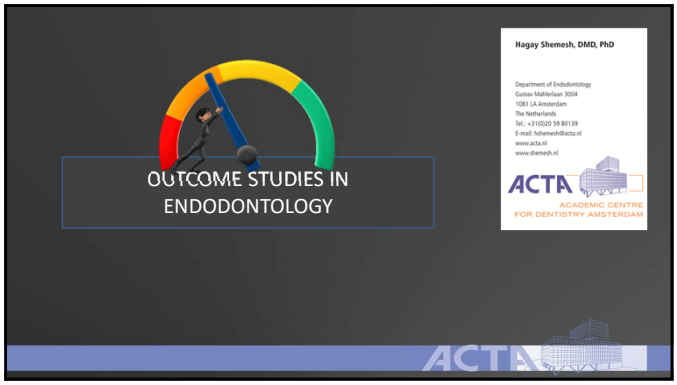
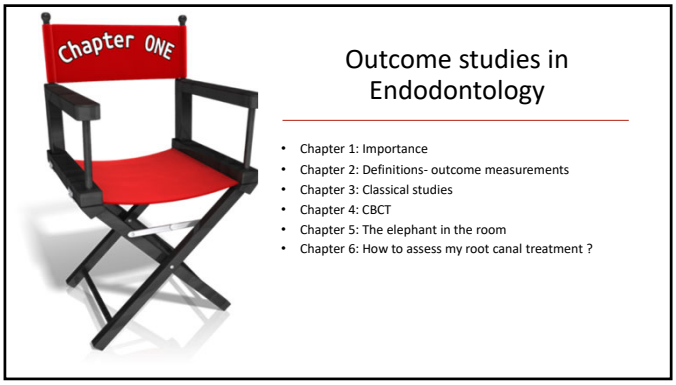
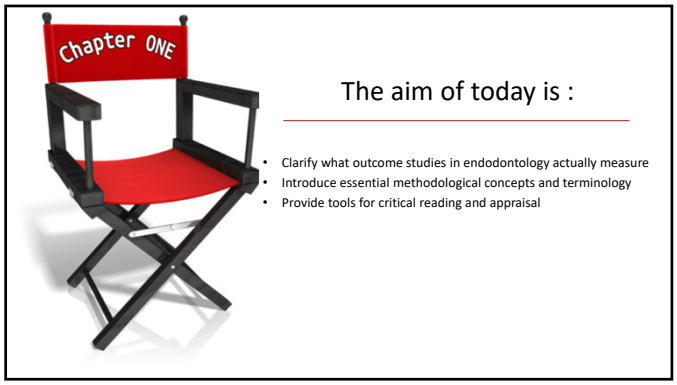

OUTCOME STUDIES IN ENDODONTOLOGY
Hagay Shemesh, DMD, PhD
Department of Endodontology
Gustav Mahlerlaan 3004
1081 LA Amsterdam
The Netherlands
Tel.: +31(0)20 59 80139
E-mail: hshemesh@acta.nl
www.acta.nl
www.shemesh.nl
ACTA
ACADEMIC CENTRE FOR DENTISTRY AMSTERDAM

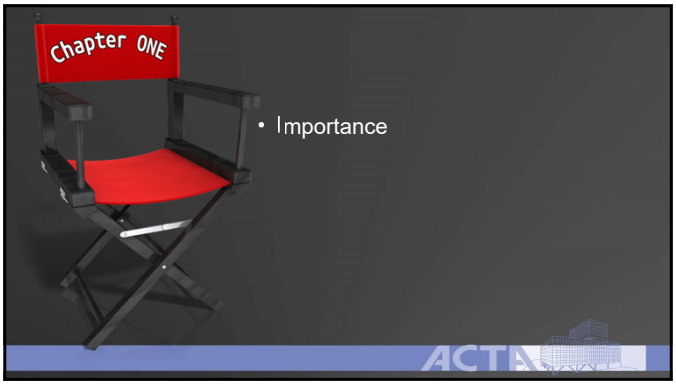
1


Chapter ONE
Outcome studies in Endodontology
Chapter 1: Importance
Chapter 2: Definitions- outcome measurements
Chapter 3: Classical studies
Chapter 4: CBCT
Chapter 5: The elephant in the room
Chapter 6: How to assess my root canal treatment ?

2


Chapter ONE
The aim of today is :
Clarify what outcome studies in endodontology actually measure
Introduce essential methodological concepts and terminology
Provide tools for critical reading and appraisal

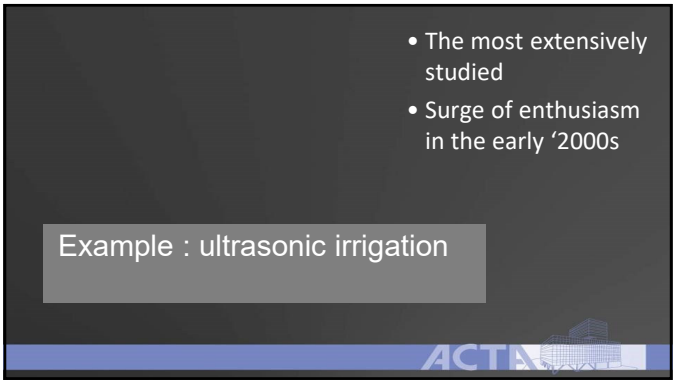
3


Chapter ONE
Importance

4


Which irrigation protocol?
To re-treat or not to re-treat?
Which file should I use?
Ultrasonic irrigation necessary?
Which obturation ?
Use calcium hydroxide?
Which sealer?
Which concentration of hypochloride?
Microscope necessary?
Outcome Studies
Bleaching with which material ?
Perforations- what to do?
Broken instruments- what to do ?
Full crown of composite ?

5


The most extensively studied
Surge of enthusiasm in the early '2000s
Example : ultrasonic irrigation

6

Radiographic healing after a root canal treatment performed in single-rooted teeth with and without ultrasonic activation of the irrigant: a randomized controlled trial

Root canal treatments with and without additional ultrasonic activation of the irrigant contributed equally to periapical healing.

JOE 2013 : Liang et al.

7

JOE 2019 : Căpută et al.

" …no strong clinical recommendations could be formulated"

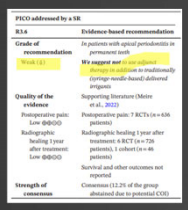
BDJ 2019 : Silva et al.

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

8

Effectiveness of adjunct therapy for treatment of apical periodontitis (R3.6)

LAI, PIPS, Ultrasonic, Sonic…



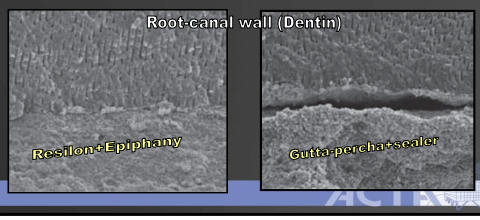
PICO addressed by a SR	
R3.6	Evidence-based recommendation
Grade of recommendation Weak (↕)	*In patients with apical periodontitis in permanent teeth* *We suggest not to use adjunct therapy in addition to traditionally (syringe needle-based) delivered irrigants*
Quality of the evidence	Supporting literature (Meire et al., 2022)
Postoperative pain: Low ⊕⊕◯◯	Postoperative pain: 7 RCTs (n = 636 patients)
Radiographic healing 1 year after treatment: Low ⊕⊕◯◯	Radiographic healing 1 year after treatment: 6 RCT (n = 726 patients), 1 cohort (n = 46 patients)
	Survival and other outcomes not reported
Strength of consensus	Consensus (12.2% of the group abstained due to potential COI)

ESE 2023 : S3 Guidelines

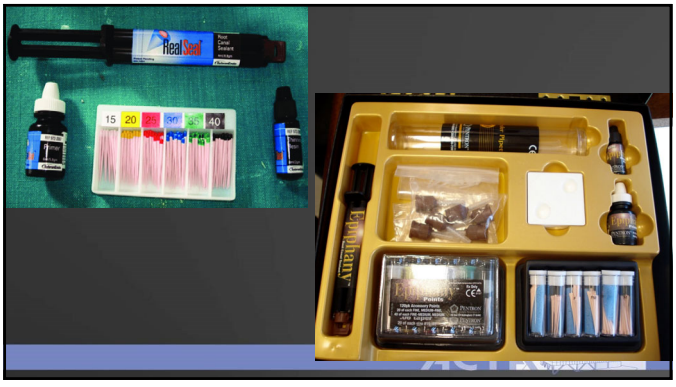
9

Resilon-Epiphany

- New composite root canal filling material
- Introduced in 2004 (Shipper *et al*. JOE)



10



11

12

Leakage studies

Resilon is better than GP	GP is better dan Resilon	GP=Resilon
Shipper *et al.* 2004	Shemesh *et al.* 2006	Shemesh *et al.* 2007
Budrumglu & Tunga 2006	Paque & Sirtes 2007	De Deus *et al.* 2007
Different conditions & models	Pasqualini et al. 2007	Baumgartner *et al.* 2007

13

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

Strange et al. JOE 2019

Resilon-treated teeth were 5.3 times more likely to have a periapical index of 3 to 5 at follow-up compared with gutta-percha .

Long-term Clinical Outcome of Teeth Obturated with Resilon.

Barborka et al. JOE 2017

Teeth obturated with Resilon had 5.7 times greater chance of failure compared with teeth obturated with GP.

14

Importance:

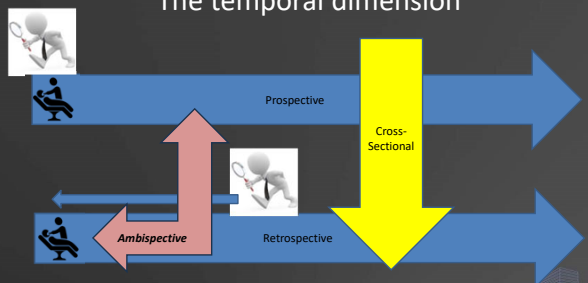
- Outcome studies are the only reliable way to check the influence of different treatment modalities/ materials/ instruments on the aims of the treatment

15

- General terms

16

The temporal dimension



17

Study Type	Data Collection Timing	Directionality	Advantages	Limitations
Retrospective	Looks **backward** in time (uses existing data)	Backward	- Faster, cheaper - Uses existing records	- Limited control over data quality - May have missing data
Prospective	Looks **forward** in time from study start	Forward	- Better control over data collection - Reduces bias	- Time-consuming - Expensive
Ambispective	Combines **past** and **future** data collection	backward & forward	- Longer observation window - Efficient use of time/resources	- Complexity in data integration - May inherit past biases

18

Primary and secondary clinical outcomes

- Primary
  - Healing of the periapical lesion
- Secondary
  - Time — Efficacy of three different rotary files to remove gutta-percha and Resilon from root canals. Marfisi K et al. Int Endod J. 2010
  - Esthetics — Biodentine Pulpotomies on Permanent Traumatized Teeth with Complicated Crown Fractures. Haikal L et al. J Endod. 2020
  - Cost effectiveness — Health economic evaluation of endodontic therapies. Schwendicke F, Herbst SR. Int Endod J. 2022

19

Endpoint and surrogate endpoint

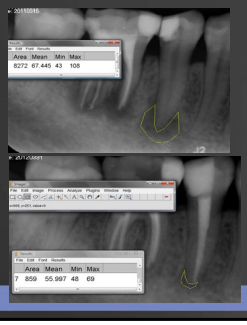
- Endpoint
  - Healing of the periapical lesion
- Surragate
  - Pain — Resolution of symptoms
  - Microbiology — Negative bacterial culture after instrumentationReduction in bacterial load (PCR-based)

20

Outcome was mostly determined by radiographs.

21

How do we measure/ determine healing?

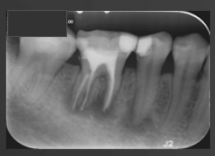


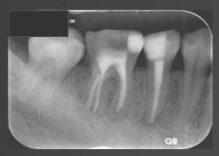
-Qualitative (strict)
-Simple measurements
-Scoring systems
-PAI
-CBCT-PAI

22

Qualitative assessment

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

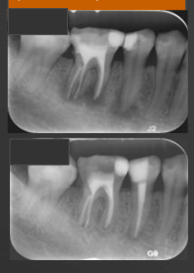




Who used this system ?
Ng et al. 2011

23

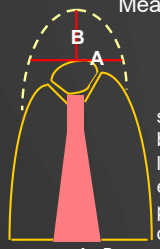
Qualitative assessment (strict criteria)



Advantage	Disadvantage
Quick & cheap	Subjective
Clinically relevant	No meaning to “ shrinkage”
	CBCT

24

Measurement of periapical lesions



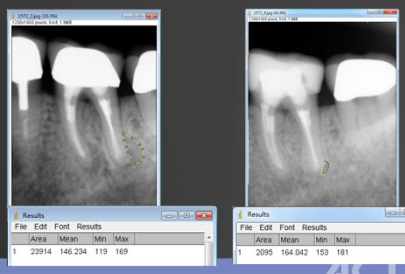
size of each lesion was calculated by taking the average of the lesion's largest dimension and its extent in the direction perpendicular to the largest dimension.

$$\text{Size} = \frac{A + B}{2}$$

JOE 1990 : Sjogren et al.

25

Measurement of periapical lesions



26

Simple measurements

Advantage	Disadvantage
cheap	Inaccurate
Quantitative	Time consuming
	Standardization of the radiographs

27

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

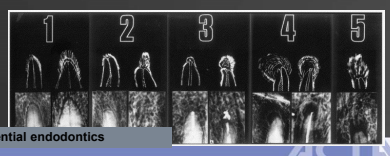
Who used this system ?
Peters & Wesselink 2002

IEJ 1983 : Reit & Gröndahl

28

PAI Score

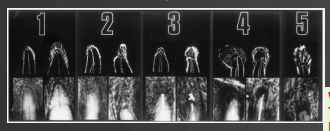
- PAI score (Ørstavik et al. 1986)
- "The PAI scoring system offers a visual reference scale for assigning a health status to the periapex. "



Essential endodontics

29

- 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

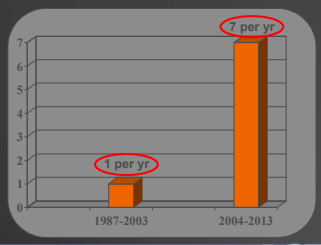


Who used this system ?
The Toronto studies
Marending et al. 2005
And
More than 70 studies !

PhD thesis 1967 : Brynolf

30

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

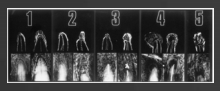


31

PAI score

Advantage

Disadvantage



Uniform

Easy to do

Maxillary incisors

Radiographs, 2D

Dichotomization

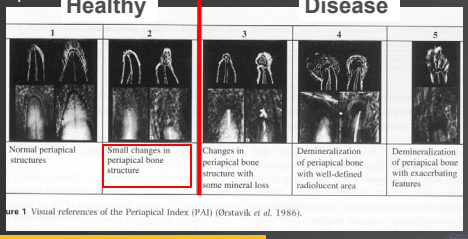
32

"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).

Endo Dent Traumat 1986 : Ørstavik et al.

33

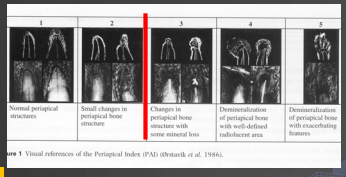
Success=	PAI 1+2	PAI 1
ALL	90	58
NO Pre-op PA	94	70
Pre-op PA	79	26

Eur J Oral Sci 2004 : Ørstavik et al.

34

Prognostic value of the full-scale Periapical Index.

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 …

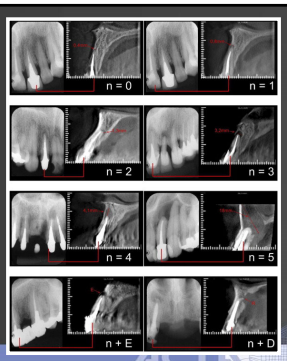


ure 1 Visual references of the Periapical Index (PAI) (Ørstavik *et al.* 1986).

IEJ 2014 : Kirkevang et al.

35

The CBCT-PAI score

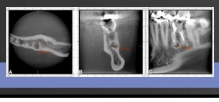


JOE 2008 : Estrella et al.

36

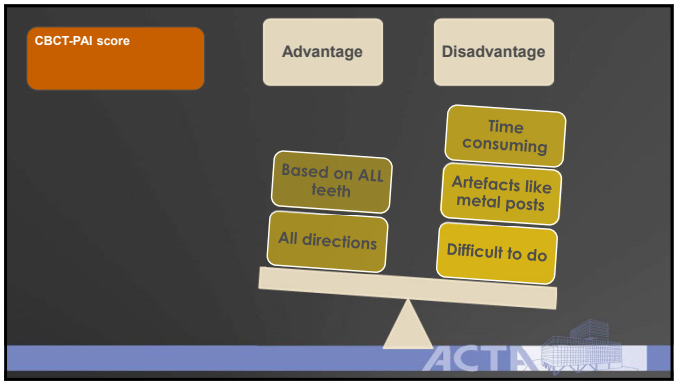
37

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

38

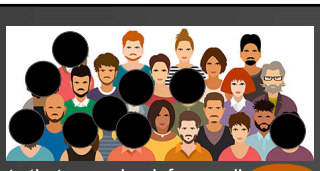


39

Outcome terminology

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

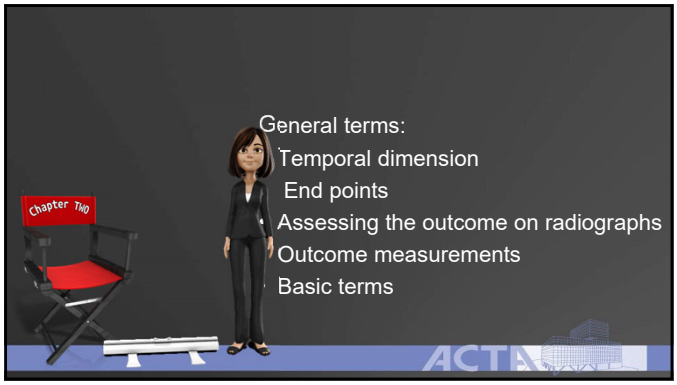
40



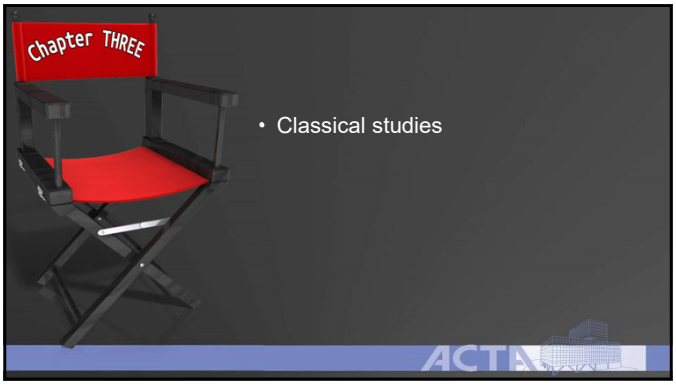
- Cohort 24
- Drop outs 9
- Recall rate- % of cohort patients that came back for recall 62.5%
- Recall rate < 70% decreases the accuracy of the conclusions
- recall rate ↑ accuracy ↑
- Follow-up period ↑ recall rate ↓

41

42



43



44

45

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

46

TERMS

- NO success or failure !!!
- PAI score
- Healed and healing

47

Toronto studies – JOE 2003-2010

Treatment outcome in endodontics: **the Toronto Study**. Phase 1: initial treatment. Friedman S, Abitbol S, Lawrence HP. 2003

Treatment outcome in endodontics- **the Toronto Study**. Phase II: initial treatment. Farzaneh M, Abitbol S, Lawrence HP, Friedman S. 2004

Treatment outcome in endodontics: **the Toronto study**. Phases I and II: Orthograde retreatment. Farzaneh M, Abitbol S, Friedman S. 2004

Treatment outcome in endodontics- **The Toronto Study**. Phases I and II: apical surgery. Wang N, Knight K, *Dao T*, Friedman S2004

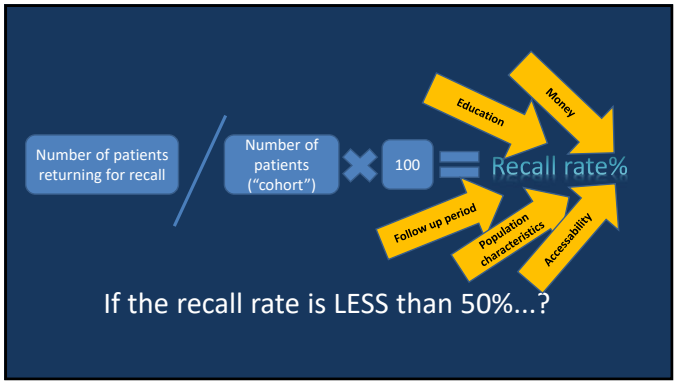
Treatment outcome in endodontics: **the Toronto Study**. Phase III: initial treatment. Marquis VL, *Dao T*, Farzaneh M, Abitbol S, Friedman S. 2006

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

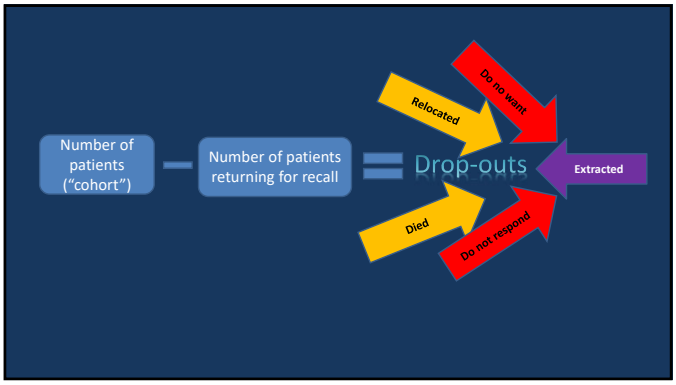
Treatment outcome in endodontics: **the Toronto study**--phase 4: initial treatment. de Chevigny C, *Dao TT, Basrani BR*, Marquis V, Farzaneh M, Abitbol S, Friedman S . 2008

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

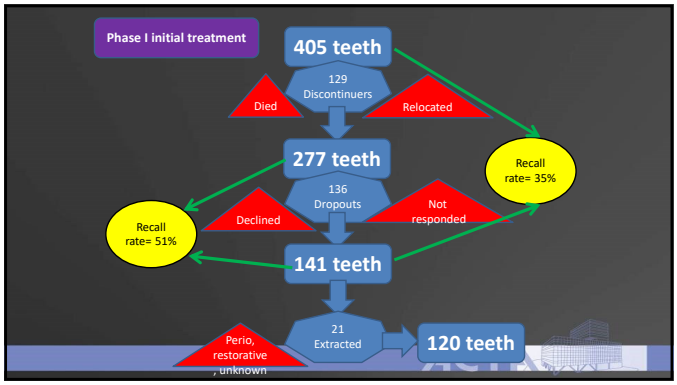
48



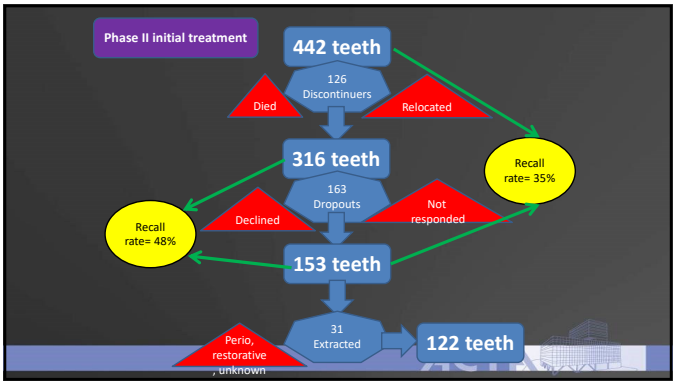
49



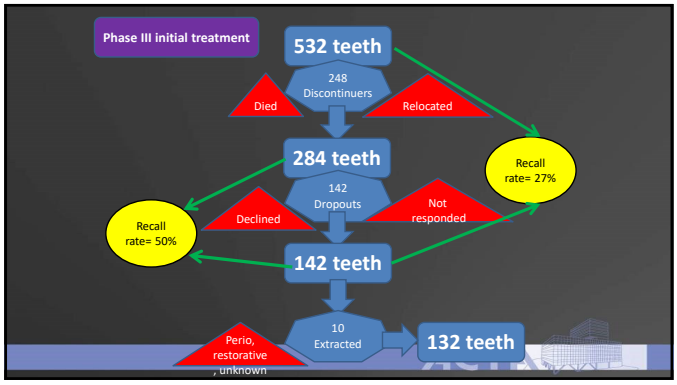
50



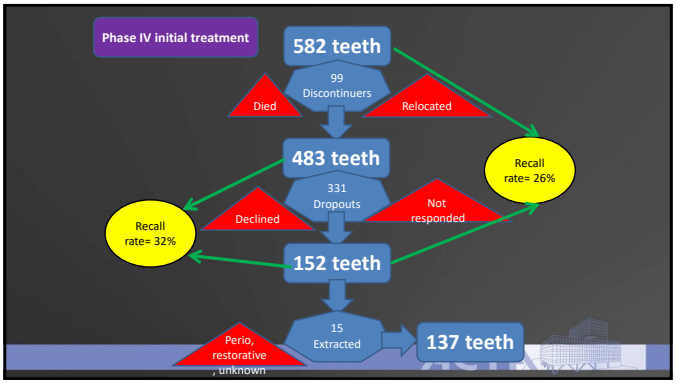
51



52



53



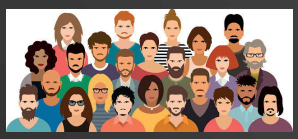
54

"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.

55

Came for the recall



Drop-outs

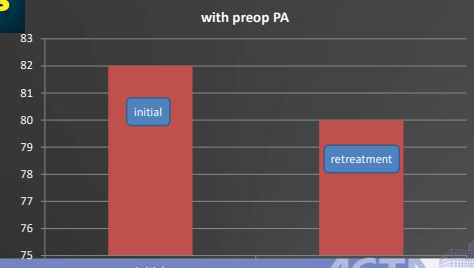
Population diversity : age, sex, smokers
Tooth characteristics : Type, diagnosis

56

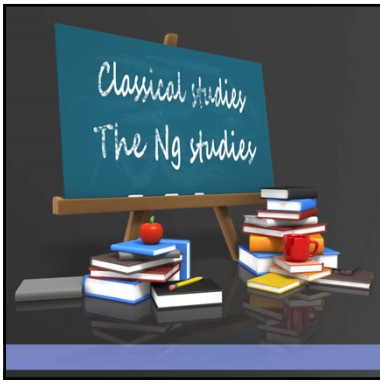
Results- Toronto studies

57

Outcome phases 1-4
Healed precentage



58



59

Ng studies- IEJ

1. "Outcome of primary…part 1 " Ng, Mann, Rahbarab, Lewsey & Gulabivala 2007
2. "Outcome of [illegible] Rahbarab, Lewsey & Gulabivala 2007
3. "Outcome of s[illegible] 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

60

A prospective study of the factors affecting outcomes of nonsurgical root canal treatment: part 1: periapical health.

- 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

IEJ 2011 : Ng et al.

61

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

IEJ 2011 : Ng et al.

62

Outcome measurements

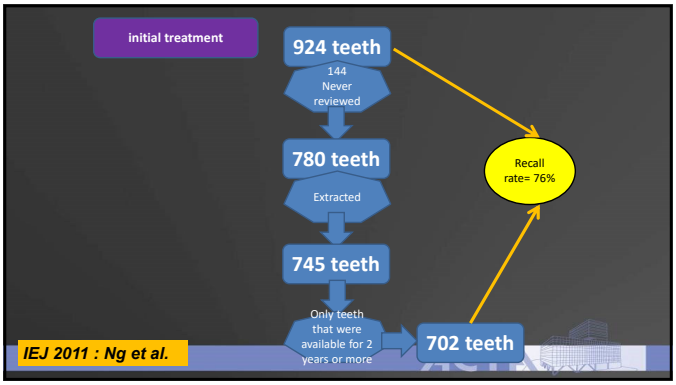
- Ng does not agree with Friedman and contantly uses the term "success rate".
- Primary: Clinical and radiographic : absence or healing of lesion for each root
- Secondary: survival

Succeess:

- 1.strict criteria : no pain, sympthoms and complete healing
- 2.Loose criteria : healing lesion.

IEJ 2011 : Ng et al.

63



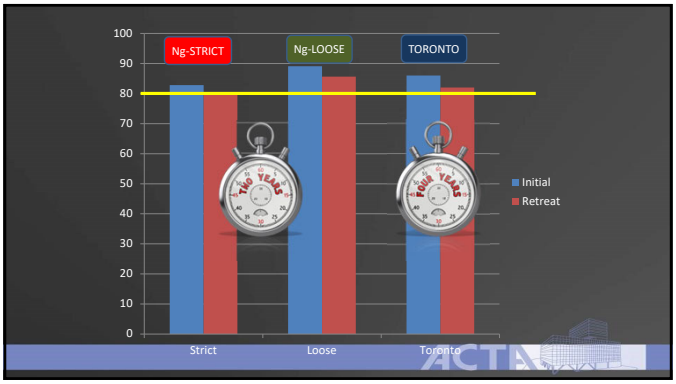
64

Results Ng

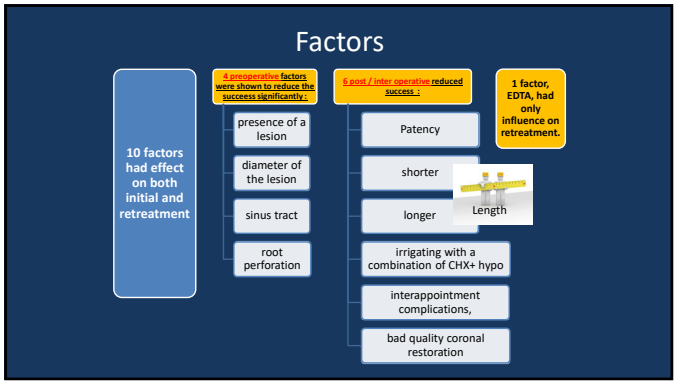
	Initial	retreatment
Strict	82,8	80,1
Loose	89,1	85,6
Toronto pooled	86	82

IEJ 2011 : Ng et al.

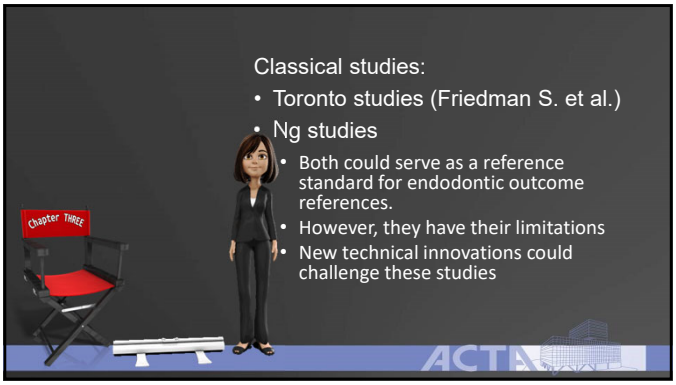
65



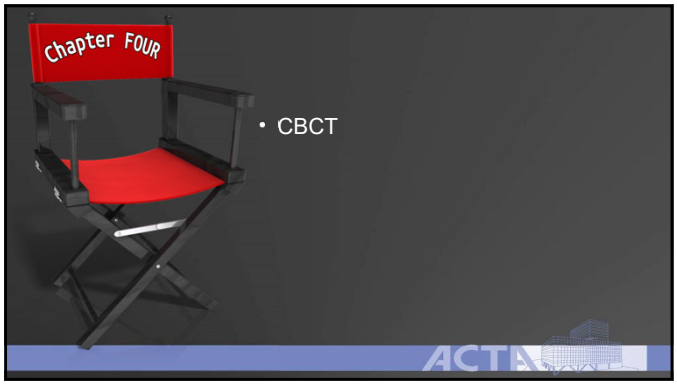
66



67

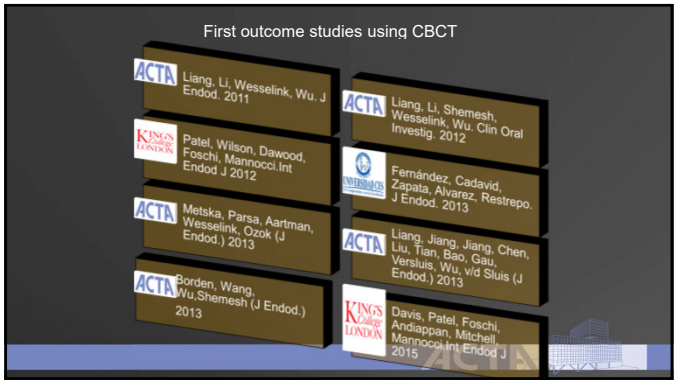


68

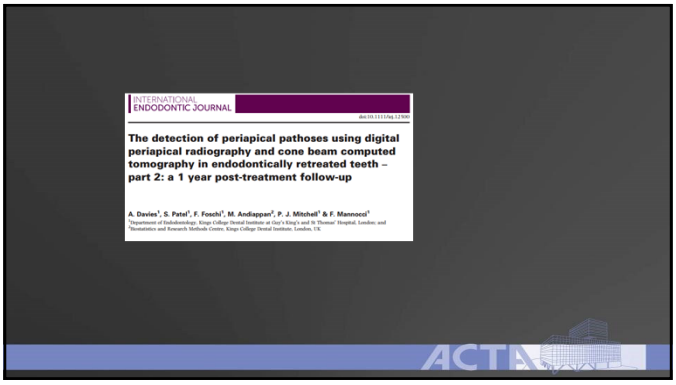


69

70



71



72

No.teeth	117
Pre-op PA?	yes
Follow up (y)	1
Method	Increase/ decrease
Recall %	86
Healed X-ray %	77
Healed CBCT %	61
Diminished lesion CBCT %	77

IEJ 2015 : Davies et al.

73

Important findings:

- Complete healing of a periapical lesion on CBCT is either slow or rare
- Looking at the “healed” and “healing” together (“ loose criteria”) results in success percentages which are not different than other studies without CBCT

IEJ 2011 : Wu, Wesselink & Shemesh

74

CBCT reveals lower success rates under strict criteria compared to loose criteria (36% vs 88%). While CBCT offers greater diagnostic accuracy, its routine use for outcome evaluation may not be necessary, as it yields results similar to periapical radiograph under loose criteria.

REVIEW ARTICLE

CBCT-Assessed Outcomes and Prognostic Factors of Primary Endodontic Treatment and Retreatment: A Systematic Review and Meta-Analysis

João Filipe Brochado Martins, DDS, MSc,† Athina Christina Georgiou, DDS, MSc, PhD,† Patrícia Diogo Nunes, MSc, PhD,‡§ Ralph de Vries, MSc,‖ Vera Mónica Almeida Afreixo, MSc, PhD,‖ Paulo Jorge Rocha da Palma, DMD, MSc, PhD,†¶ and Hagay Shemesh, DDS, PhD†

JOE 2025 : Brochado Martins et al

75

- Selective retreatment

76

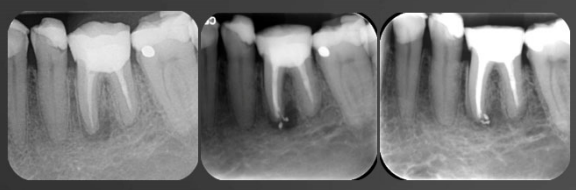
Outcome of Selective Root Canal Retreatment - a retrospective study

JOÃO FILIPE BROCHADO MARTINS

J. Brochado Martins, P. Diogo, O. Guerreiro Viegas, R. Cristescu, H. Shemesh

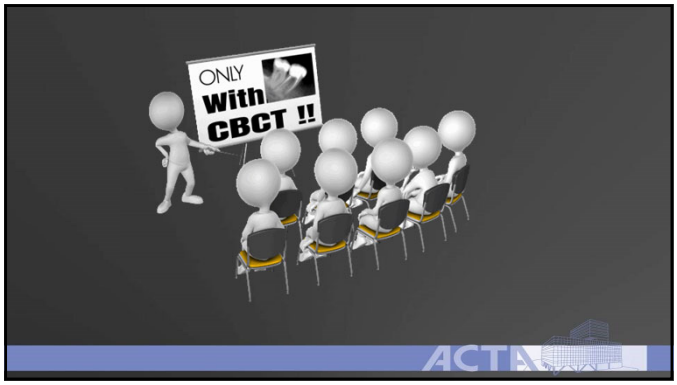
IEJ 2022 : Brochado-Martins et al.

77

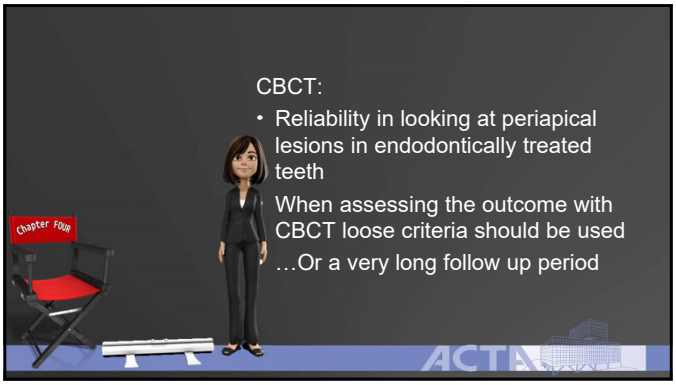


IEJ 2022 : Brochado-Martins et al.

78

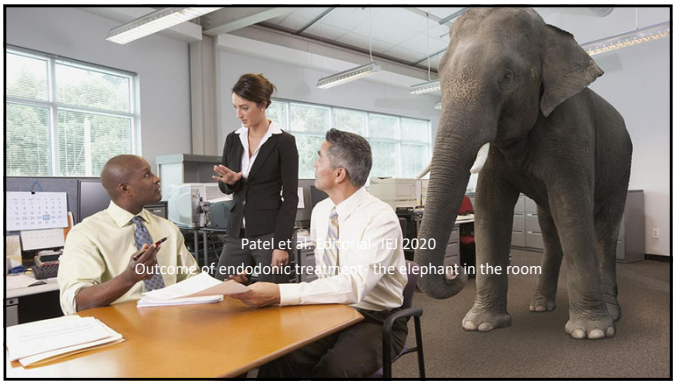


79



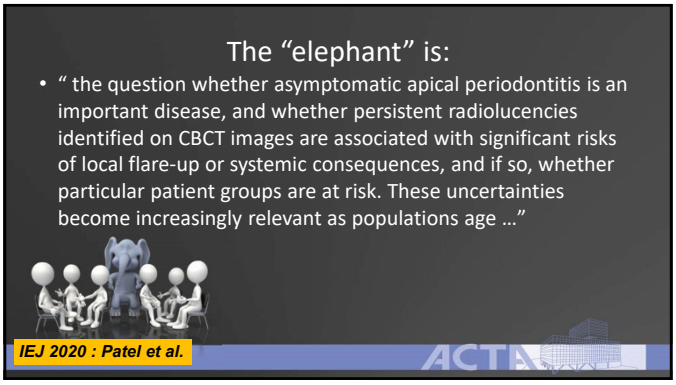
80

81



82

83



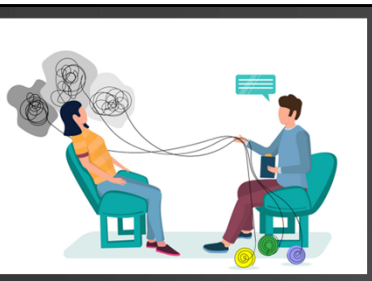
84

Apical Periodontitis Is Associated with Elevated Concentrations of Inflammatory Mediators in Peripheral Blood: A Systematic Review and Meta-analysis.

Conclusions: The existing literature indicates that AP adds on to systemic inflammation by elevating C-reactive protein, interleukin 6, asymmetric dimethylarginine, and C3 levels.

JOE 2019 : Georgiou et al.

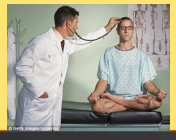
85



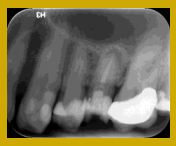
Individually designed treatments

86

Patient-centered outcome: Quality of Life Costs/ pain Functionality



Disease-centered outcome: Healing of the periapical lesion



87

The elephant in the room:

- How important is an asymptomatic periapical lesion and should we treat it ?

88

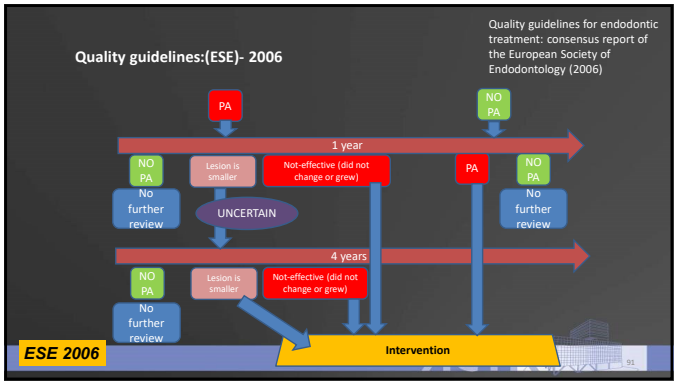
- Monitoring the outcome

89

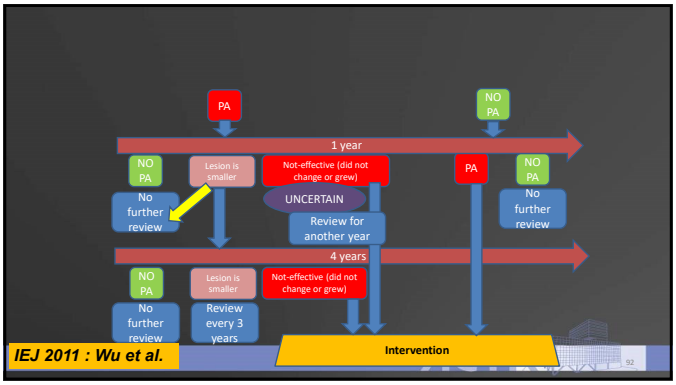
Monitoring the outcome

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

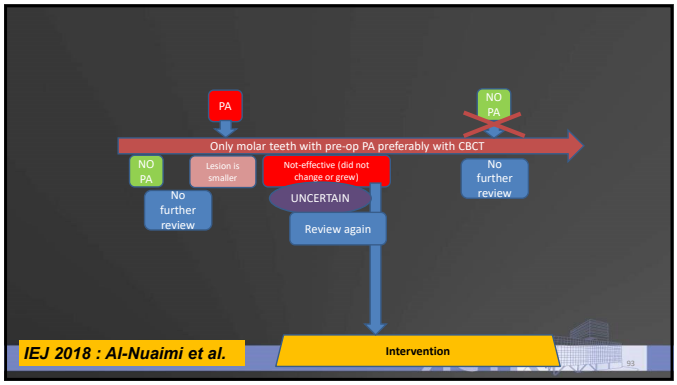
90



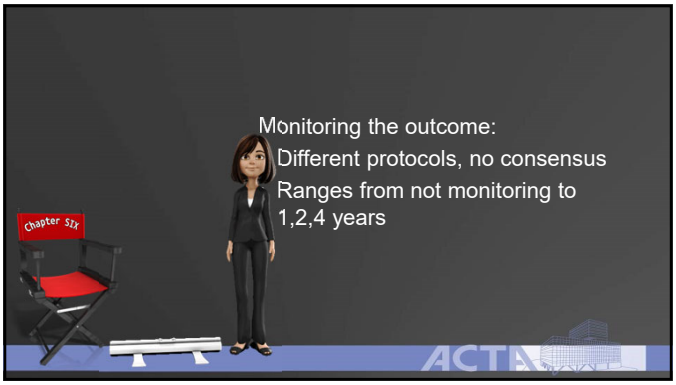
91



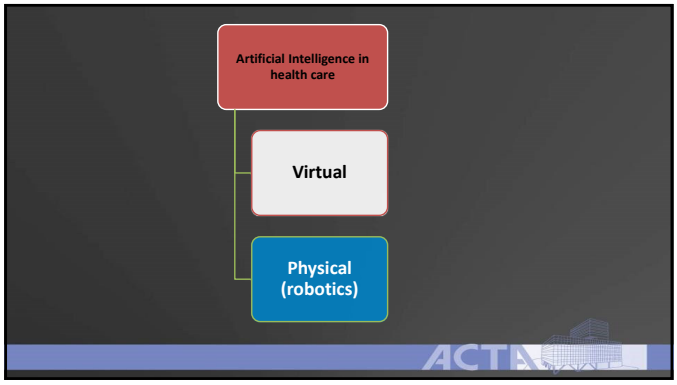
92



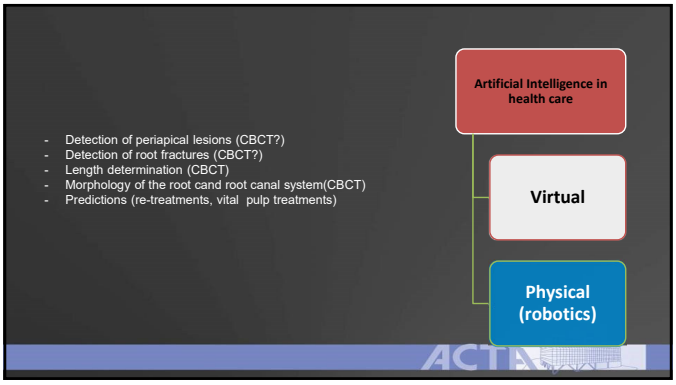
93



94

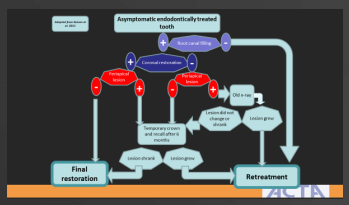


95



96

Artificial intelligence (AI) has the potential to replicate human intelligence to make predictions and complex decision making in the health care systems



Artificial Intelligence in Endodontics: Current Applications and Future Directions.

JOE 2021 : Aminoshariae et al.

97

Development and evaluation of a deep learning segmentation model for assessing non-surgical endodontic treatment outcomes on periapical radiographs: A retrospective study

Plos One 2024: Dennis et al.

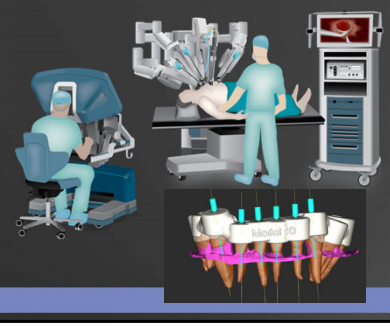
98

Association between patient-, tooth- and treatment-level factors and root canal treatment failure: A retrospective longitudinal and machine learning study.

Predicting failure was only limitedly possible, also with more complex Machine Learning.

J Dent 2022 : Herbst et al.

99

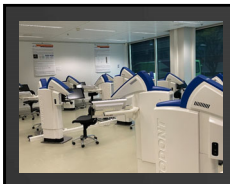


Artificial Intelligence in health care

Virtual

Physical (robotics)

100



Artificial Intelligence in health care

Virtual

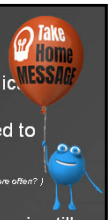
Physical (robotics)

First experiences with patient-centered training in virtual reality.

J Dent Educ 2020: Serrano, Wesselink, Vervoorn

101

- 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!)
- The importance of persistent asymptomatic periapical lesions is still unknown
- Hopefully more uniform outcome studies will be conducted (COS)
- AI will be able to predict the outcome in the near future



102

The aim of today is :

- Clarify what outcome studies in endodontology actually measure
- Introduce essential methodological concepts and terminology
- Provide tools for critical reading and appraisal

103

104