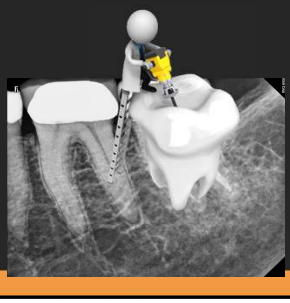
Retreat or not retreat ?



Hagay Shemesh, DMD, PhD

Department of Endodontology
Gustav Mahlerlaan 3004
1081 LA Amsterdam
The Netherlands
Tel.: + 31(0)20 59 80139
E-mail: hshemesh@acta.nl
www.acta.nl
www.shemesh.nl

ACTA
ACADEMIC CENTRE FOR DENTISTRY AMSTERDAM

1

Outcome studies in Endodontology

- Importance and general concepts
- Definitions
- The Toronto studies
- The Ng Studies
- CBCT studies
- How to assess an outcome study myself?

2

Why are OUTCOME studies so important ?

- Which irrigation protocol?
- Ultrasonic irrigation necessary?
- Pulpotomy or direct pulp capping ?
- Which file should I use?
- Screening before bone marrow transplantation
- Which obturation ?
- Use calcium hydroxide?
- MTA or Biodentine?
- Which sealer?
- Which concentration of hypochloride?
- Bleaching with which material ?
- Microscope necessary?
- Follow up period ?
- Perforations- what to do?
- Pulpotomy or pulpectomy?
- CBCT before every treatment?
- Full crown of composite ?
- To re-treat or not to re-treat?
- Broken instruments- what to do ?

3

- The Association between Choice of Diagnostic Imaging Modality and Long-term Treatment Outcomes for Patients Undergoing Nonsurgical Root Canal Treatment on Maxillary First Molars

Ptak et al. J Endod 2021

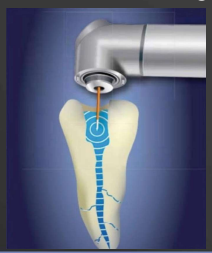
The decision to use CBCT imaging appears to serve as a proxy for case complexity and the associated increase in risk of posttreatment disease. This is important to keep in mind when assessing treatment prognosis.

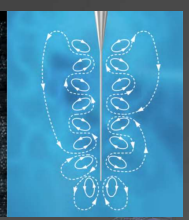
4

- Outcome studies show us sometimes how careful we must be when making clinical recommendations based on in-vitro studies

5

- The most extensively studied
- Surge of enthusiasm in the early '2000s





6

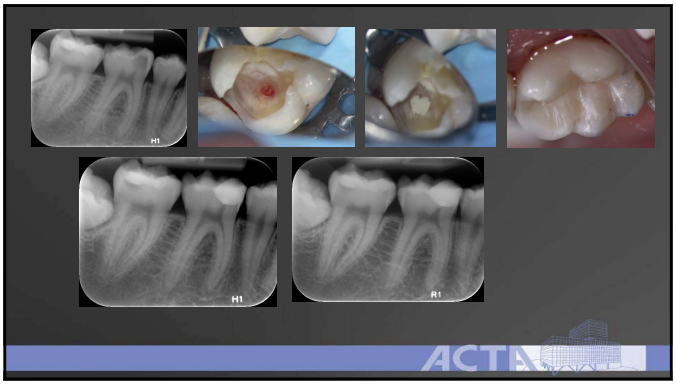
Căpută PE et al. J Endod. **2019**

…no strong clinical recommendations could be formulated.

Silva EJNL et al. Br Dent J. **2019**

…there was no evidence of effective improvement on periapical healing …that supports the use of ultrasonic irrigation…

7



8

Outcome was mostly determined by radiographs.

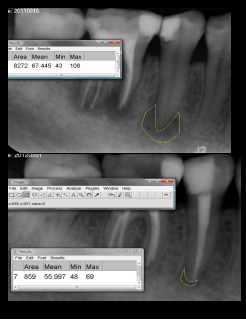
Evidence shows that radiographs show only half of the truth…

9

- **Radiographic success: half true half false**
- **Evidence:**
- Absence of AP on radiograph: half true half false or 2/3 true 1/3 false (Brynolf 1967, Barthel et al. 2004)..
- Absence of AP on radiograph: 60% true 40% false (Estrela et al. 2008, Christiansen et al. 2009).

10

How do we measure/ determine healing?

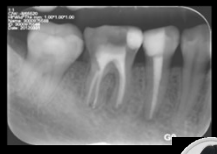


-Qualitative (strict)
-Simple measurements
-Scoring systems
-PAI
-CBCT-PAI
-3D measurements

11

Qualitative assessment

- Healed or not healed (“strict criteria”) –
- no measurement of the lesion, just present or absent.



Who used this system ?
Ng et al. 2011

12

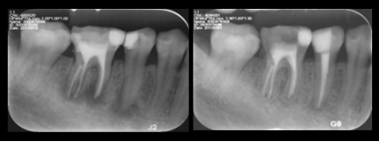
Advantages

- Quick and cheap method
- Gives clinically relevant information

13

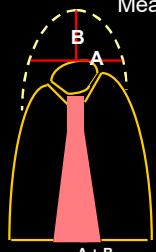
Disdvantages

- Subjective
- No meaning for “shrinkage”
- On CBCT- lower healed rate on teeth with pre-treatment lesions (Liang et al. 2012: less than 50% after 2 years)



14

Measurement of periapical lesions

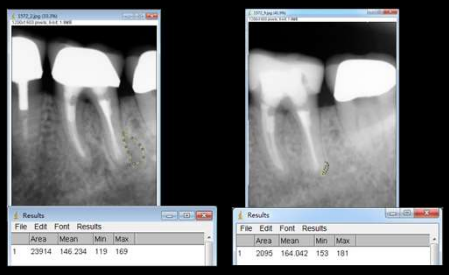


size of each lesion was calculated by taking the average of the lesion's largest dimension and its extent in the direction perpendicular to the largest dimension.

Sjorgen et al. JOE 1990

15

Measurement of periapical lesions



16

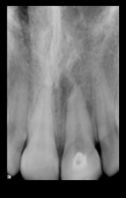
Advantages

- Cheap method
- Quantitative

17

Disdvantages

- Time consuming
- Not accurate- difficult to standardize



18

Scoring systems

- Periapical scores for treatment outcome. Periapical destruction:
- 1= definitely NOT present
- 2= probably NOT present
- 3= unsure
- 4= probably present
- 5= definitely present

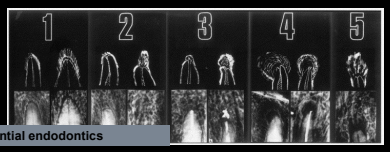
Who used this system ?
Peters & Wesselink 2002

Reit & Gröndahl IEJ 1983

19

PAI Score

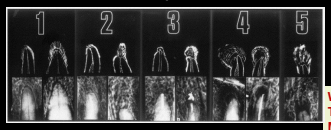
- PAI score (Ørstavik et al. 1986)
- "The PAI scoring system offers a visual reference scale for assigning a health status to the periapex. "



Essential endodontics

20

- In order to evaluate periapical section according to the PAI score, you have to compare periapical radiographs with a set of 5 radiographic images derived from Brynolf's histological-radiographic correlation study

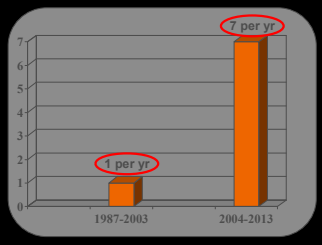


Who used this system ?
The Toronto studies
Marending et al. 2005
And
More than 70 studies !

Brynolf, 1967

21

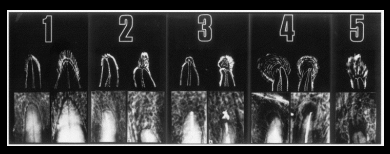
PAI has been used in more than 70 outcome studies since 1987



22

Advantages

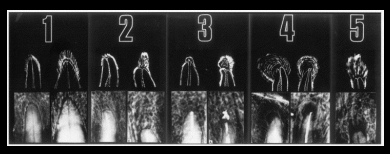
- Relatively easy to perform
- Many studies and experience with this method
- Uniformity



23

Disadvantages

- Based on findings from maxillary incisors
- Based on 2D information



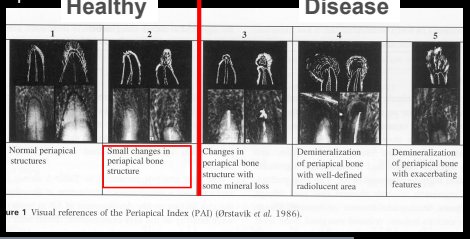
24

"Scores 2 to 5 represent increasing extent and severity of apical periodontitis."

Toronto studies 2003-2006
Healed: PAI ≤ 3

Healthy

Disease



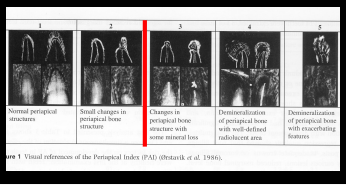
ure 1 Visual references of the Periapical Index (PAI) (Ørstavik *et al.* 1986).

Ørstavik et al. Endod Dent Traumatol 1986

25

Prognostic value of the full-scale Periapical Index. Kirkevang et al. Int Endod J. 2014

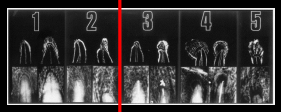
Repeated radiographic assessments of teeth using the full-scale PAI reveal that each of the five scores had distinct prognostic value for the course of periapical disease …



ure 1 Visual references of the Periapical Index (PAI) (Ørstavik *et al.* 1986).

26

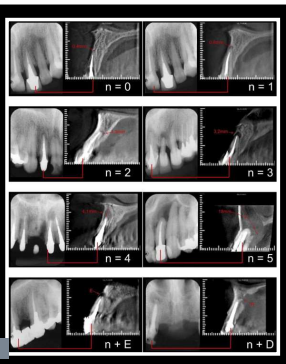
Success=	PAI 1+2	PAI 1
ALL	90	58
NO Pre-op PA	94	70
Pre-op PA	79	26



Ørstavik et al. *Eur J Oral Sci* 2004

27

The CBCT-PAI score



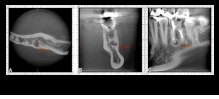
Estrella et al. JOE 2008

28

Estrella et al. JOE 2008

29

The sizes of radiolucent periapical lesions were measured on CBCT scans in 3 dimensions: buccopalatal, mesiodistal, and diagonal . The CBCT-PAI was determined by the largest extension of the lesion. A 6-point (0–5) scoring system was used.

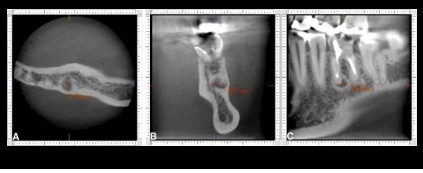


Who used this system ?
Esposito et al. 2011

30

Advantages

- Based on findings from all teeth
- Based on 3D information
- Take 3 planes into consideration



31

Disadvantages

- Measurements are still based on personal interpretation and 2D concepts
- Radiation
- Artifacts like metal posts and radiodense materials
- Time consuming

32

3D volume measurements

1. Threshould technique
2. The expansion technique

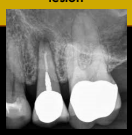
Who used this system ?
Metska et al. 2013
Van der Borden et al. 2013

33

Terminology

Patient-centered outcome: Survival, functionality

Disease-centered outcome: Healing of the periapical lesion



34

Outcome terminology

- Success & failure
  Too general ?
- Healing & healed
  Disease centered
- Effective & ineffective
  Patient centered
- Favourable and unfavourable outcome
  Too general ?
- Survival & Functionality
  Patient centered

35

Toronto studies

36

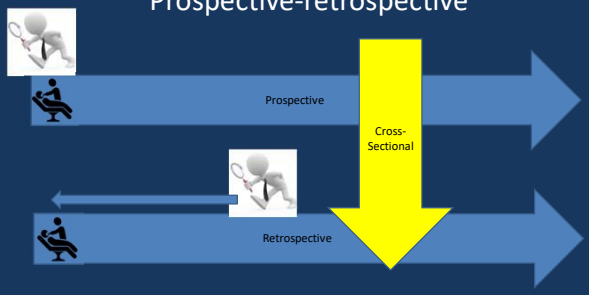
The Toronto Study Project, established in 1993, is a continuous prospective investigation of the 4- to 6-year outcome of endodontic treatment performed by graduate endodontics students in a university clinic environment.

Patient recall has been divided into 2-year phases.

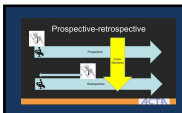
This modular design provides cumulative data with the completion of each successive phase, with the aim of amassing a sufficient sample to study the prognostic value of various factors.

37

Prospective-retrospective



38

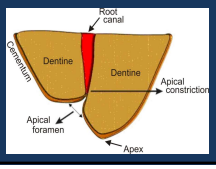


- Advantage of prospective : all treatment factors could be controlled and planned- fewer potential sources of bias and confounding
- Advantage of retrospective: easier to preform because you look at charts of previous patients

39

TERMS

- NO success or failure !!!
- Healed and healing
- Functional
- Difference between functional and survival



40

Toronto studies - JOE

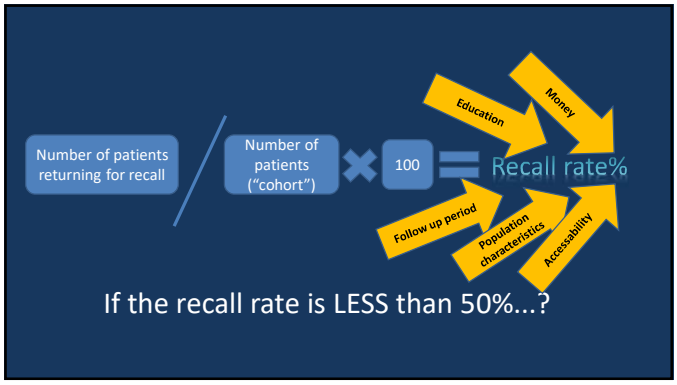
1. Treatment outcome in endodontics: the Toronto Study. Phase 1: initial treatment. Friedman S, Abitbol S, Lawrence HP. 2003
2. Treatment outcome in endodontics- the Toronto Study. Phase II: initial treatment. Farzaneh M, Abitbol S, Lawrence HP, Friedman S. 2004
3. Treatment outcome in endodontics: the Toronto study. Phases I and II: Orthograde retreatment. Farzaneh M, Abitbol S, Friedman S. 2004
4. Treatment outcome in endodontics- The Toronto Study. Phases I and II: apical surgery. Wang N, Knight K, Dao T, Friedman S2004
5. Treatment outcome in endodontics: the Toronto Study. Phase III: initial treatment. Marquis VL, Dao T, Farzaneh M, Abitbol S, Friedman S. 2006
6. Treatment outcome in endodontics: the Toronto study--phases 3 and 4: orthograde retreatment. de Chevigny C, Dao TT, Basrani BR, Marquis V, Farzaneh M, Abitbol S, Friedman S. 2008
7. Treatment outcome in endodontics: the Toronto study--phase 4: initial treatment. de Chevigny C, Dao TT, Basrani BR, Marquis V, Farzaneh M, Abitbol S, Friedman S. 2008
8. Treatment outcome in endodontics: the Toronto study--phases 3, 4, and 5: apical surgery. Barone C, Dao TT, Basrani BR, Wang N, Friedman S. 2010

41

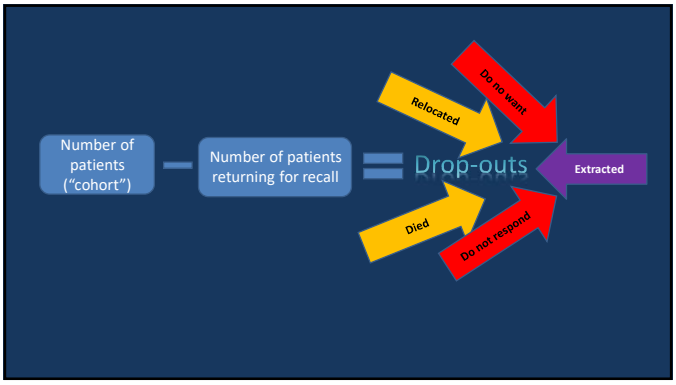
- Accumulation of results mean that the last 3 articles that report the accumulated results of all phases are the most important in terms of results and outcome predictors

6. Treatment outcome in endodontics: the Toronto study--phases 3 and 4: orthograde retreatment. de Chevigny C, Dao TT, Basrani BR, Marquis V, Farzaneh M, Abitbol S, Friedman S. 2008
7. Treatment outcome in endodontics: the Toronto study--phase 4: initial treatment. de Chevigny C, Dao TT, Basrani BR, Marquis V, Farzaneh M, Abitbol S, Friedman S. 2008
8. Treatment outcome in endodontics: the Toronto study--phases 3, 4, and 5: apical surgery. Barone C, Dao TT, Basrani BR, Wang N, Friedman S. 2010

42



43

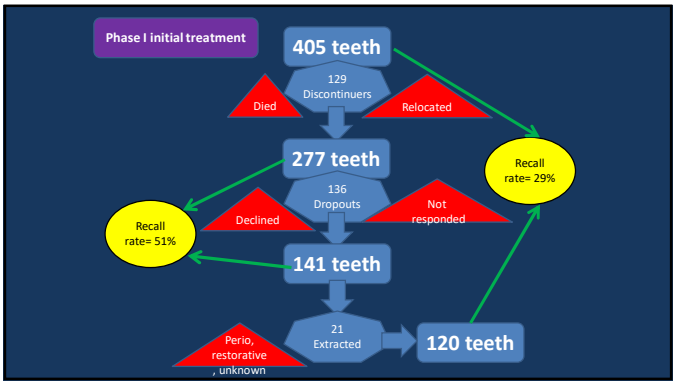


44

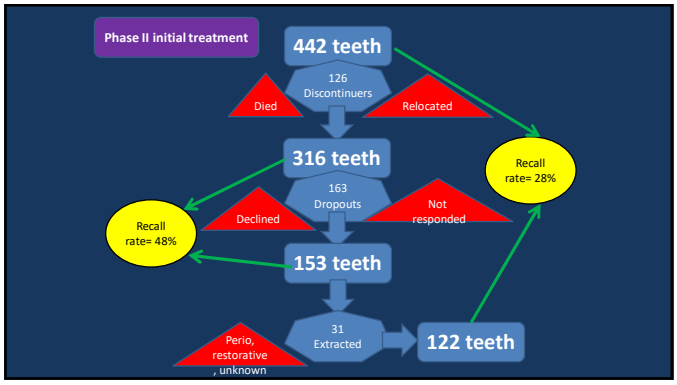
Calculation of recall rate by Friedman
Phase I –initial treatment

- **INCEPTION COHORT**: **405** teeth in 350 patients
- **DISCONTINUED**: deceased or relocated and could not be reached : 128 teeth. They are EXCLUDED from the cohort. We remain with 405-128= 277
- **DROPOUTS**: Declined or did not respond : 136 teeth, of the 277
- **RESPONDING :** 277-136= 141
- **RECALL RATE:** 51% of the 277
- **STUDY SAMPLE**= RESPONDING – EXTRACTED

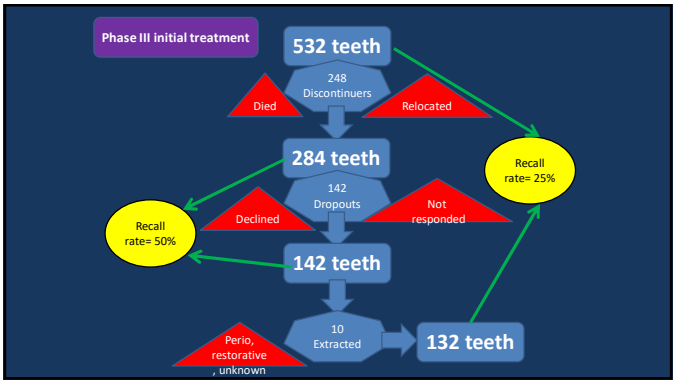
45



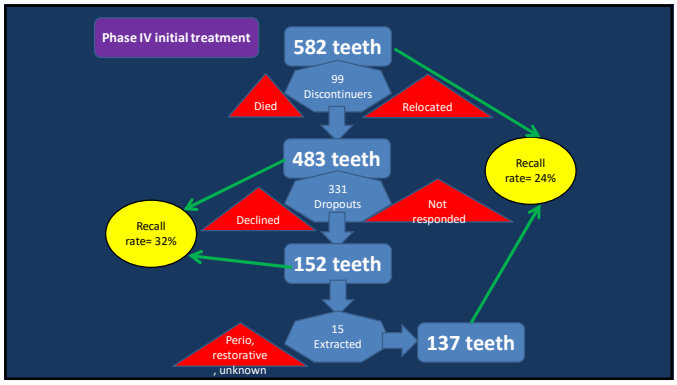
46



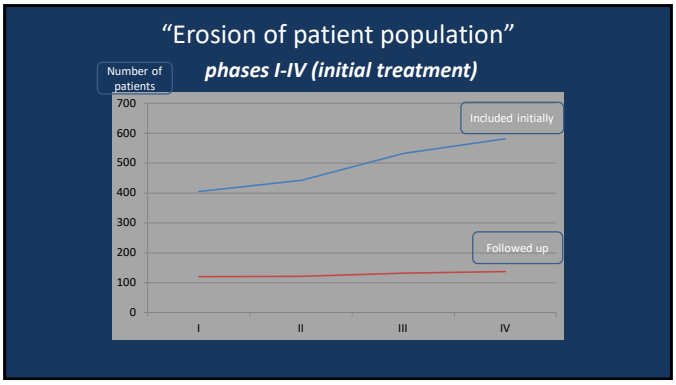
47



48



49

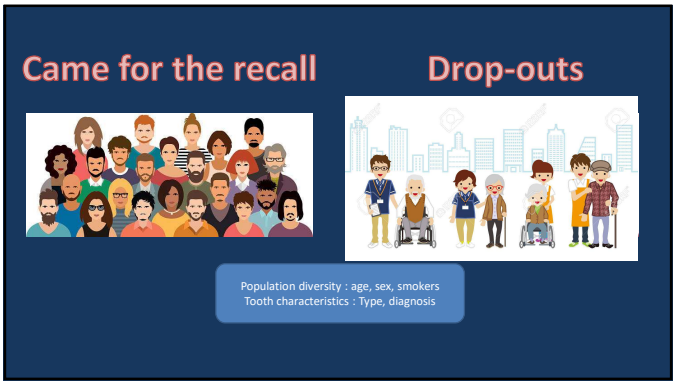


50

"Response bias analysis"

- Explores whether the results could be skewed by the loss of follow-up.
- Patients lost to follow-up are checked for different characteristics (gender, pre-op diagnosis, tooth type…)
- If the populations lost to follow up and attending are significantly different in parameters which were identified as an outcome predictor, than the results could be skewed.

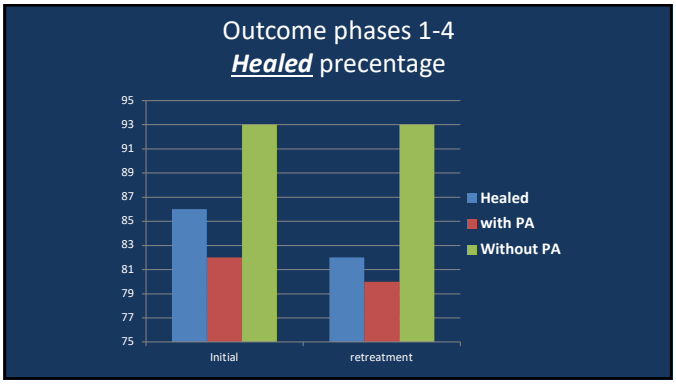
51



52

Results- Toronto studies

53



54

Conclusions Toronto studies

- Importance
- Methodology
- Relevance
- Future

55

The Ng Studies

56

Ng studies- IEJ

1. "Outcome of primary…part 1 " Ng, Mann, Rahbarab, Lewsey & Gulabivala 2007
2. "Outcome of primary…part 2 " Ng, Mann, Rahbarab, Lewsey & Gulabivala 2007
3. "Outcome of s… Ng, Mann & Gulabivala 2008
4. "Tooth survival…" Ng, Mann & Gulabivala 2010
5. "A prospective study…part 1 "- Ng, Mann & Gulabivala 2011
6. "A prospective study…part 2 "- Ng, Mann & Gulabivala 2011

Reviews

Outcome studies

57

A prospective study of the factors affecting outcomes of nonsurgical root canal treatment: part 1: periapical health. - Ng, Mann & Gulabivala 2011

- The goal was to identify the prognostic factors for root canal (re) treatment.
- Observational design : factors cannot be controlled but only accounted for.
- All patients undergoing RCT of retreatment from 1st October 1997 until June 2005. By residents in Eastman. (Toronto : 1993-2001)
- Excluded from the study: perio or if the apex was not discernible on the x-ray
- Excluded from the analysis: follow-up less than 2 years, extracted, not enough data

58

- All treatments with anesthesia
- Various instrumentations
- GP + Roth canal sealer
- Various filling techniques
- Was magnification (microscope) used ?!

59

Classification

- Preoperative: 1. intact PDL 2. Widened PDL, 3. Lesion
- Diameter of the lesion measured with a ruler
- Diameter of widened PDL 0.5 mm

60

Outcome measurements

- Ng does not agree with Friedman and contantly uses the term "success rate".
- Primary: Clinical and radiographic : absebce or healing of lesion for each root
- Secondary: survival
- Succeess: 1.strict criteria : no pain, sympthoms and complete healing
- 2. Loose criteria- healing lesion.

61

PAI score

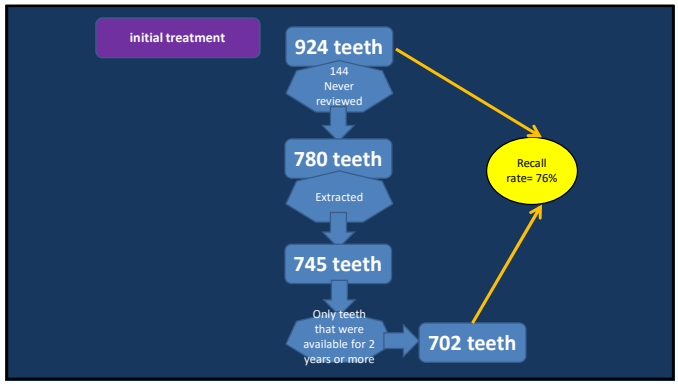
62

Numbers

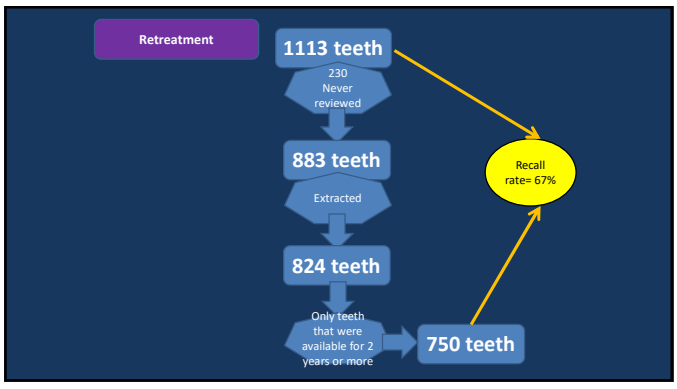
- Total: 924 teeth for initial treatments and 1113 teeth for retreatments

	Initial-Ng		***Retr-Ng***	
Cohort	**924**		**1113**	
Analysis	**702**		**750**	

63



64

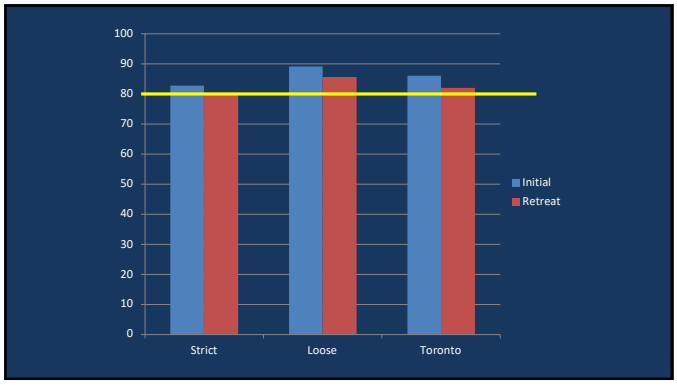


65

Results Ng

	Initial	retreatment
Strict	82,8	80,1
Loose	89,1	85,6
Toronto pooled	86	82

66



67

The root as a unit

- Friedman claimed that you SHOULD NOT use the root as a unit of measure because it had a tendency to OVERESTIMATE success.
- This study and Hoskinson et al. 2002 do not support this.
- Reason: root-level independent variables are more relevant

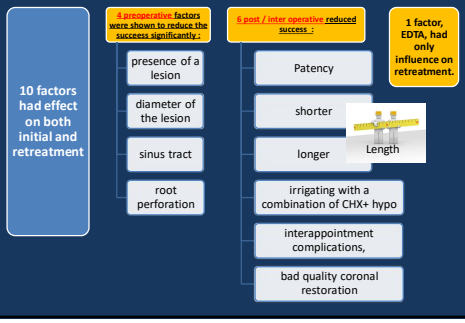
68

Sensitivity of the radiographs

- CBCT

69

Factors



70

On what do Ng and Friedman dissagree?

- Root level- tooth level
- PAI score
- Calculation of the recall rate
- Factors

Still, their results are similar !!!

71

The Ng Studies II : Survival

72

Definitions

- Survival –time to extraction after RCT
- Functional survival (Friedman & Mor 2004)

73

Tooth survival- Review (2010)

1966-2007

31 articles identifies, 14 included

Pooled survival 2-10 years 86-93%

74

Questions

- Why are there so few studies on survival compared to studies on healing of periapical lesion ?
- Sample size is larger than studies on periapical healing. Why ?
- Influence of follow up time on the survival. Pooled results for 3-10 years but if you look at 8-10 years it is lower than 2-4 years.

75

Endodontic treatment outcomes in a large patient population in the USA: an epidemiological study.

Salehrabi R, Rotstein. JOE 2004

- outcomes of initial endodontic treatment done in 1,462,936 teeth of 1,126,288 patients from 50 states across the USA was assessed over a period of 8 yr.
- Overall, 97% of teeth were retained in the oral cavity 8 yr after initial nonsurgical endodontic treatment.
- In conclusion, it appears that initial nonsurgical endodontic treatment is a predictable procedure with high incidence of tooth retention after 8 yr.

76

Problems

- Tooth exists in the mouth.
- But in which condition? Unclear (but irrelevant for “survival”)
- No prognostic factors checked

77

Prognostic factors influencing survival

according to the review **:**

- 1. Crown restoration
- 2. Proximal contacts
- 3. Not an abutment
- 4. non-molar teeth

78

Tooth survival- Study (2011)

- Follow up 2-4 years
- Initial treatment & retreatment

- Initial : 95%
- Retreatment: 95%
- 13 prognostic factors were identified

79

- "The extraction outcome was reported either by the patient at the follow-up appointment, or without their attendance by phone or letter through the patient or referring dentist "

- Is this a big limitation ???
- No, because the recall rate was high.

80

Prognostic factors

- Diabetes
- Steroid therapy

Patient factors

- Probing depth
- Pain
- Discharging sinus tract
- Perforations (2nd treatment only)

Pre-op factors

- 1. Crown restoration
- 2. Proximal contacts
- 3. Not an abutment
- 4. non-molar teeth

- Perforations
- Patency
- Extrusion of filling material

Intra-op factors

- Cast restoration vs. temporary
- Post & core
- Proximal contacts
- Terminal location of the tooth

Post-op factors

Periapical healing

81

Why was the most important factor for healing (*pre-op periapical lesion) NOT a factor for survival ?

- "A mere presence of a periapical lesion was NOT a sufficient reason for active treatment" (Reit & Gröndahl 1988)

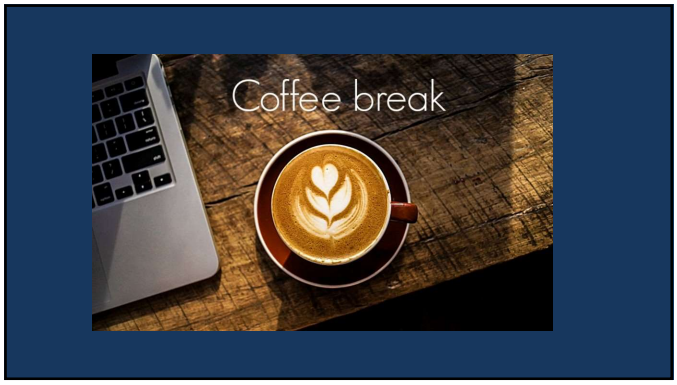
82

Conclusions Ng studies

- Importance
- Methodology
- Relevance
- Future

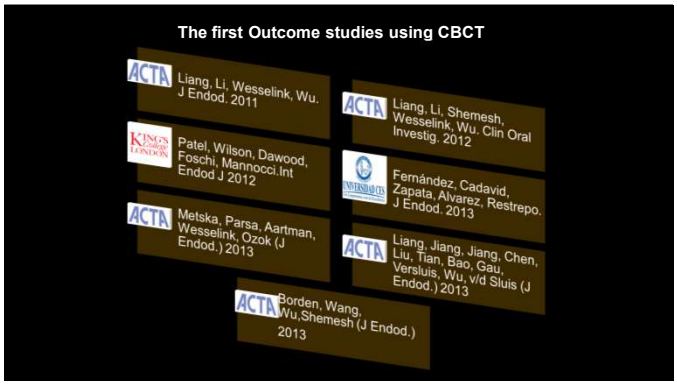
83

84

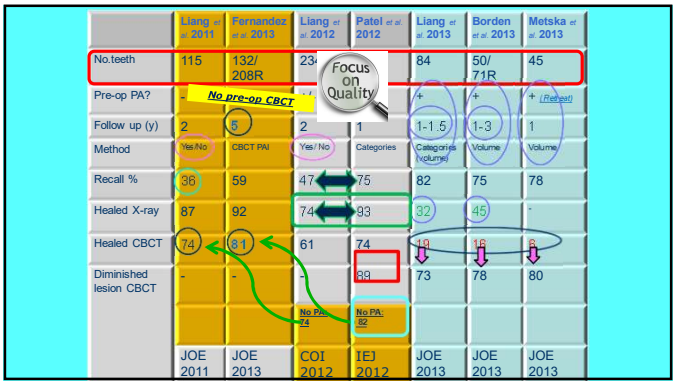


85

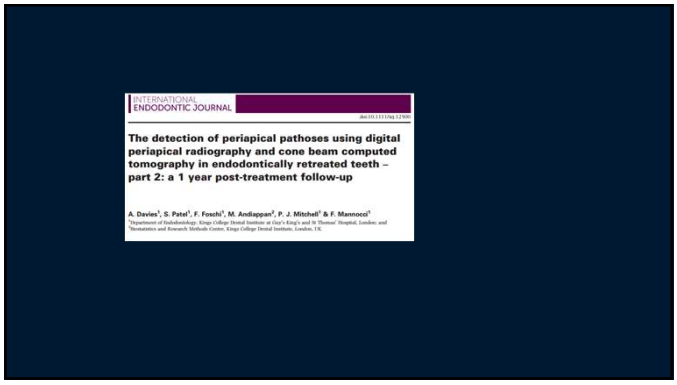
86



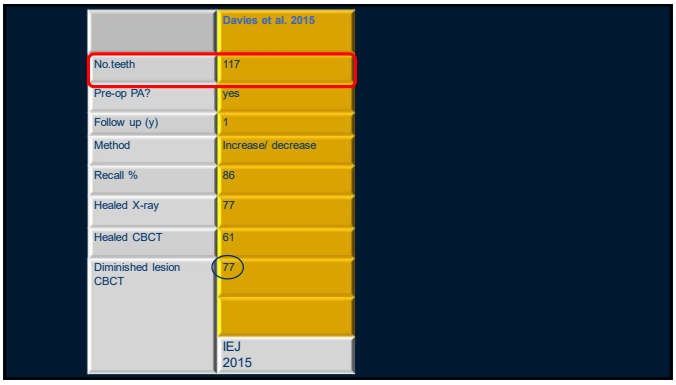
87



88



89

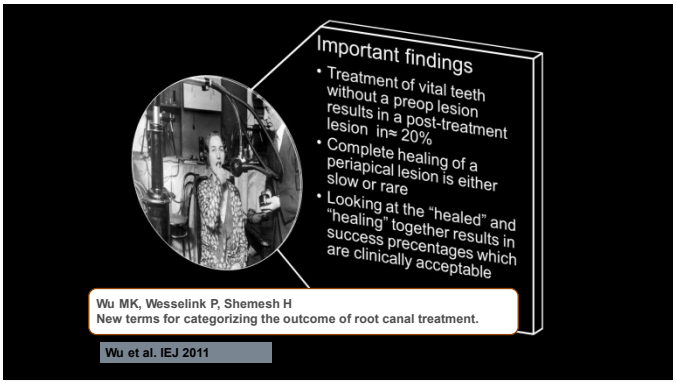


90

ESE guidelines advise 1 year follow up

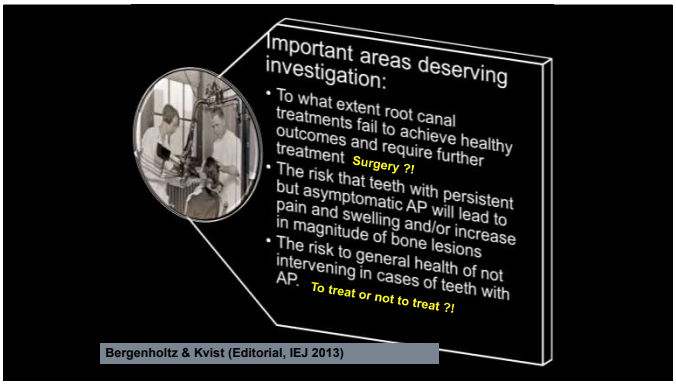
- Due to the generally high number of favourable outcomes, and the insensitivity of radiogrphs in detecting unfavourable outcomes it is reasonable to question whether a 1 year follow up with radiographs is justified especially in cases with small/ no pre-op radiolucencies

91



92

93



94

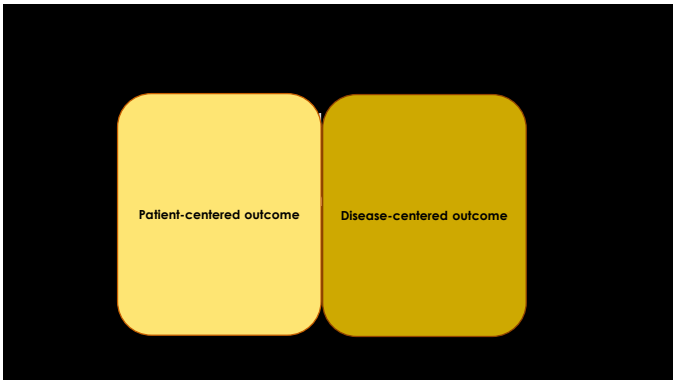
- If we accept that for the time being the availability of CBCT remains limited:

"loose criteria"? | "survival"? | "Signs & symptoms"?

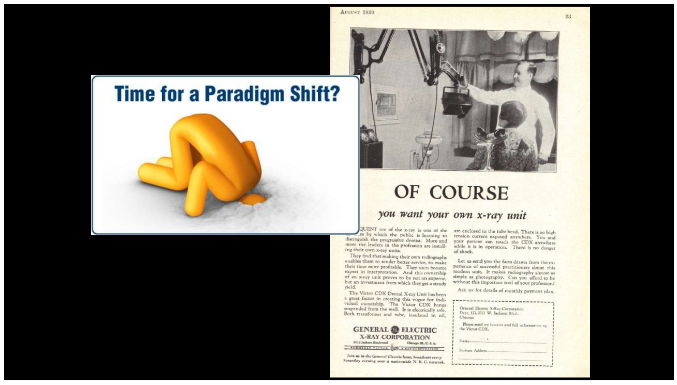
X-rays not needed for follow up!

"Shrinking" of the lesion

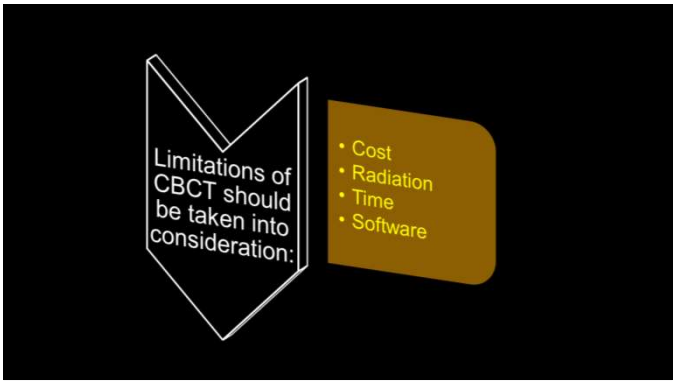
95



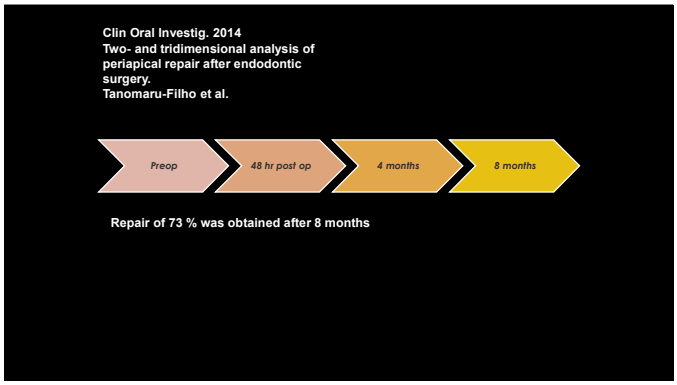
96



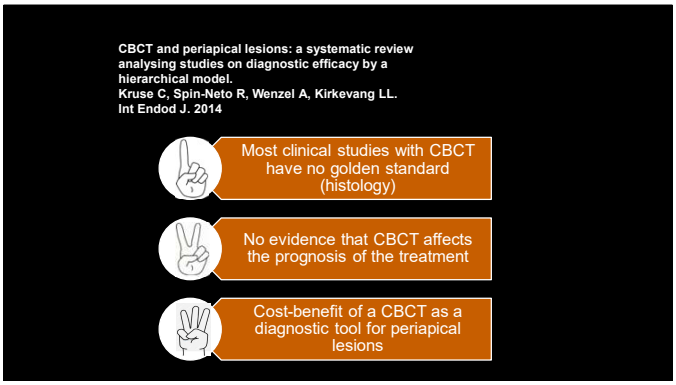
97



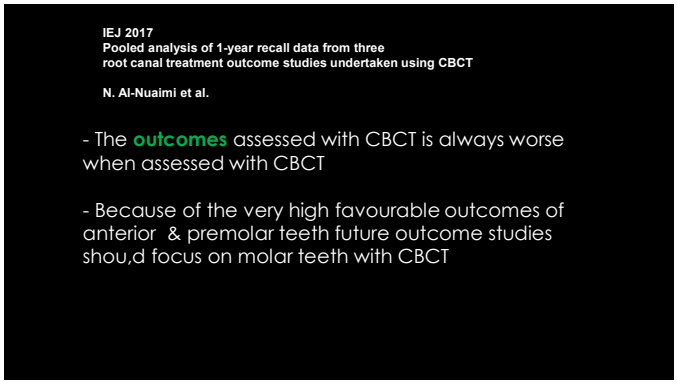
98



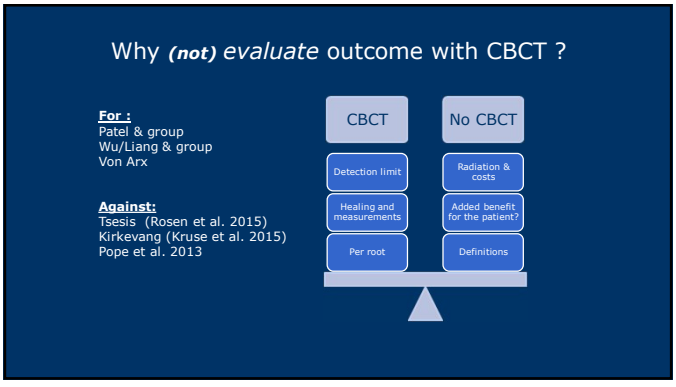
99



100



101



102

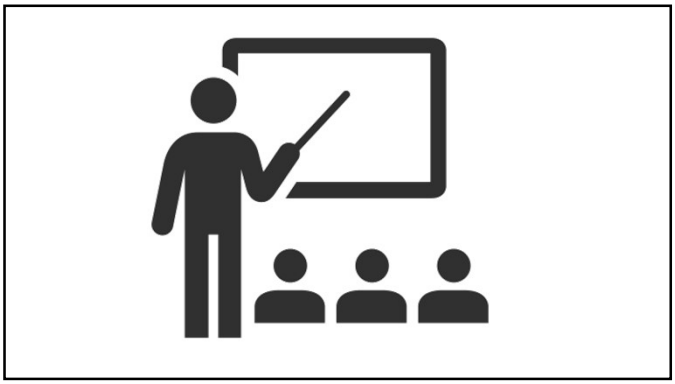
Summary

- Toronto studies
- Ng studies
- CBCT studies
- Outcome terminology and measurements
- Recall rate
- Outcome of root canal treatment

103

Now ***you*** :
Assess the following outcome article by yourself!

104



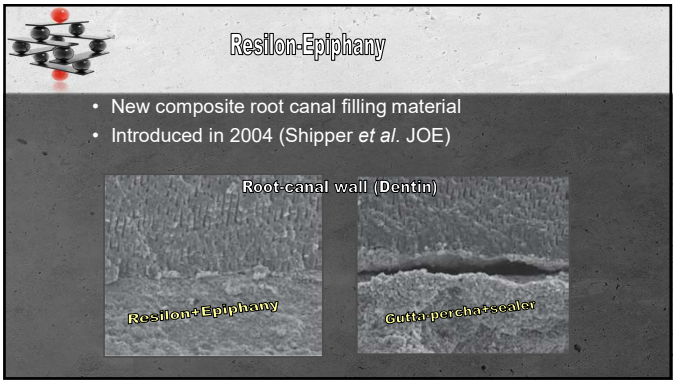
105

Long-term Outcomes of Endodontic Treatment Performed with Resilon/Epiphany

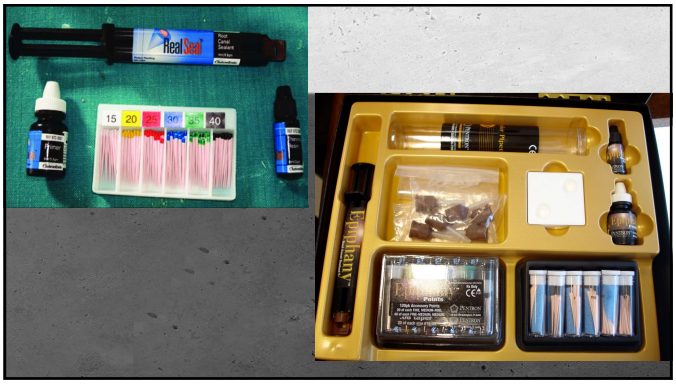
Strange et al. 2019

Read it in www.shemesh.nl (see " seminars and lectures")

106

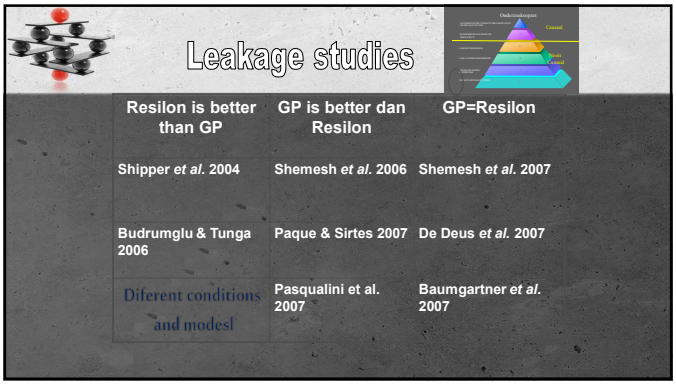


107

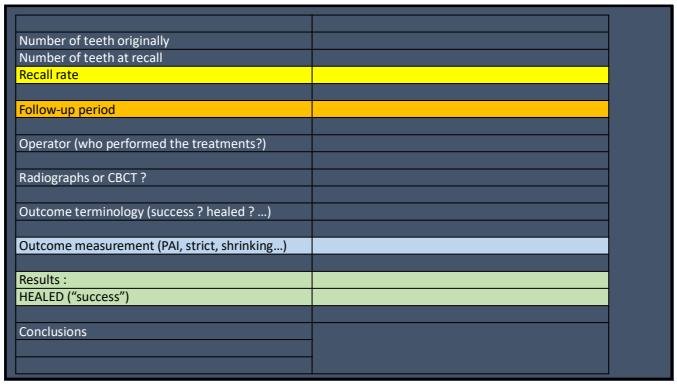


108

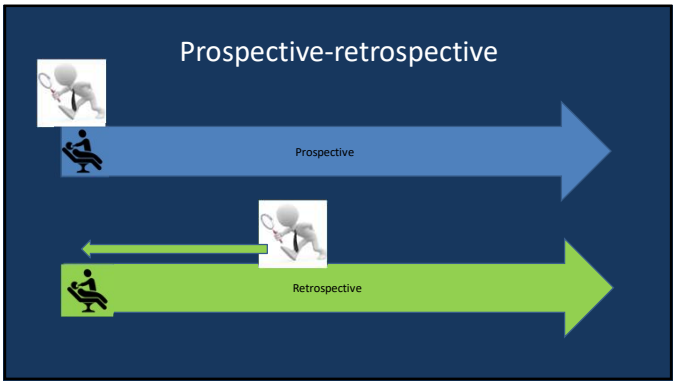
109



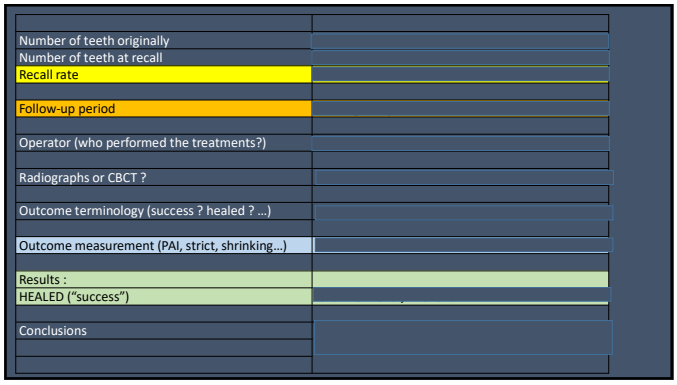
110



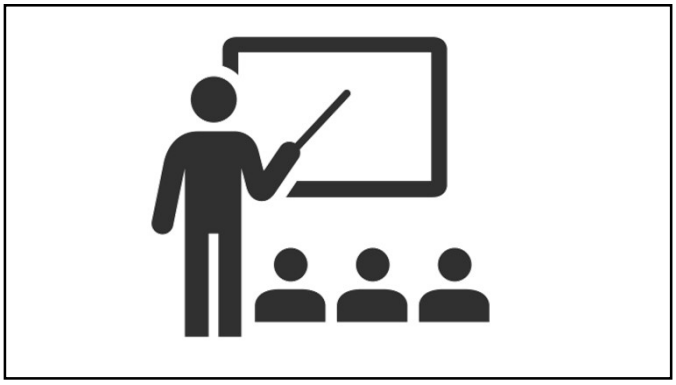
111



112



113



114

So how do ***you*** monitor the results of your endodontic treatment?

115

Monitoring the outcome

1. A radiograph one year after the treatment
2. A radiograph 6 months after the treatment
3. I don't monitor the outcome
4. A CBCT one year after treatment
5. I follow it up after one and 4 years
6. I just call the patient on the phone

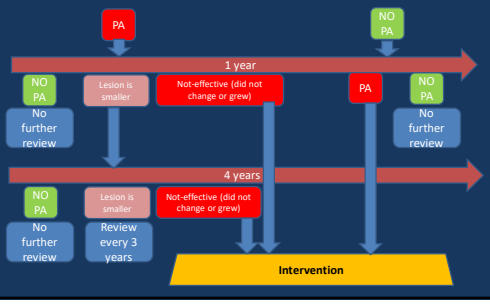
116

- Monitoring the outcome of root canal re-treatments - 2008 endodontic Topics
- Sathorn & Parashos


117

117

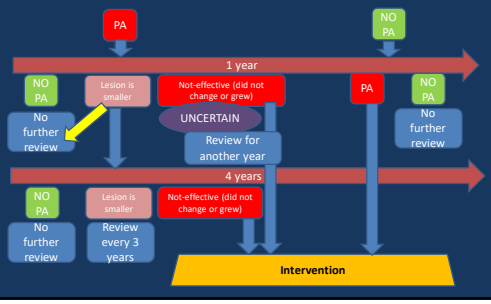
Non-surgical retreatment :(Sathurn & Parashos follow-up protocol)



118

118

Effectivity (Wu, Shemesh, Wesselink)- 2011



119

119

Take home message

- Outcome studies are the essence of clinical studies in endodontology because they can give answers to most clinical questions
- Healing of the periapical lesion on radiograph is mostly used to assess the outcome
- Patient centered outcomes are also being used (and should be used more often?)
- CBCT as a new tool to assess outcome (limited!)
- Important concepts of outcome assessment were discussed

120

120

Editorial
Outcome of endodontic treatment – the elephant in the room
S. Patel et al. International Endodontic Journal 2020

Le Roi est nu

www.shemesh.nl

121

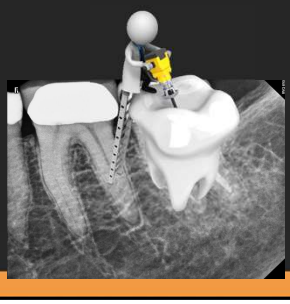
Take home message

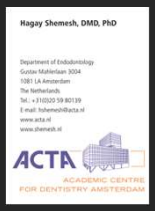
- Outcome studies are the essence of clinical studies in endodontology because they can give answers to most clinical questions
- Healing of the periapical lesion on radiograph is mostly used to assess the outcome
- Patient centered outcomes are also being used
- CBCT as a new tool to assess outcome
- Important concepts of outcome assessment were discussed

122

122

Retreat or not retreat ?

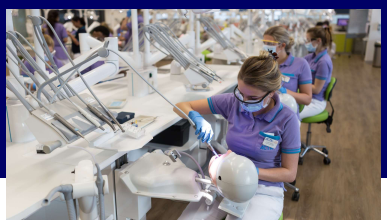




123

ACTA Academic Centre for Dentistry Amsterdam

Download handouts from www.shemesh.nl



University of Amsterdam VU Vrije Universiteit Amsterdam

124

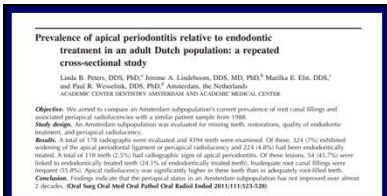
ACTA Academic Centre for Dentistry Amsterdam

PRIMARY TREATMENTS
82,8% - 89,1%

NG, Y.-L. ET AL. INT ENDOD J. 2011 JUL;44(7):583-609.

University of Amsterdam VU Vrije Universiteit Amsterdam

125



ACTA Academic Centre for Dentistry Amsterdam

24% of the endodontically treated teeth were associated with a periapical lesion

University of Amsterdam VU Vrije Universiteit Amsterdam

126

35%of the root-filled teeth had AP

34%of the root-filled teeth had AP

34%of the root-filled teeth had AP

41%of the root-filled teeth had AP

52%of the root-filled teeth had AP

ACTA Academic Centre for Dentistry Amsterdam

University of Amsterdam VU Vrije Universiteit Amsterdam

127

93 STUDIES INCLUDED
about root filled teeth

39% are associated with a lesion

TIBURCIO-MACHADO, C. S. ET AL.. INT ENDOD J. 2021 MAY;54(5):712-735.

128

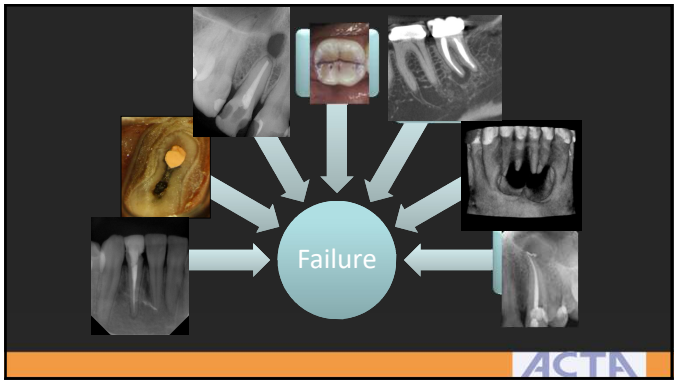
- How to explain the discrepancy ?
  - Cross sectional vs. Outcome study with follow-up
  - Do outcome studies correctly reflect the situation?
  - How long ago was the treatment done ?
  - Healing of the lesion but not (yet) full recovery
  - Apical scar tissue
  - Quality of the treatment

LAUKKANEN ET AL.. ACTA ODONTOL SCAND . 2021

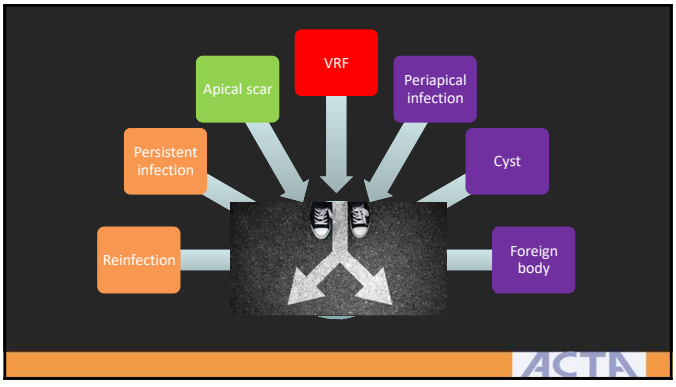
129

Why do root canal treatments fail?

130



131



132

How to manage failure of a root canal treatment?

- Monitor
- Retreatment
- Surgical endodontics
- Combination
- Extraction

Reit C, Gröndahl HG. Swed Dent J. 1984;8(1):1-7.

133

How to manage failure of a root canal treatment?

- Monitor
- Retreatment
- Surgical endodontics
- Combination
- Extraction

Reit C, Gröndahl HG. Swed Dent J. 1984;8(1):1-7.

134

Monitor

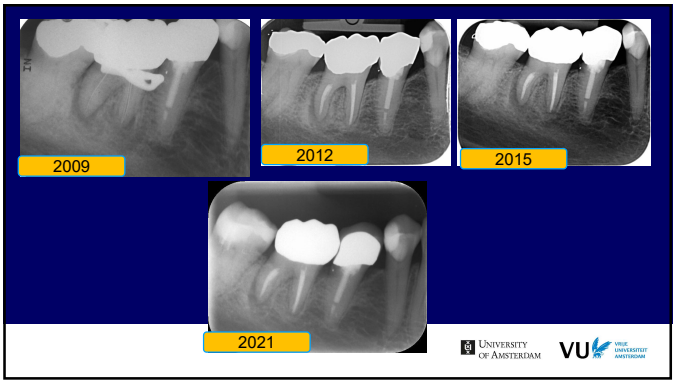
- When there are no complaints (of symptoms…?)
- When the treatment was recently (<4 years?)
- When we see no difference compared to older radiographs

135

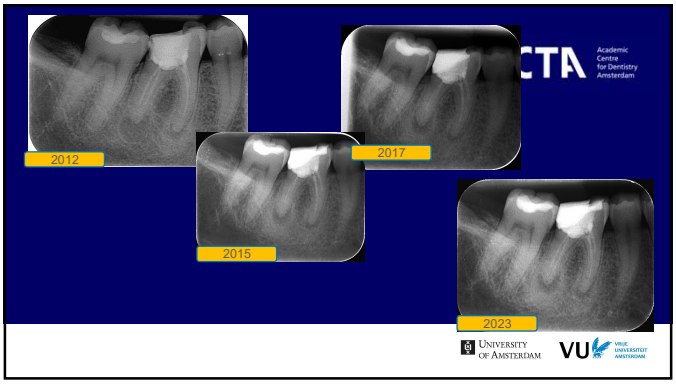
Monitor

- When there is no clear diagnosis
- When there is no restorative plan
- When there are no systemic risks

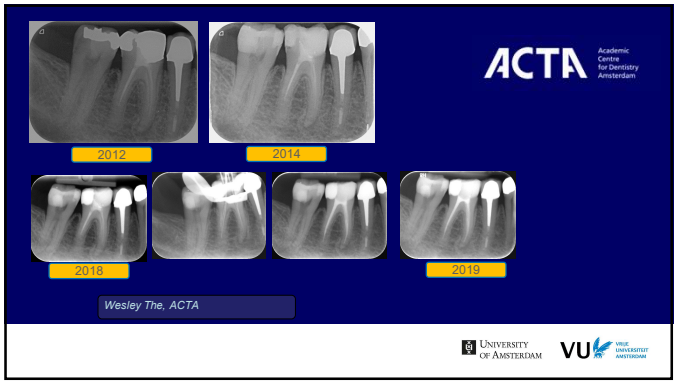
136



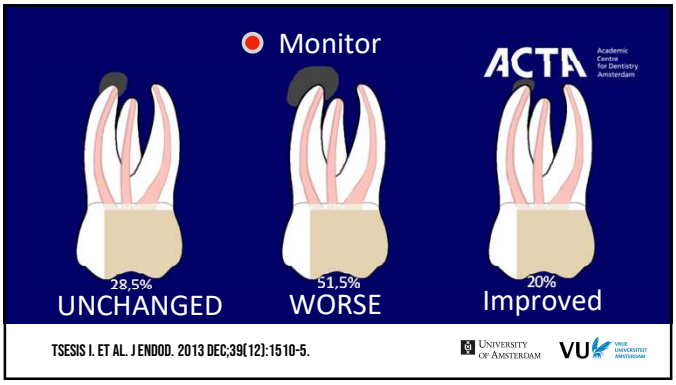
137



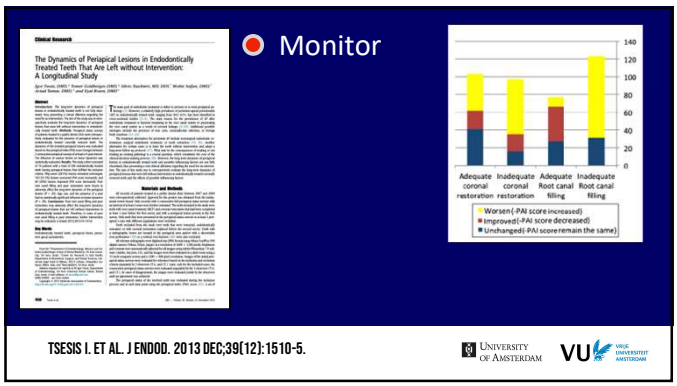
138



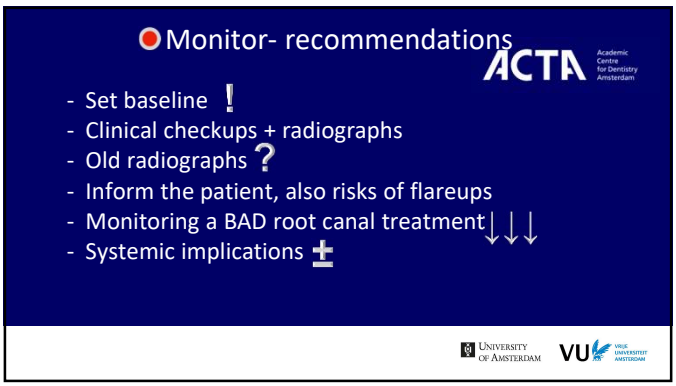
139



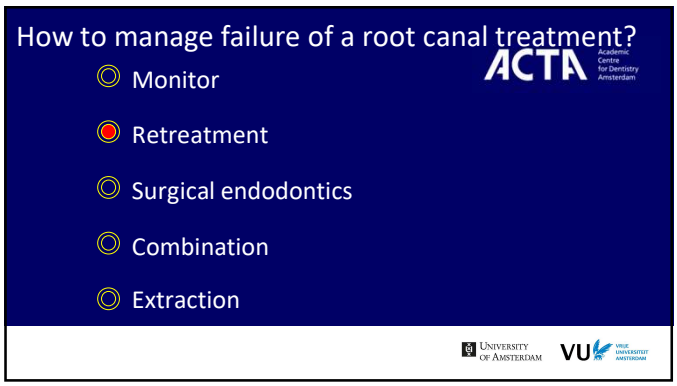
140



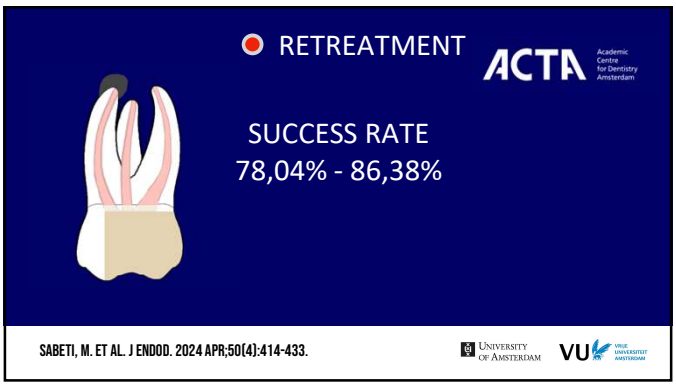
141



142

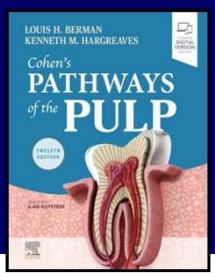


143



144

RETREATMENT

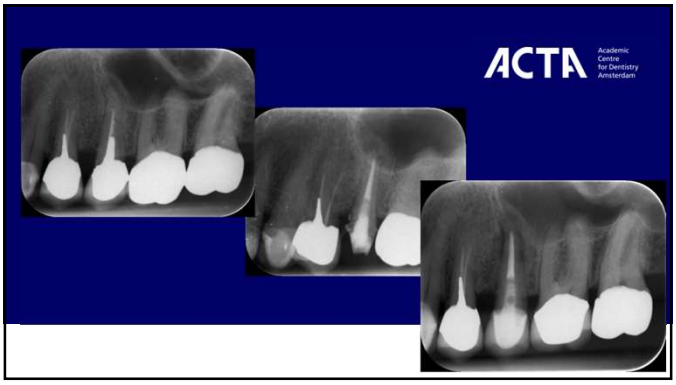


NONSURGICAL ENDODONTIC RETREATMENT

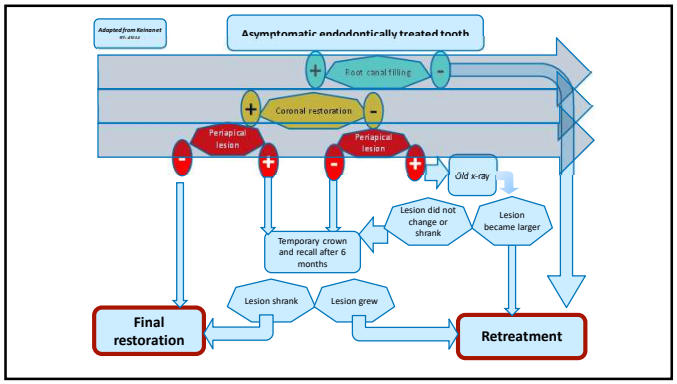
The primary difference between nonsurgical management of primary endodontic disease and that of posttreatment disease is the need to regain access to the apical area of the root canal space in the previously treated tooth. After that, all of the principles of endodontic therapy apply to the completion of the retreatment case. Coronal access needs to be completed, all previous root-filling materials need to be removed, canal obstructions must be managed, and impediments to achieving full working length must be overcome. Only then can cleaning

COHEN'S PATHWAYS OF THE PULP (12TH ED.). ST. LOUIS, MO

145

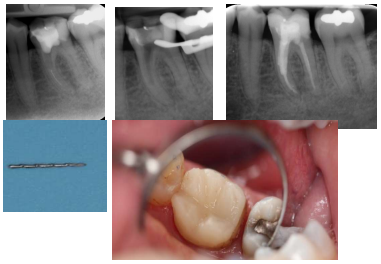


146



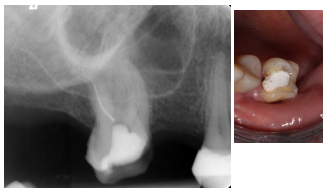
147

148

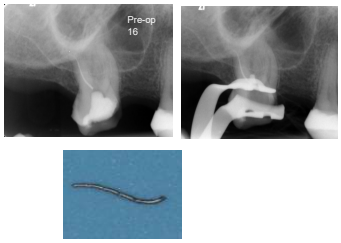


149

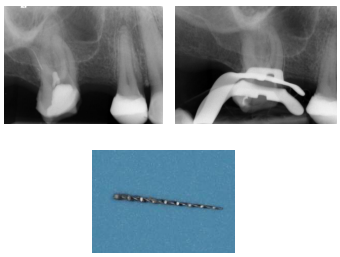
150



151

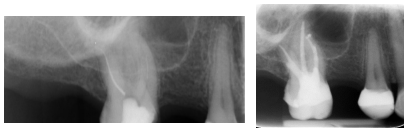


152

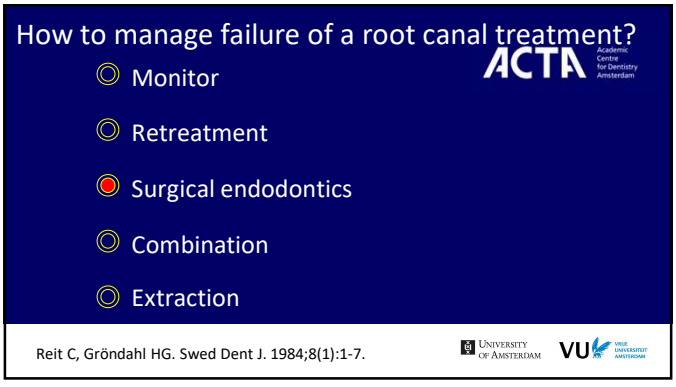


153

154

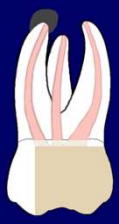


155



156

Surgical endodontics

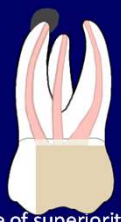


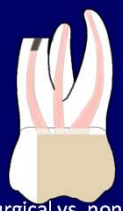
SUCCESS RATE
78.4 - 91.3%

PINTO D, MARQUES A, PEREIRA JF, PALMA PJ, SANTOS JM. MEDICINA (KAUNAS). 2020 SEP 3;56(9):447

157

Surgical endodontics

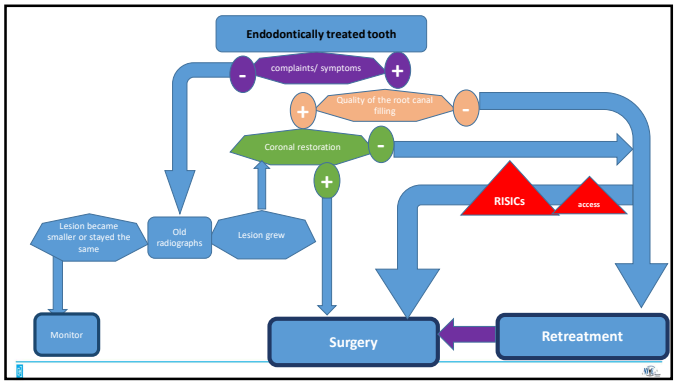




no clear evidence of superiority of the surgical vs. non-surgical approach

AZIM A. ET AL. INT ENDO J. 2021 MAR;54(3):301-318.

158



159

Review Cochrane Database Syst Rev 2016

Del Fabbro M, Corbella S, Sequeira-Byron P, Tsesis I, Rosen E, Lolato A, Taschieri S

160

How to manage failure of a root canal treatment?

- Monitor
- Retreatment
- Surgical endodontics
- Combination
- Extraction

Reit C, Gröndahl HG. Swed Dent J. 1984;8(1):1-7.

161

How to manage failure of a root canal treatment?

- Monitor
- Retreatment
- Surgical endodontics
- Combination
- Extraction

Reit C, Gröndahl HG. Swed Dent J. 1984;8(1):1-7.

162

Extraction

- Should be presented to the patient as an option

163

How to manage failure of a root canal treatment?

- Monitor
- Retreatment → Selective retreatment
- Surgical endodontics
- Combination
- Extraction

Reit C, Gröndahl HG. Swed Dent J. 1984;8(1):1-7.

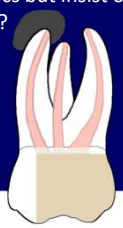
164

The partial retreatment

165

- Partial/ selective retreatment

Why do we resect and treat only the root with a periapical lesion with surgical endodontics but insist on retreating all canals in an orthodgrade approach ?



166

37 Mandibular Molars

First Time Surgery

PAI SCORE (PAI ≥ 3 - APICAL PATHOSIS)

5 Years follow up

Periapical X-Rays

KRAUS RD ET AL. J ENDOD. 2015;41(4):442-6.

167

Assessment of the Nonoperated Root after Apical Surgery of the Other Root in Mandibular Molars: A 5-year Follow-up Study

NON OPERATED ROOT

8,1%

KRAUS RD ET AL. A 5-YEAR FOLLOW-UP STUDY. J ENDOD. 2015;41(4):442-6.

168

Conclusions
Nonoperated roots rarely developed signs of new apical pathosis 5 years after apical surgery of the other root in mandibular molars. It appears reasonable to resect and fill only roots with a radiographically evident periapical lesion.

NON OPERATED ROOT

8,1%

KRAUS RD ET AL. A 5-YEAR FOLLOW-UP STUDY. J ENDOD. 2015;41(4):442-6.

169

The partial retreatment

170

Selective Root Retreatment: A Novel Approach

1 Case Report

Pre Operative CBCT

circumscribed lesion around the disto-lingual root

1 Year follow up with CBCT

Favourable outcome

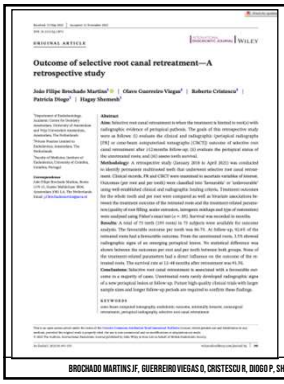
NUDERA WJ. J ENDOD. 2015;41(8):1382-8.

171

The partial retreatment

Outcome of selective root canal retreatment-A retrospective study.
Brochado Martins JF, Guerreiro Viegas O, Cristescu R, Diogo P, Shemesh H.
Int Endod J. 2023

172



Outcome of selective root canal retreatment—A retrospective study

- RETROSPECTIVE STUDY
- January 2018 - April 2021
- 82 multirooted teeth (215 roots)
  - 59 teeth (151 roots) - PERIAPICAL X-RAY
  - 16 teeth (44 roots) - CBCT
- OUTCOME EVALUATION
- NEW LESIONS IN NON TREATED ROOTS

BROCHADO MARTINS JF, GUERREIRO VIEGAS O, CRISTESCU R, DIOGO P, SHEMESH H. OUTCOME OF SELECTIVE ROOT CANAL RETREATMENT-A RETROSPECTIVE STUDY. INT ENDOD J. 2023

173

Survival rate
91,5%

Outcome
FAVOURABLE
TREATED ROOTS 92,7%
Untreated roots 96,5%

3,5% of the untreated roots developed a new lesion

BROCHADO MARTINS JF, GUERREIRO VIEGAS O, CRISTESCU R, DIOGO P, SHEMESH H.
INT ENDOD J. 2023

174

Outcome

PER TOOTH

FAVOURABLE

86,7%

UNFAVOURABLE

13,3%

BROCHADO MARTINS JF, GUERREIRO VIEGAS O, CRISTESCU R, DIOGO P, SHEMESH H. OUTCOME OF SELECTIVE ROOT CANAL RETREATMENT-A RETROSPECTIVE STUDY. INT ENDOD J. 2023

175

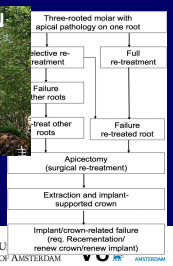
Pros

- Less expensive
- Less iatrogenic errors
- Minimal invasive
- Less time

176

Additional aspects

Cost effectiveness :



Selective retreatment, when clinically applicable, is likely to be more cost-effective than full retreatment in endodontically treated molars with persistent apical periodontitis.

BROCHADO MARTINS JF, SHEMESH H, HERBST SR, SCHWENDICKE F.. INT ENDOD J. 2023

177

Additional aspects

Resistance to fracture:

BROCHADO MARTINS JF, ASIC H, SHEMESH H, GRESNIGT M..

178

BMC Oral Health

RESEARCH Open Access

Does selective root canal retreatment preserve the tooth's fracture resistance? An ex-vivo study

Conclusions Selective root canal retreatment preserved the tooth's fracture resistance compared to the conventional retreatment approach.

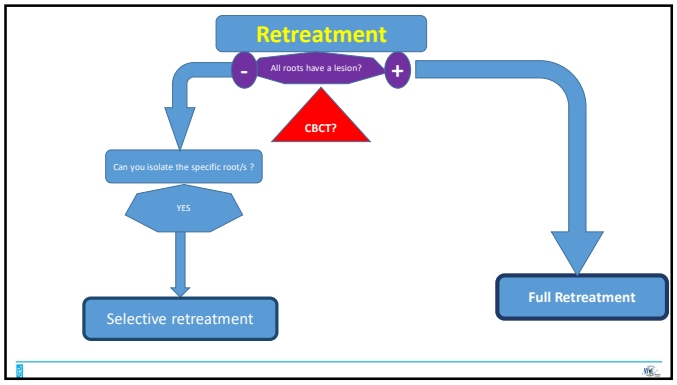
BMC Oral Health. 2024 Oct 19;24(1):1251.
Mohammed Turky, Yasmine Ahmed Mortada Abd Elfatah, Shaimaa Hamdy

179

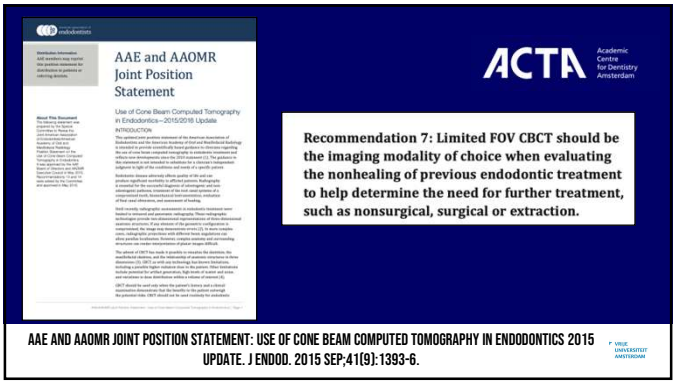
Question still unanswered:

- Is 2D imaging enough ? CBCT ?

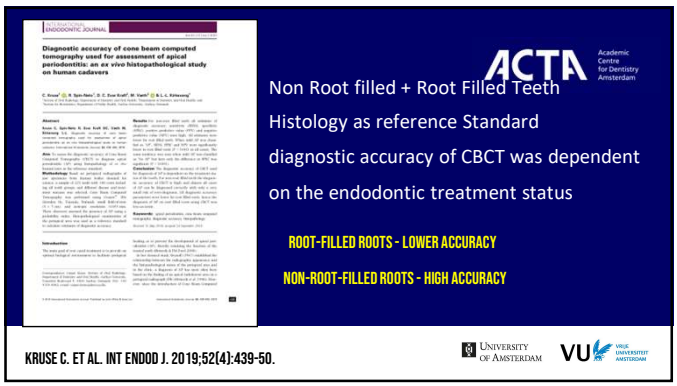
180



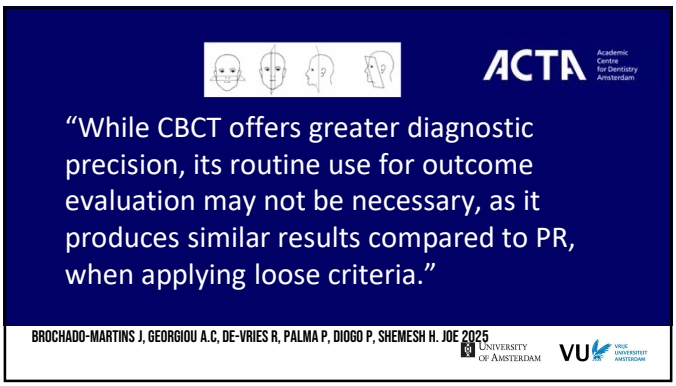
181



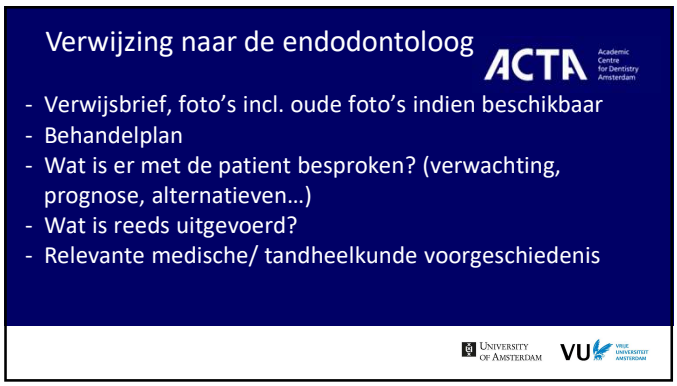
182



183



184



185

186