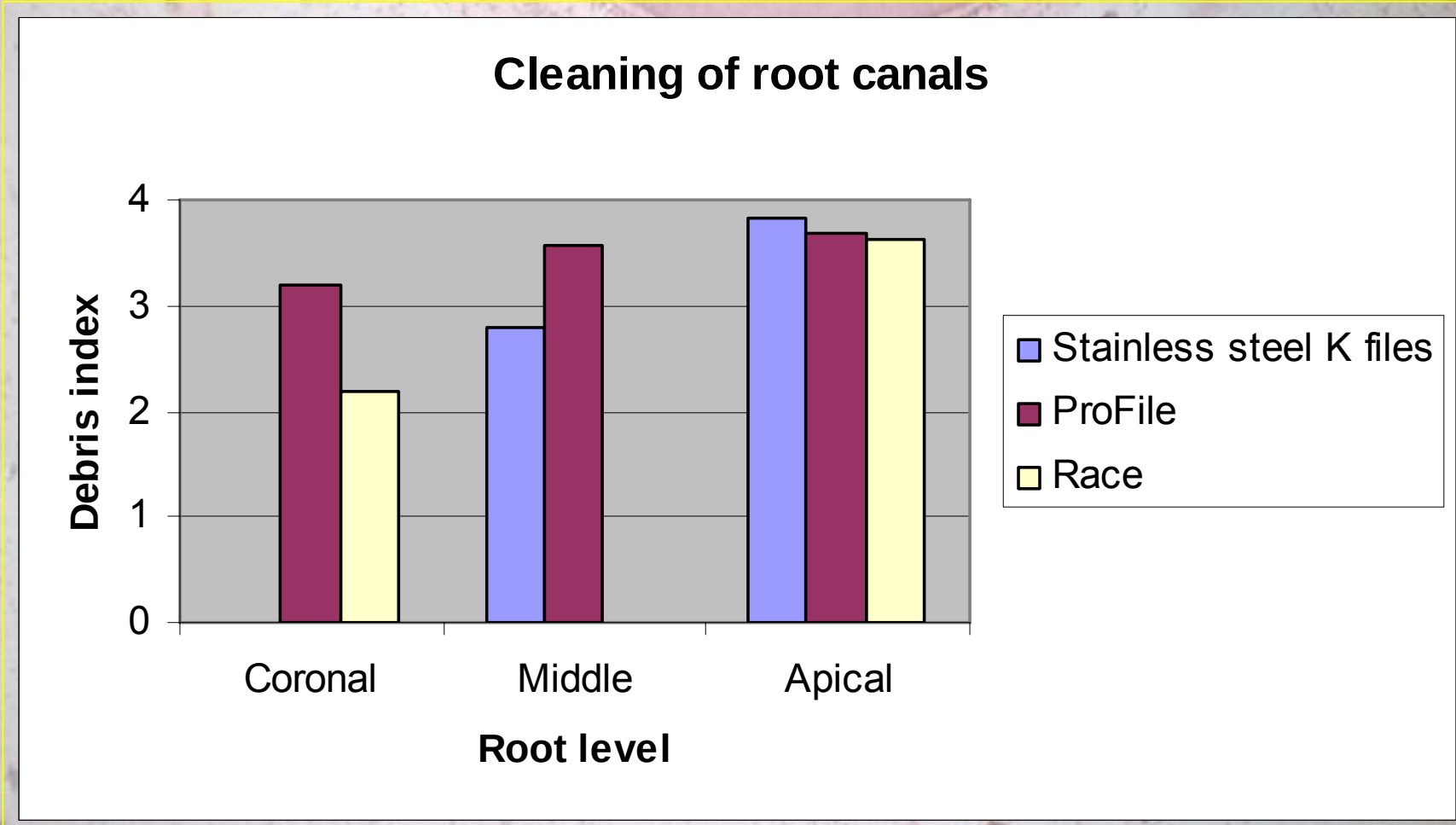
Distribution of end points of root fillings



A: Dental School I; B: Dental School II; C: Endodontist Private Practice. N > 100

Suppose we get there – how well do we clean? Effectiveness of three instrumentation systems in the cleaning of root canals

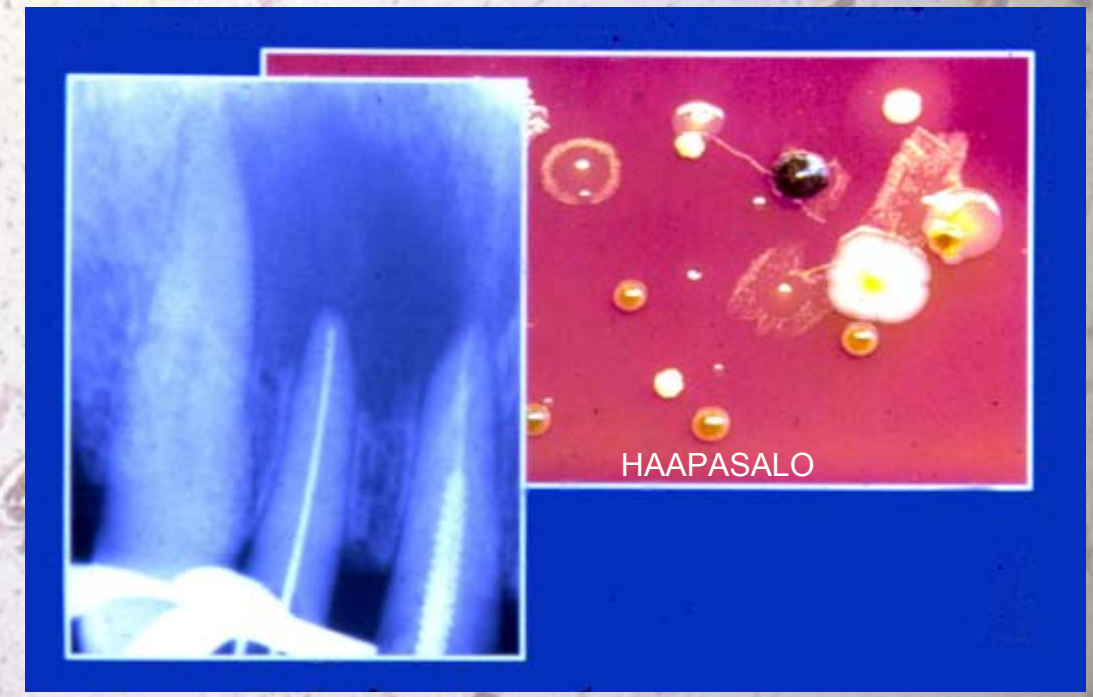
Appelstein et al. JOE April 2003, OR 17



Bacteriological effects

The qualitative aspect of bacteriological sampling is becoming increasingly sophisticated, with gene technology and analyses also being used for identification of bacteria in the root canal.

The problem of representativity of sampling remains, however.

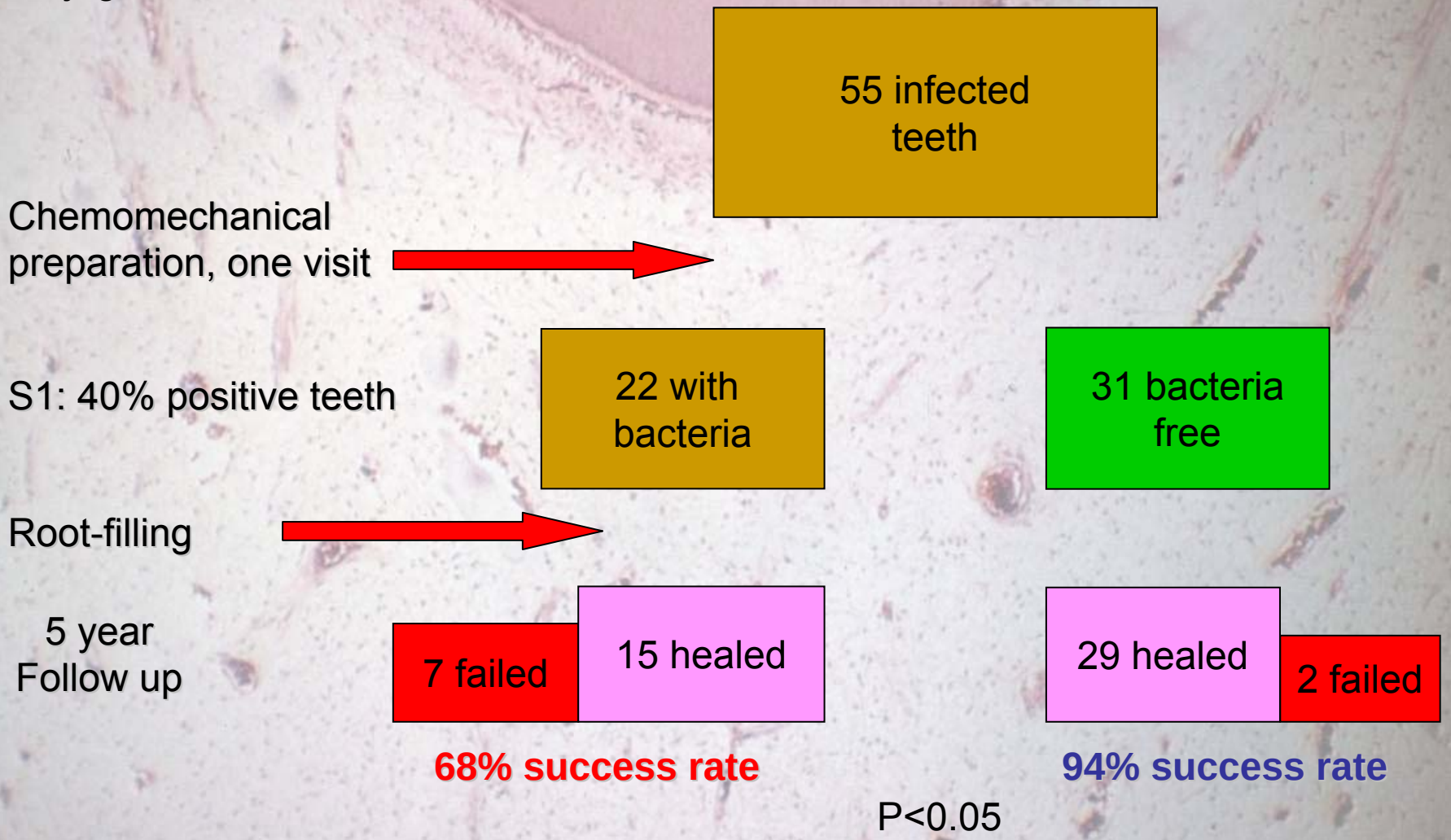


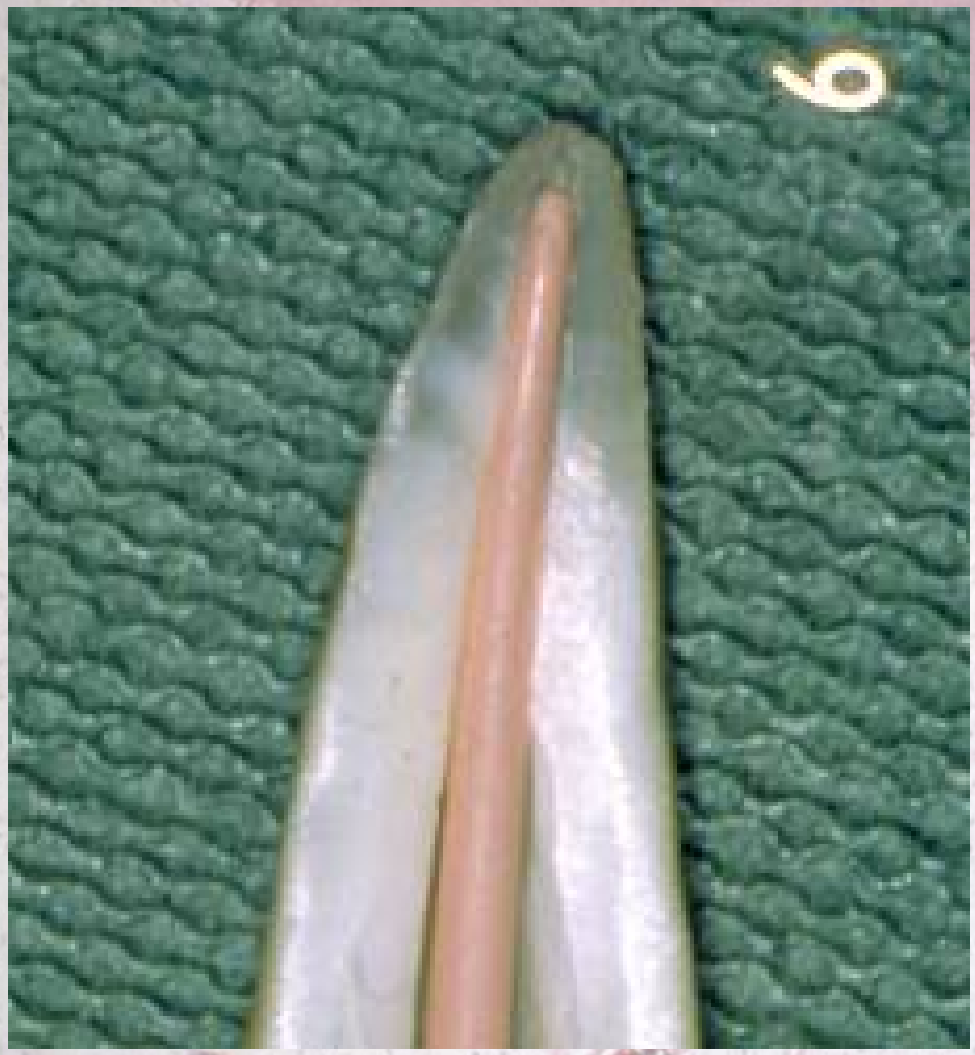
Use of microbial markers

- Endodontics is the prevention or treatment of apical periodontitis
- Apical perio is caused by microbial infection of the root canal system
- Presence of cultivable bacteria at the time of filling is directly associated with the probability of healing
- Can we use microbial sampling as a tool predicting long-term outcome?

Influence of infection at the time of root filling on the outcome of endodontic treatment of teeth with apical periodontitis.

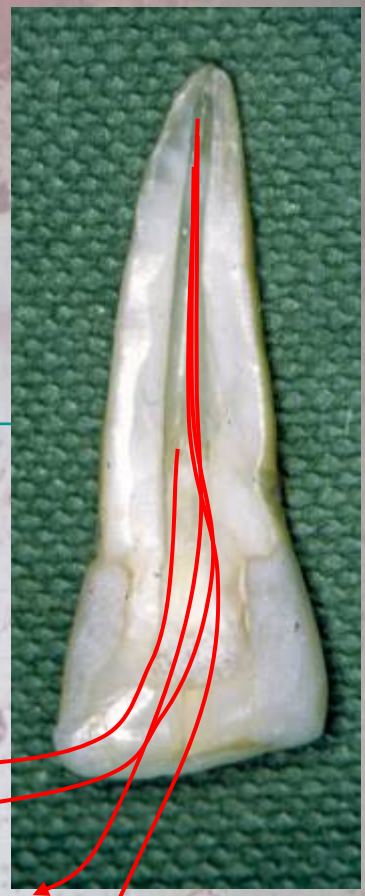
Sjögren et al. 1997



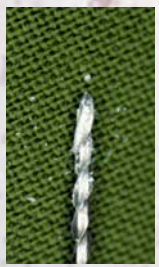


Bacteriological sampling procedures:
Complete vs. discrete

Growth after extensive reaming: a clinical pilot

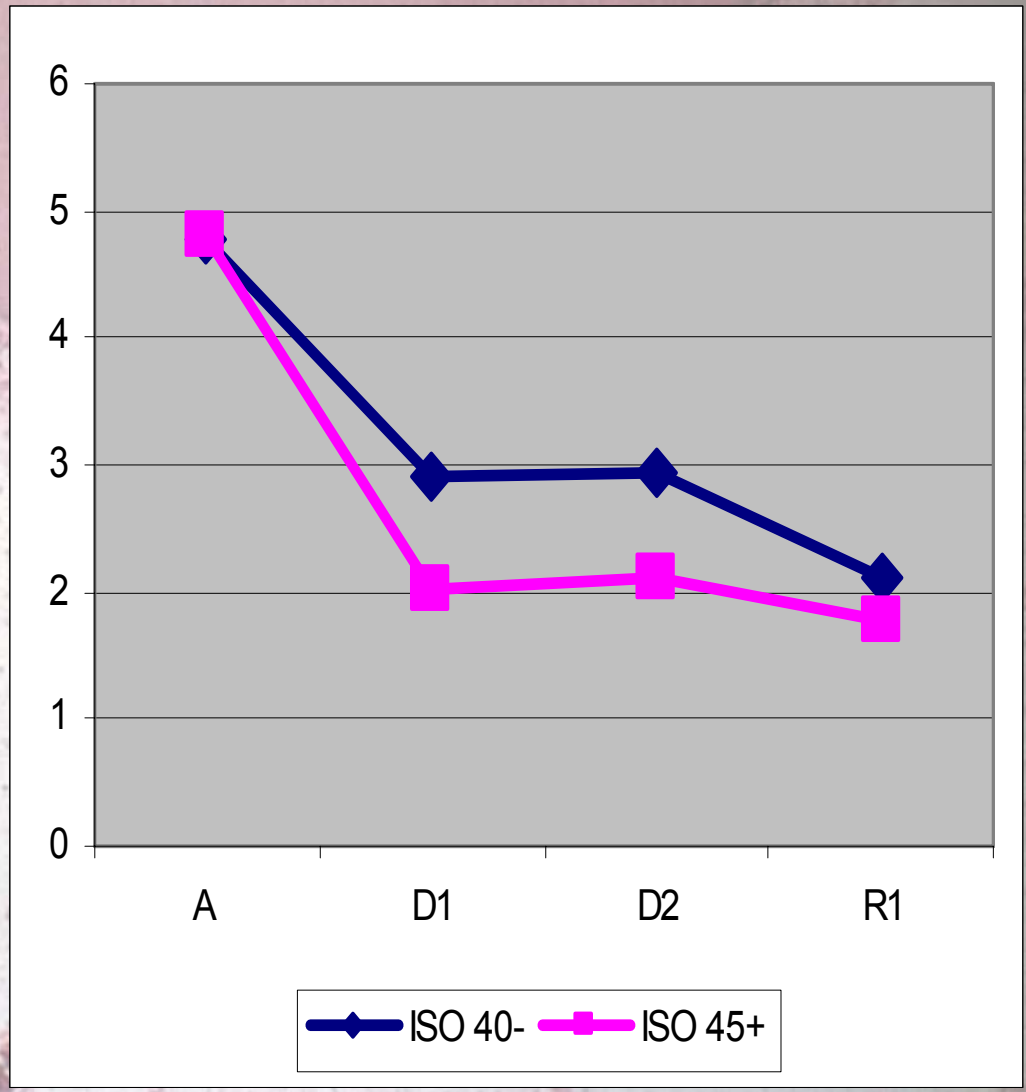


Sample

A		On admission
D1		First reamer to bite
D2		Final reamer, complete apical circle
R1		Second appointment, next reamer up

Ørstavik et al. 1991

Growth after extensive reaming: log10 values



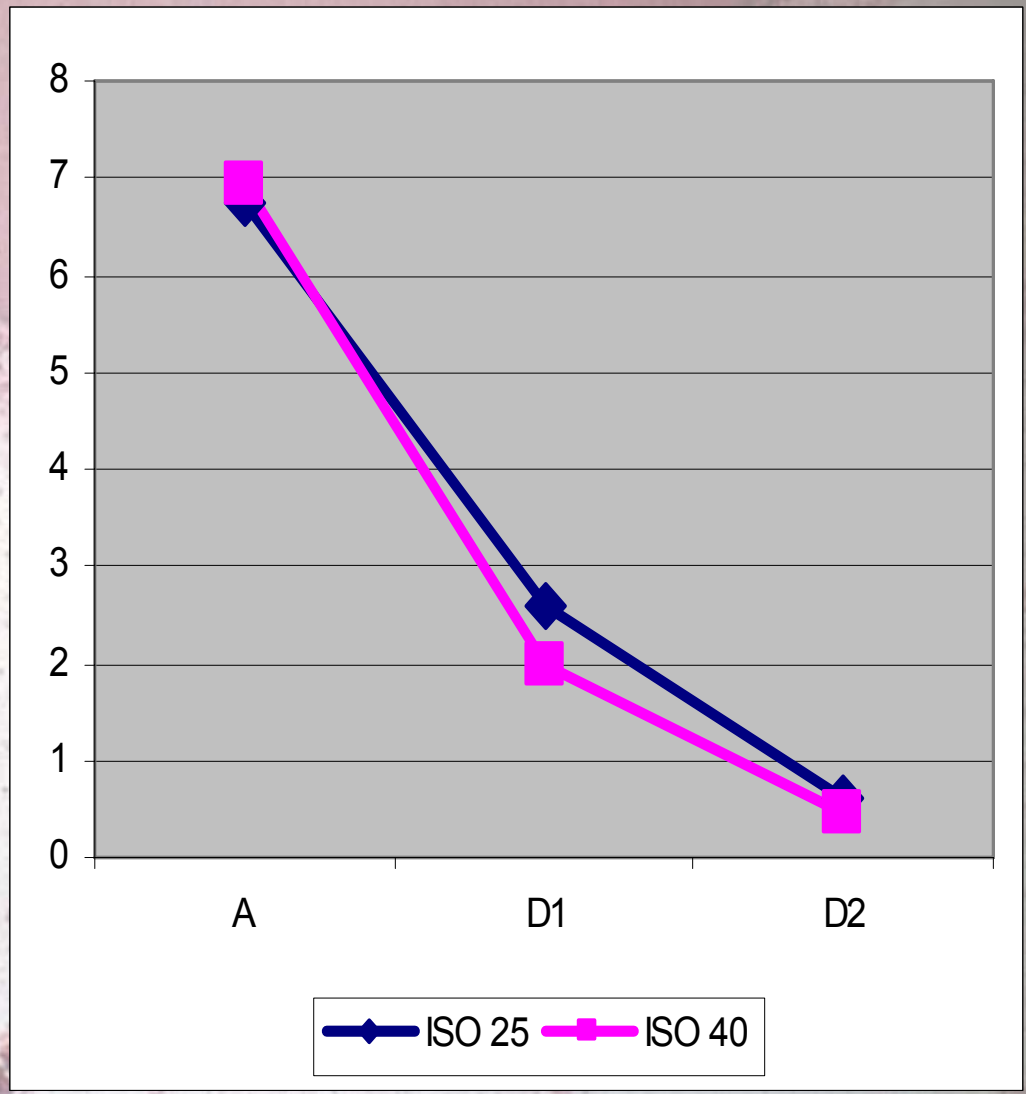
Ørstavik et al. 1991

Growth after extensive reaming: log10 values

Sample	ISO 25	ISO 40
1	6.76	6.95
2	2.59	2.00
3	0.60	0.44

Yared & Bou Dagher 1994

Growth after extensive reaming: log10 values



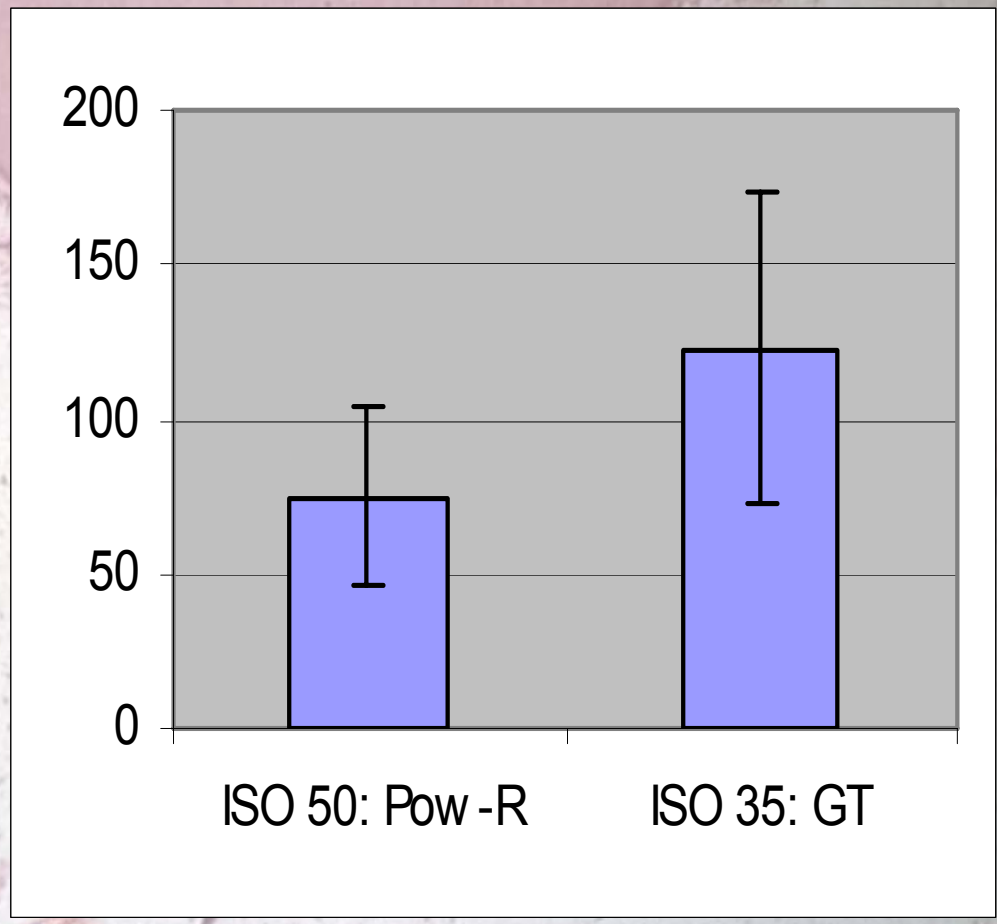
Yared & Bou Dagher 1994

Growth after extensive reaming: Radio-assay

22 .. were instrumented with GT and Profile instruments to apical size #35 ..and 22 teeth with Pow-R instruments to apical size #50

Rollison S, Barnett F, Stevens RH. JOE 2002

Growth after extensive reaming: Radio-assay



Rollison S, Barnett F, Stevens RH. JOE 2002

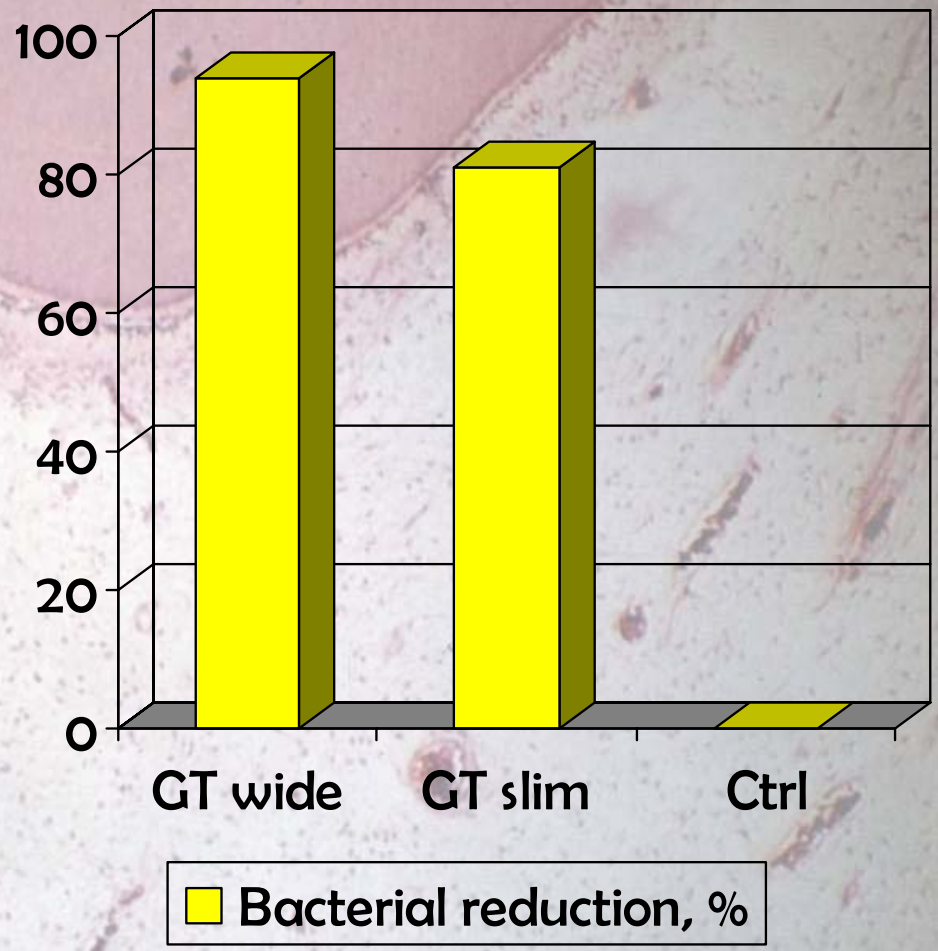
Reduction in intracanal bacteria during root canal preparation with and without apical enlargement

Thirty-eight palatal roots of maxillary molar teeth.. were .. randomly assigned to two experimental and one control groups. The roots were .. reinfected with Enterococcus faecalis.. All roots in the experimental groups were prepared in a step-down sequence with engine-driven GT rotary files at 350 rpm. In experimental group A (n = 16) additional apical enlargement to ISO size 35 was performed. In group B (n = 16) a serial step-back technique was followed with no apical enlargement. This was combined in groups A and B with irrigation with NaOCl and EDTA. In the control group (group C, n = 6) irrigation only was carried out, with no mechanical preparation. Samples were then taken from the root canals to determine the numbers of remaining bacteria.

Coldero LG, McHugh S, MacKenzie D, Saunders WP.

Int Endod J. 2002 May;35(5):437-46

Reduction in intracanal bacteria during root canal preparation with and without apical enlargement



Coldero LG, McHugh S, MacKenzie D, Saunders WP.

Int Endod J. 2002 May;35(5):437-46

J Endod 1998 Nov;24(11):763-7

Bacterial reduction with nickel-titanium rotary instrumentation.

Dalton BC, Orstavik D, Phillips C, Pettiette M, Trope M.

Department of Orthodontics, University of North Carolina School of Dentistry, Chapel Hill 27599, USA.

Study Design

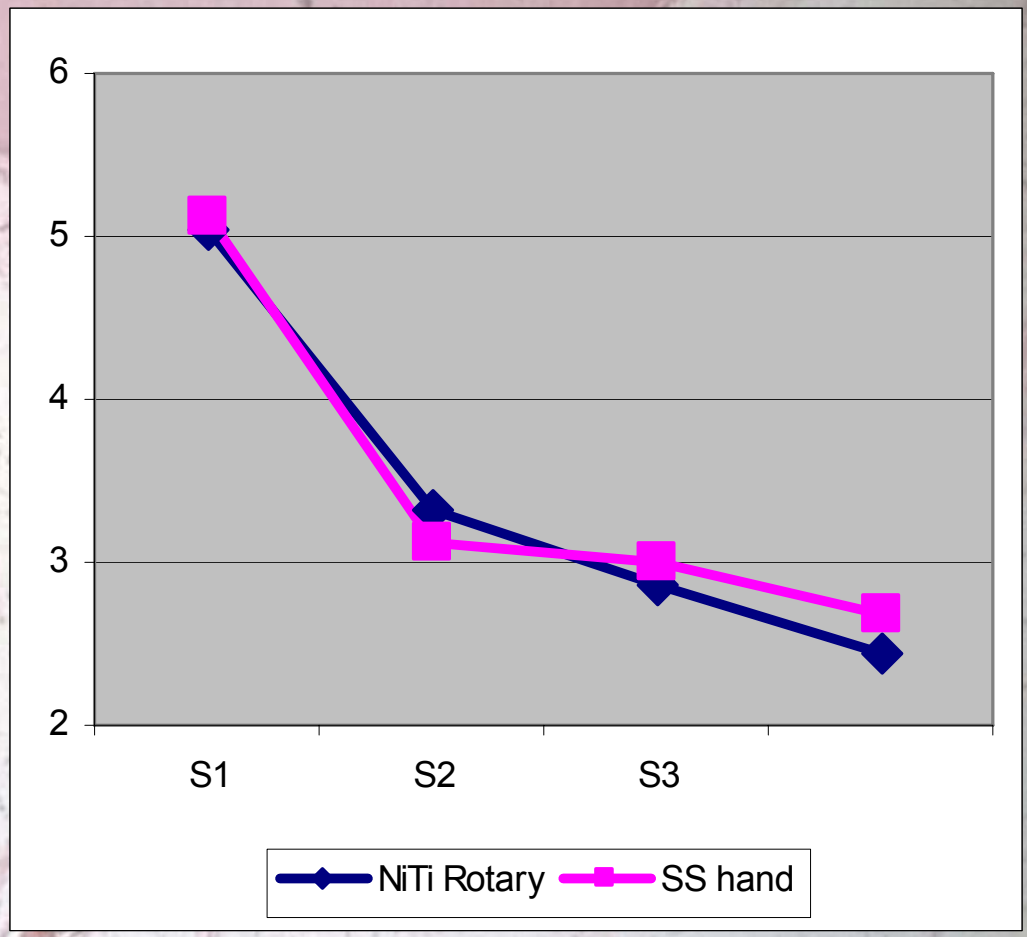
- Human teeth, infected canals, *in vivo*
- Instrumentation with either Ni-Ti .04 taper rotary or stainless steel by hand
- Bacterial samples collected at increasing widths of instrumentation

Dalton et al. 1998

Growth after instrumentation: log10 values

Sample	NiTi rotary	SS K-file
S1	5.06	5.12
S2	3.32	3.13
S3	2.85	3.01
S4	2.44	2.68

Growth after extensive reaming: log10 values



Dalton et al., 1998

Radiographic Evaluation and Follow-Up

- Different methods of radiographic follow-up methods
- Assessment of one's own cases
- Testing of medicaments, materials and techniques

Overview

- What is clinical research?
- Relevance: Legal aspects, manufacturers' claims
- Importance: Necessary for improvement
- The relative irrelevance of experience
- Use of microbial markers
- The need for scepticism along side with enthusiasm


In the distant memory of the vital, uninflamed pulp: thank you for your attention!

Overview

- What is clinical research?
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- The relative irrelevance of experience
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Overview

- What is clinical research?
- Relevance: Legal aspects, manufacturers' claims
- Importance: Necessary for improvement
- The relative irrelevance of experience

The ’boldness’ of the radiographic contrast may lead us to assume better results than is actually the case

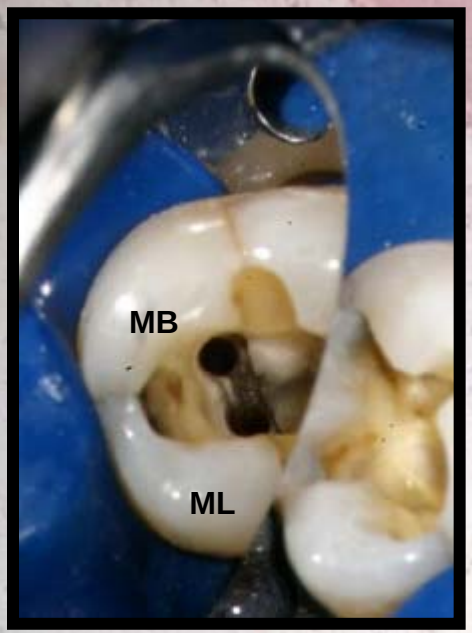
35 asymtomatisk pulpitt

One visit endodontisk behandling med Epiphany/Resilon

46 Necrotic pulp

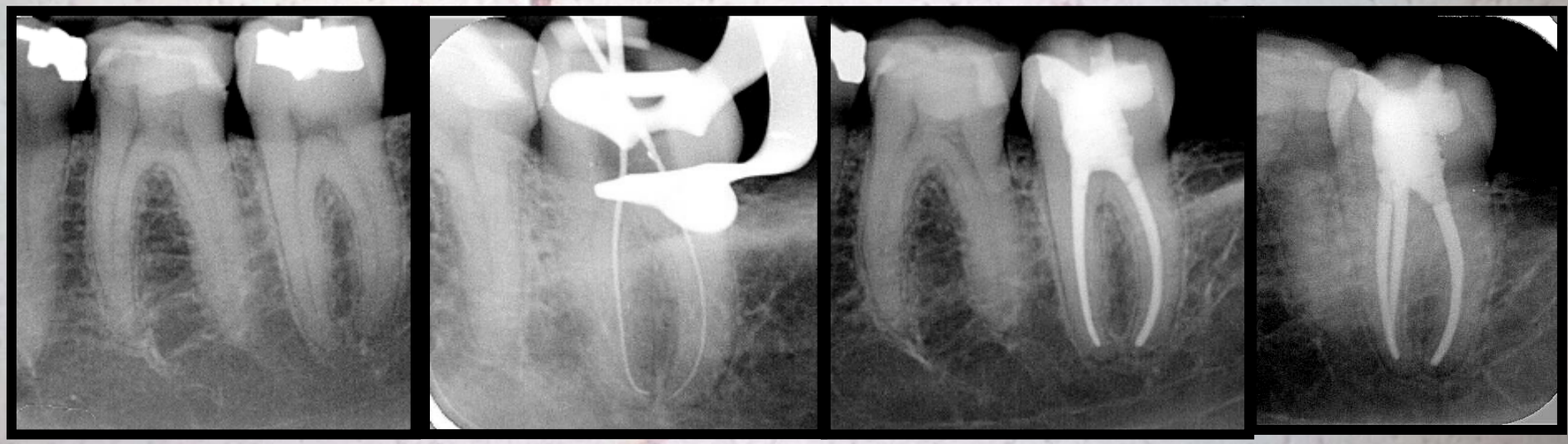
One visit endodontisk behandling med Epiphany/Resilon

Courtesy Dr Harald Prestegaard




47 partially necrotic pulp *Courtesy Dr Harald Prestegaard*

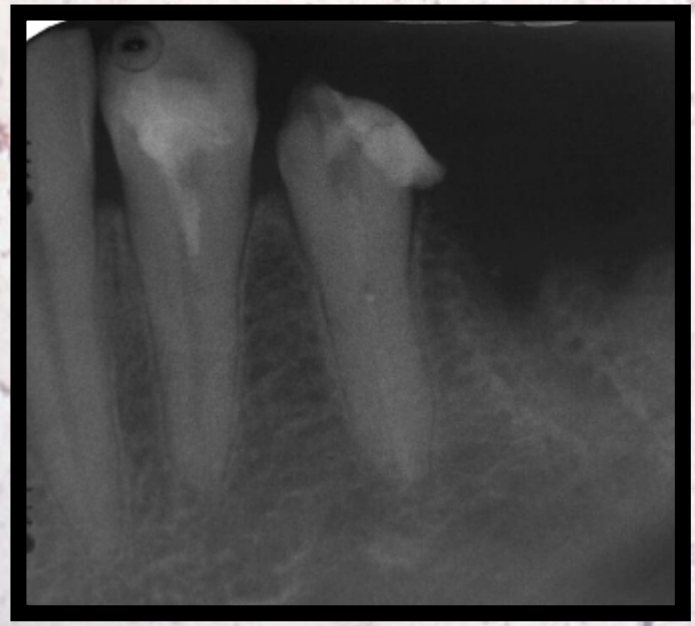
One visit endodontisk behandling med Epiphany/Resilon

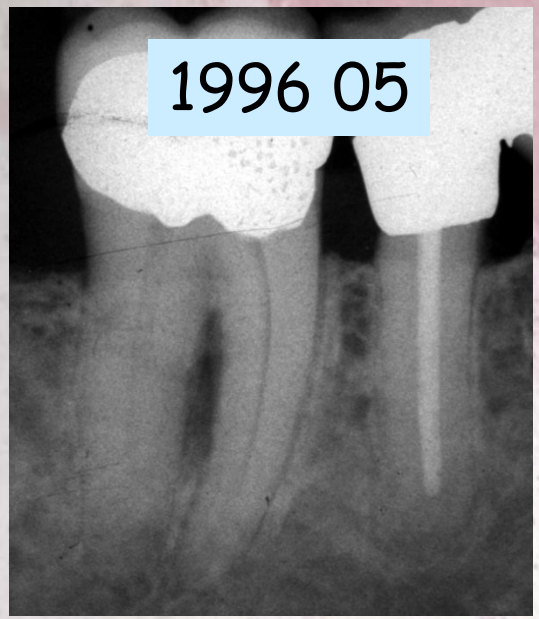


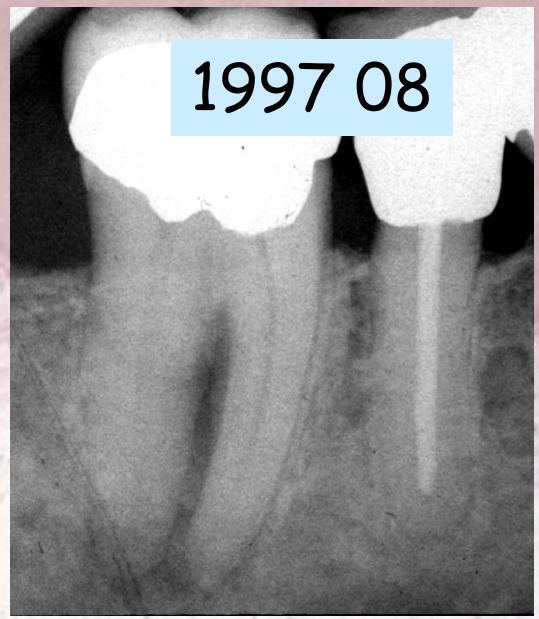
34 nekrotisk tann 2 kanaler

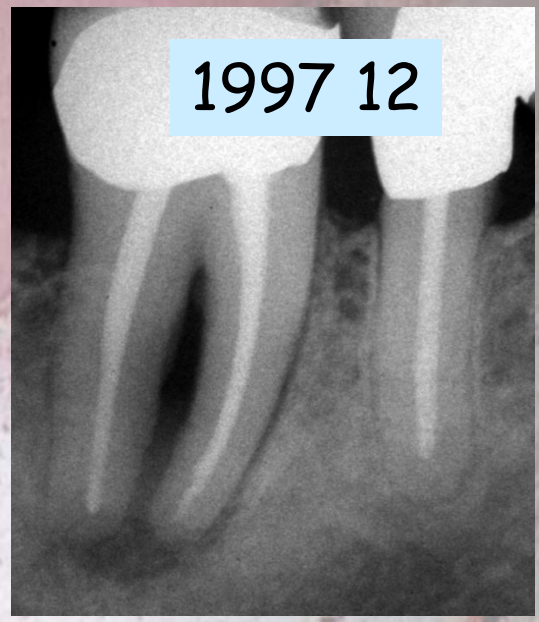
35 nekrotisk tann

Two visit endodontisk behandling med $CaOH_2$ og Epiphany/Resilon




1996 05


1997 08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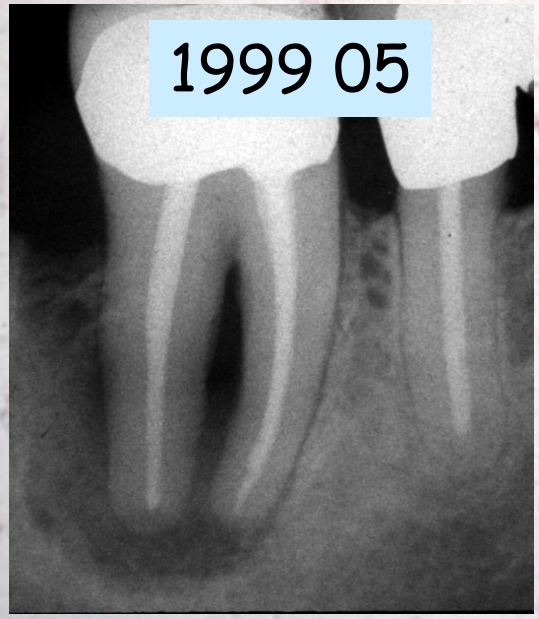
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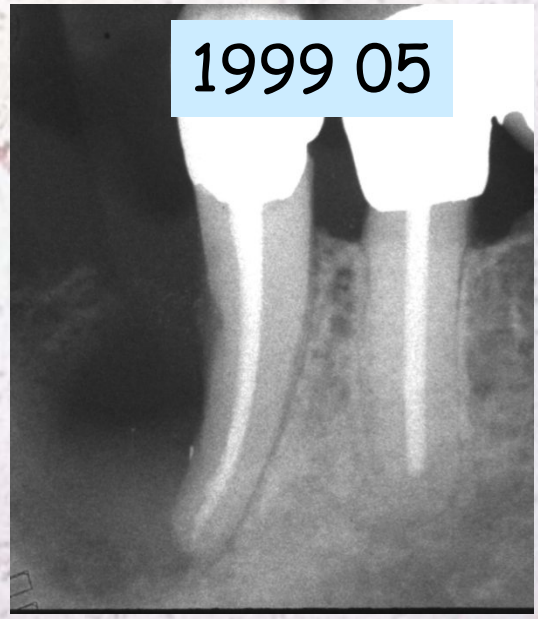
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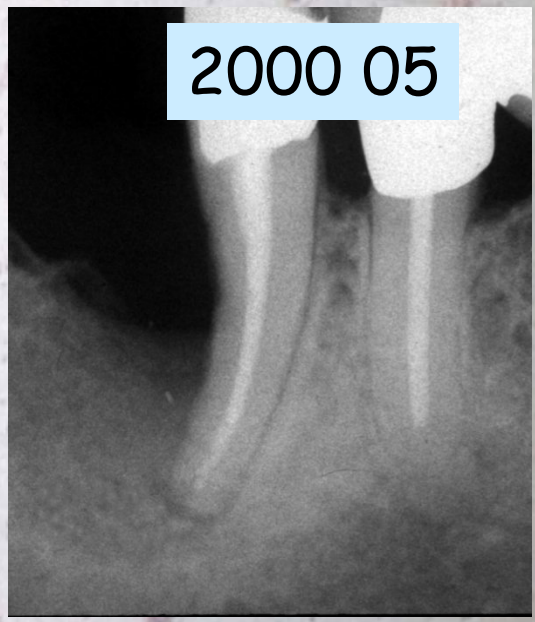
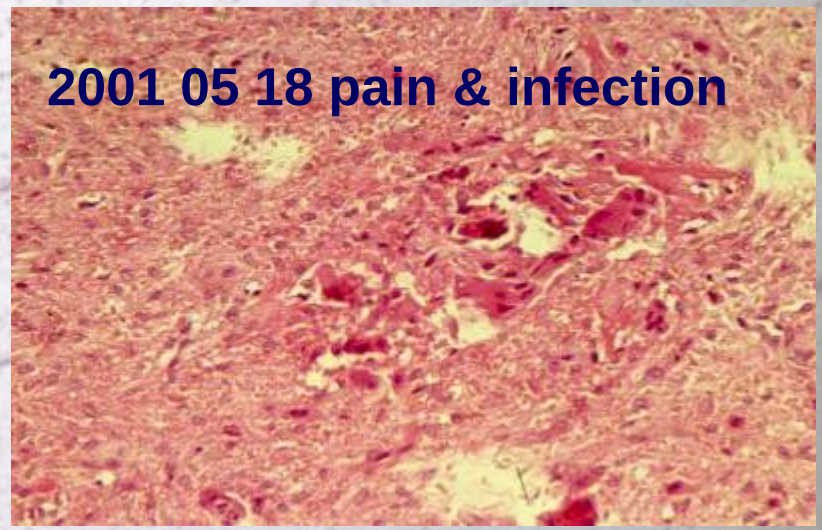
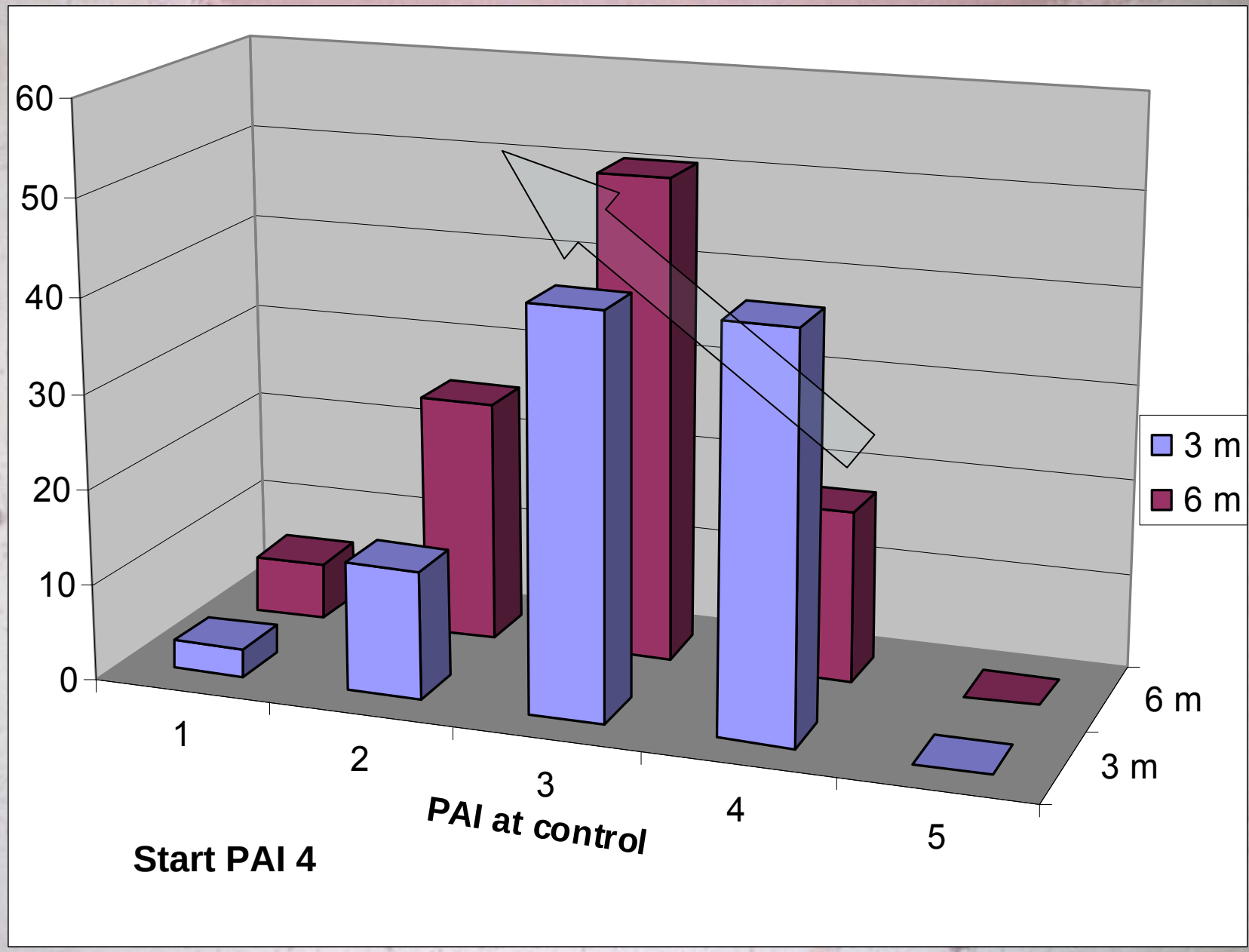

2000 05

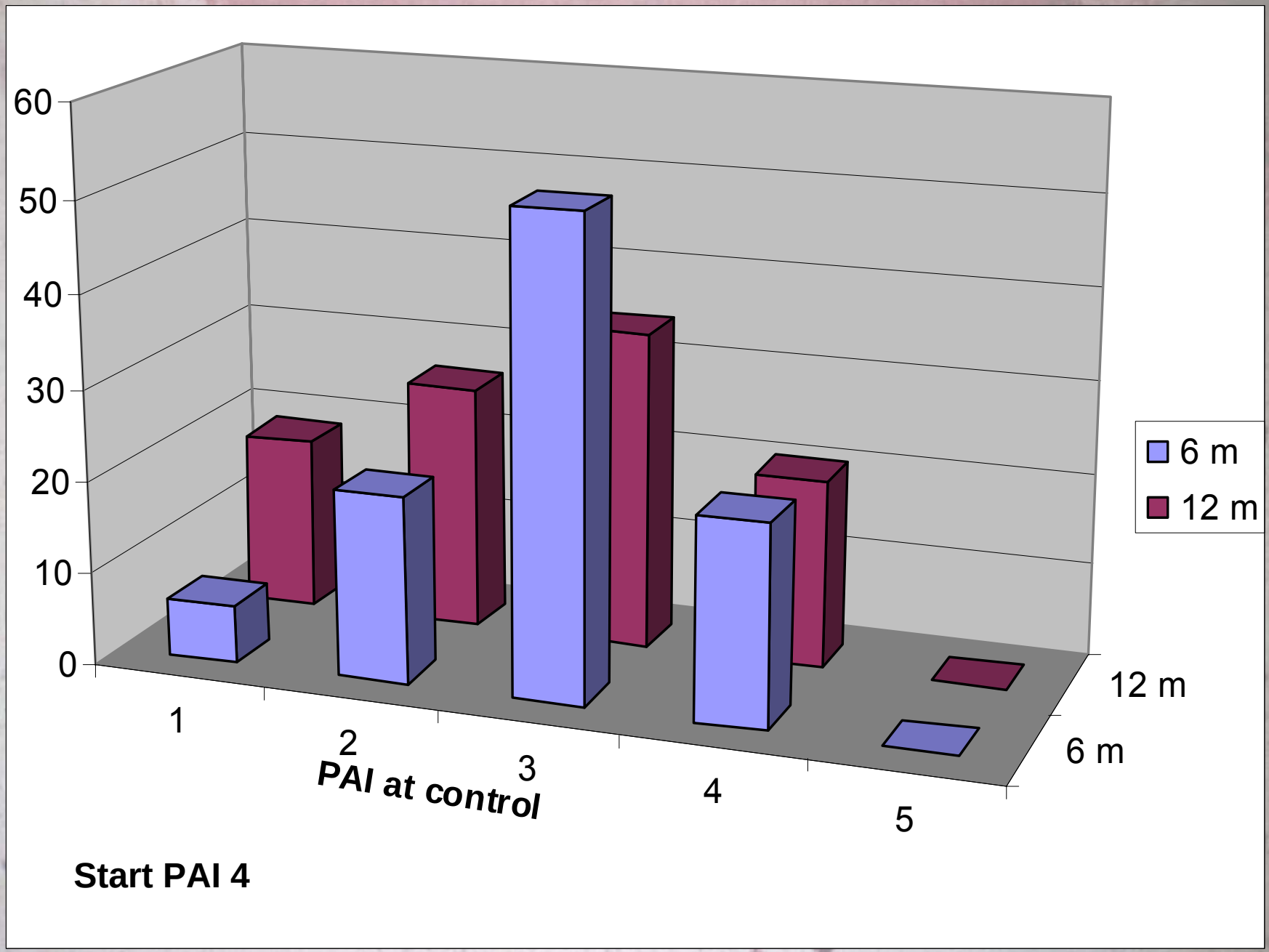
Giant cell granuloma



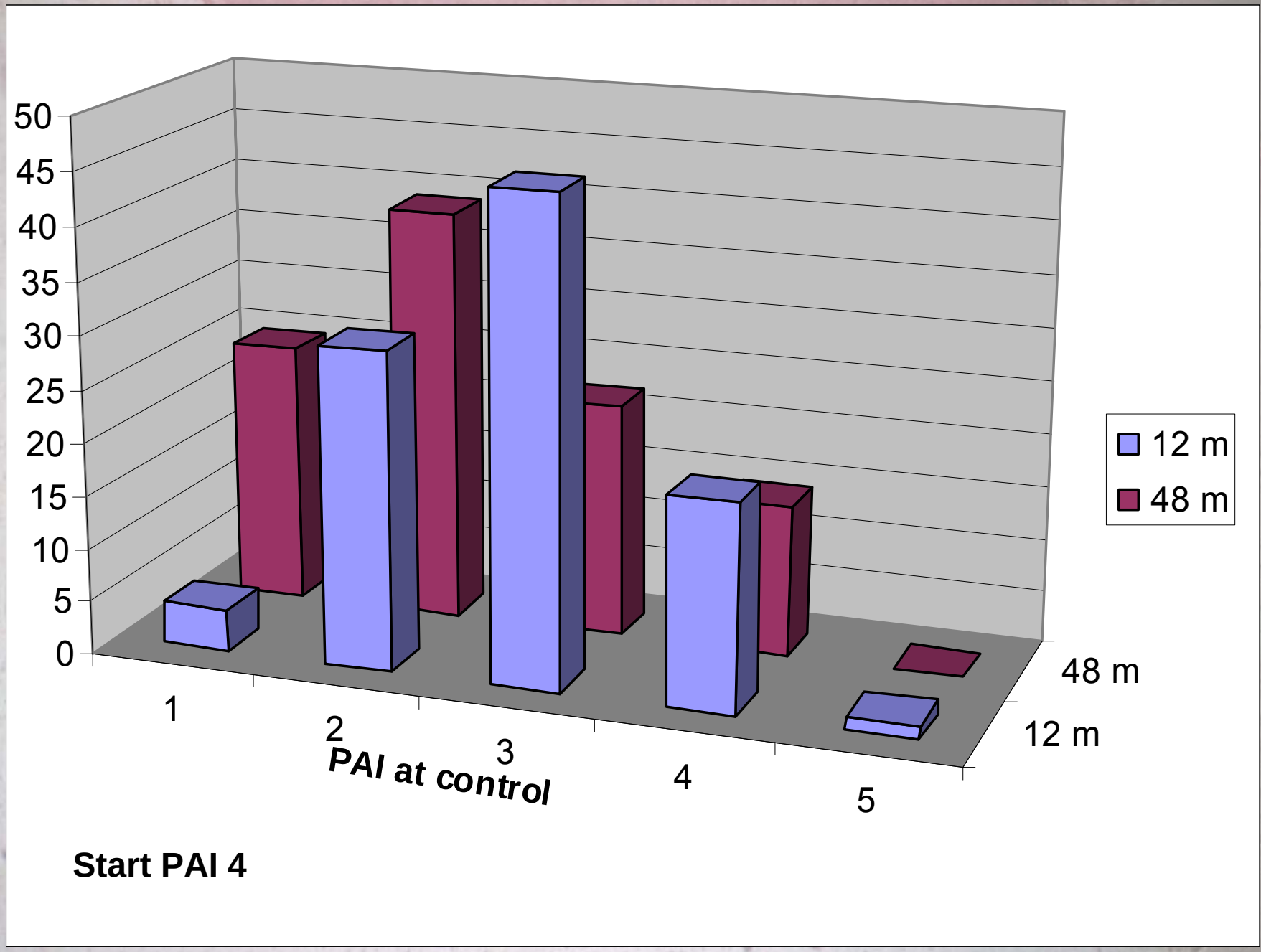
Clinical research: a definition with hows and whys

- Clinical studies: done at chairside
- Ex vivo
- In vivo
- In vitro
- Technological


60
50
40
30
20
10
0
1
2
3
4
5
PAI at control
3 m
6 m
6 m
3 m
Start PAI 4

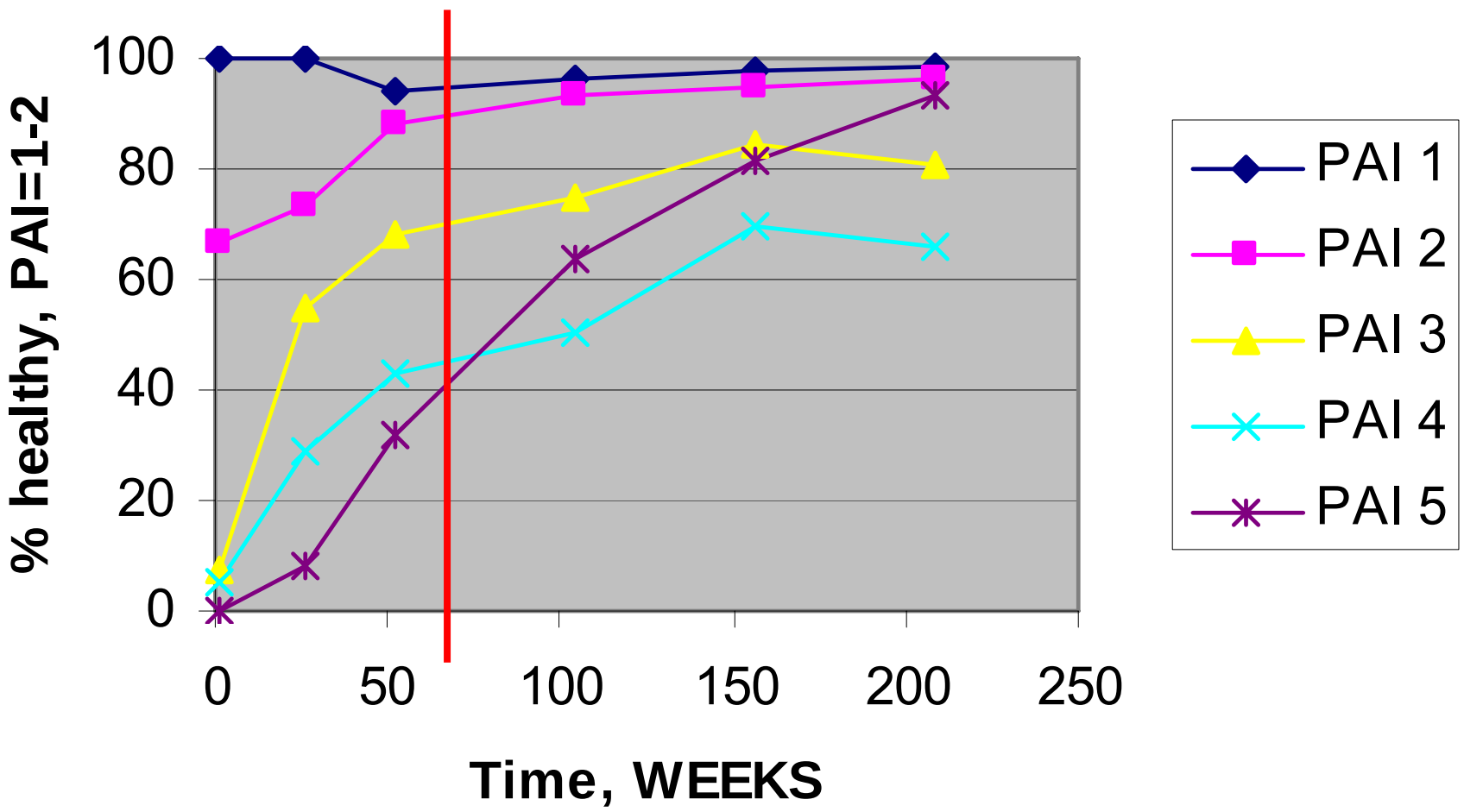


Start PAI 4



Start PAI 4

Periapical changes after treatment



Art

The case report: See what I can do, by listening, you share the glory

From Visual Endodontics

Best average

Typically institutional or specialist practice follow-up studies; the self-assured clinician comfortably states, ”I have more than a 90 per cent success rate!”

Real average?

Cross-sectional, epidemiological approaches: the whole range; nobody wants to be associated with this.