Tissue Responses to Injury

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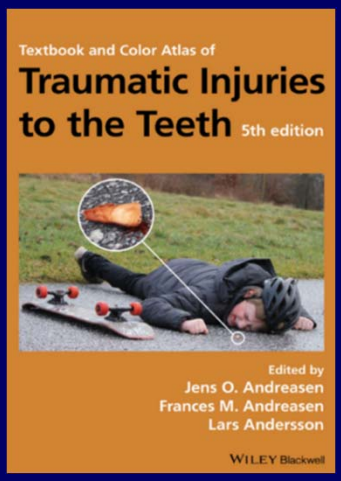
Tissue Responses to Injury



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References







3

Strategies to Minimise the Consequences of Trauma to the Teeth

Abbott PV,
Castro Salgado J.

J Oral Health & Dental Management
2014; 13: 229-42.



Prevention and Management of External Inflammatory Resorption following Trauma to Teeth

Abbott PV.

Aust Dent J
2016; 61 (1 Suppl): 82-94.





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Outline

- Introduction
- Potential consequences of trauma
- Tissue responses to trauma
  - Pulp
  - Peri-radicular tissues
  - Gingiva and oral mucosa
- Factors that affect healing

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What is Trauma ???

- An injury or wound to the tissues
  - Can be caused by:
    - An accident
      - e.g. MVA, fall, fight, etc
    - Chemical means
      - e.g. Erosion
    - Mechanical means
      - e.g. Abrasion, Attrition
    - Bacteria
      - e.g. Caries

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Some Things to Consider …

- **Trauma is a common occurrence**
  - One in every 2 children by the age of 14 years
    - → 30% of children - primary dentition trauma
    - → 22% of children - permanent dentition trauma
  - Boys twice as often as girls

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Some Things to Consider …

- **Peak age ranges:**
  - 2 - 4 years old
    - → Primary dentition
    - → Underlying developing permanent teeth
      - ✪ May be damaged and affect their development
  - 8-10 years old
    - → Permanent dentition
    - → Incompletely developed teeth
      - ✪ May be problematic if pulp necrosis occurs

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Some Things to Consider …

- Trauma often occurs "after hours"
- Trauma is an "emergency"
  - Patients often present to hospital clinics (usually no dentist)
- General dentists do not treat trauma regularly
  - Can lead to uncertainty about treatment
- The long-term prognosis depends largely on the *"emergency management"*
  - Correct treatment is essential to help reduce the consequences of dental trauma

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Outline

- Introduction
- Potential consequences of trauma
- Tissue responses to trauma
  - Pulp
  - Peri-radicular tissues
  - Gingiva and oral mucosa
- Factors that affect healing

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Potential Consequences of Trauma

- Many potential consequences - range from:
  - NIL:
    - e.g. Infractions, concussion
      - Monitor and review

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Potential Consequences of Trauma

- Many potential consequences - range from:
  - NIL ➔ VARIOUS TREATMENTS:
    - e.g. Complicated crown fracture
      - RCF, cast post/core, full crown, review

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Potential Consequences of Trauma

- Many potential consequences - range from:
  - NIL ➔ VARIOUS TREATMENTS:
    - e.g. Complicated crown fracture
      - RCF, cast post/core, full crown, review



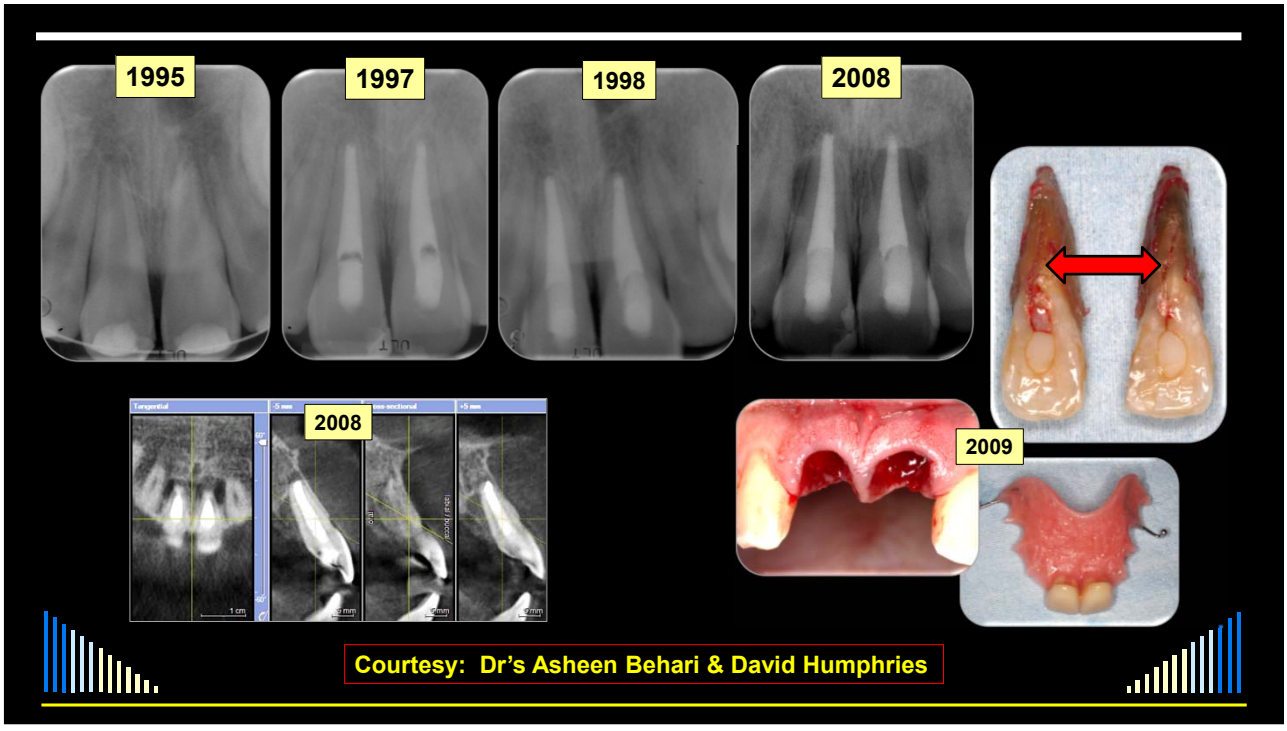
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Potential Consequences of Trauma

- Many potential consequences - range from:
  - NIL → VARIOUS TREATMENTS → EXTRACTION:
    - → e.g. Avulsion
      - Replant, apexification, RCF, restoration, review

      AND then subsequent cracks + infection of RCS
      - Extraction, partial denture, implant, review, maintain

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Outline

- Introduction
- Potential consequences of dental trauma
- Tissue responses to trauma
  - Pulp
  - Peri-radicular tissues
  - Gingiva and oral mucosa
- Factors that affect healing

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Trauma and Healing Responses

- Traumatic dental injuries are complex
  - 6 types of luxations and 9 types of fractures
  - Each is a unique injury to hard & soft tissues
- Often concurrent luxations + fractures
  - Hence 6 x 9 = 54 healing scenarios
- 19 cellular systems in the dental organ
  - All with different healing potentials

Andreasen - *Dent Traumatol* 2012

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Responses after Trauma

✓ Favourable
× Unfavourable

⟷

- Short-term
- Medium-term
- Long term

- Pulp / Root Canal System
- Peri-Radicular Tissues
- Gingivae

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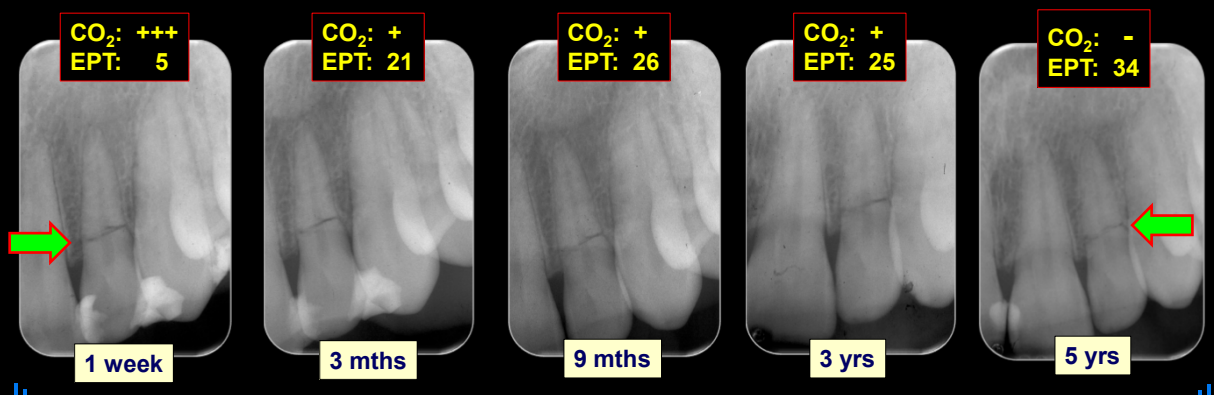
Pulp Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Pulp fibrosis

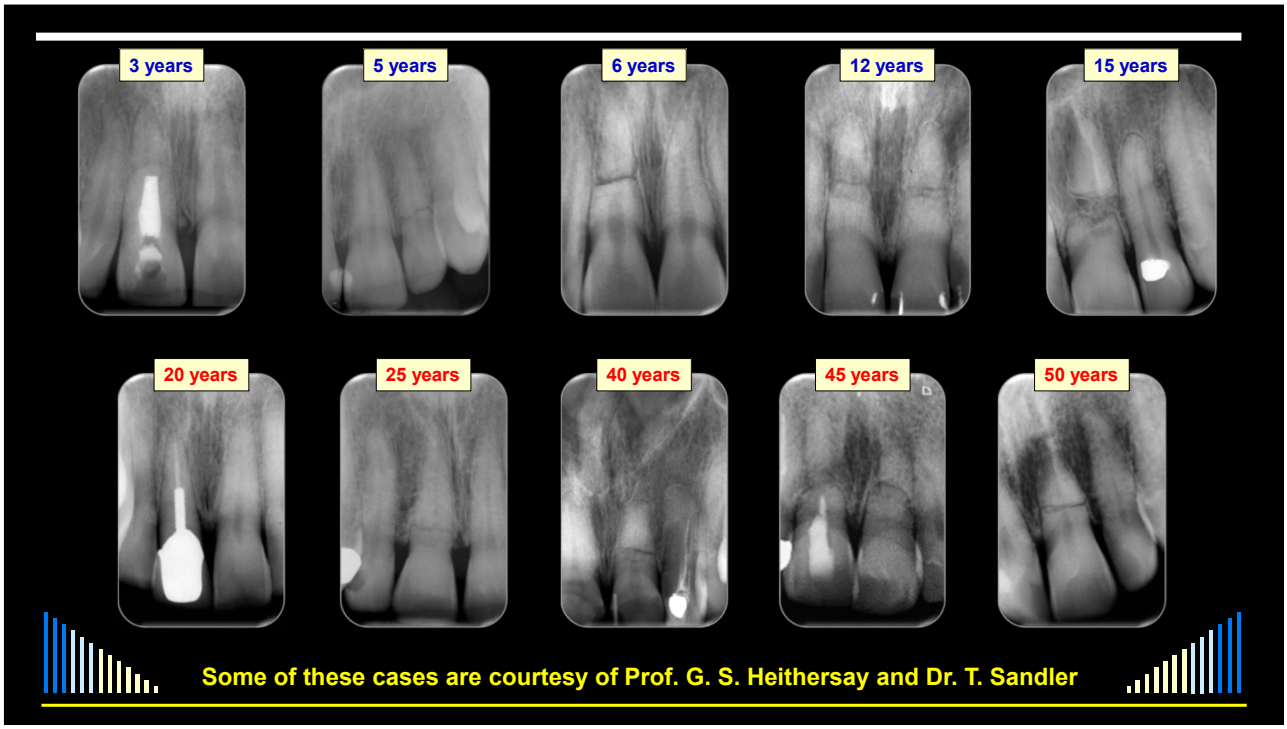
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Pulp Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Pulp fibrosis



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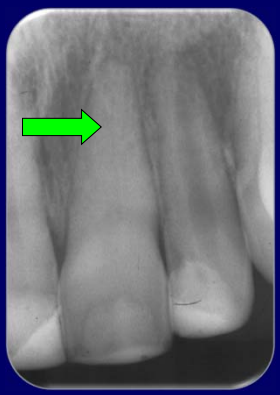


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Pulp Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Pulp fibrosis
- ☑ Pulp Canal Calcification (PCC)
  - Partial
  - "Complete" - i.e. radi
    - → PCC - can usuall within the first ye
      - Andreasen FM





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Pulp Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Pulp fibrosis
- ☑ Pulp Canal Calcification (PCC)
  - Partial
  - "Complete" - i.e. radiographically
- ✗ Pulp necrosis
- ✗ Infection of the pulp space
  - PN - can usually diagnose within 3 mths after luxations and root fractures
    - → Andreasen FM *et al* - *EDT* 1985



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Pulp Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Pulp fibrosis
- ☑ Pulp Canal Calcification (PCC)
  - Partial
  - "Complete" - i.e. radiographically
- ✗ Pulp necrosis
- ✗ Infection of the pulp space
- ✗ Internal resorption
  - Surface
  - Inflammatory
  - Replacement

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Pulp Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Pulp fibrosis
- ☑ Pulp Canal Calcification (PCC)
  - Partial
  - "Complete" - i.e. radiographically
- ✗ Pulp necrosis
- ✗ Infection of the pulp space
- ✗ Internal resorption
  - Surface
  - Inflammatory
  - Replacement

✚ Combinations of the various responses
- Simultaneously
- Sequentially over time

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Lateral Luxation + Infractions - 8 years ago

Favourable

Unfavourable

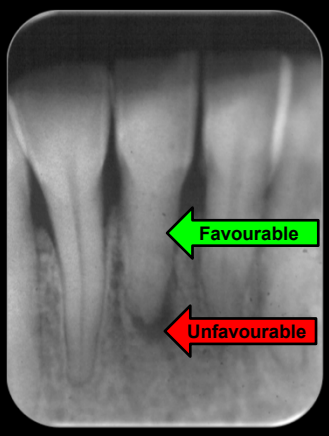
Initially - the Pulp survived

Then - Pulp Canal Calcification
- Partial
- "Complete" - i.e. radiographically

Later - Pulp Necrosis & Infection of the Root Canal System

Chronic Apical Periodontitis

2° Acute Apical Periodontitis



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Peri-Radicular Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Fibrous healing

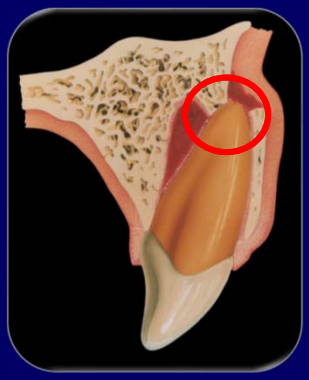
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Peri-Radicular Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Fibrous healing
- ☑ Transient Apical Breakdown (TAB)
  - Andreasen FM *et al* - *EDT* 1986

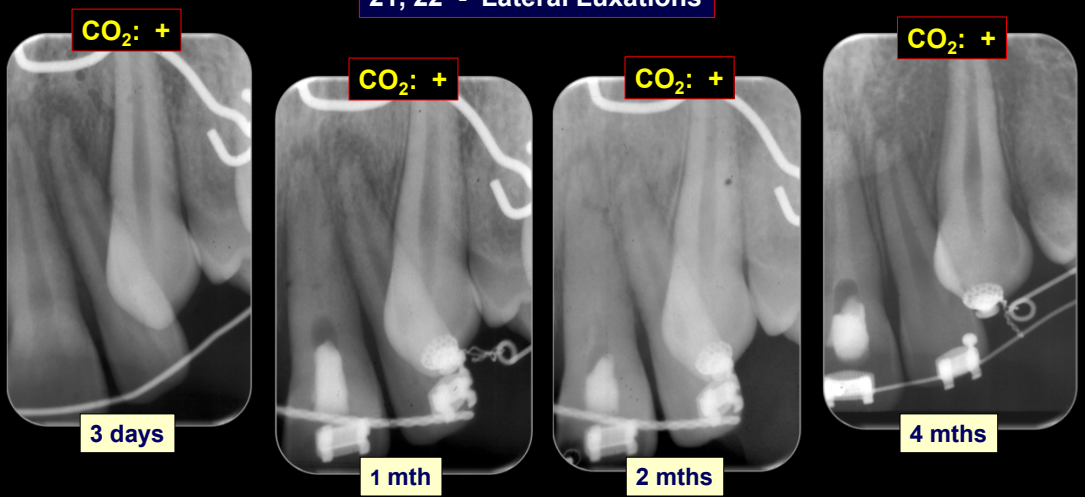




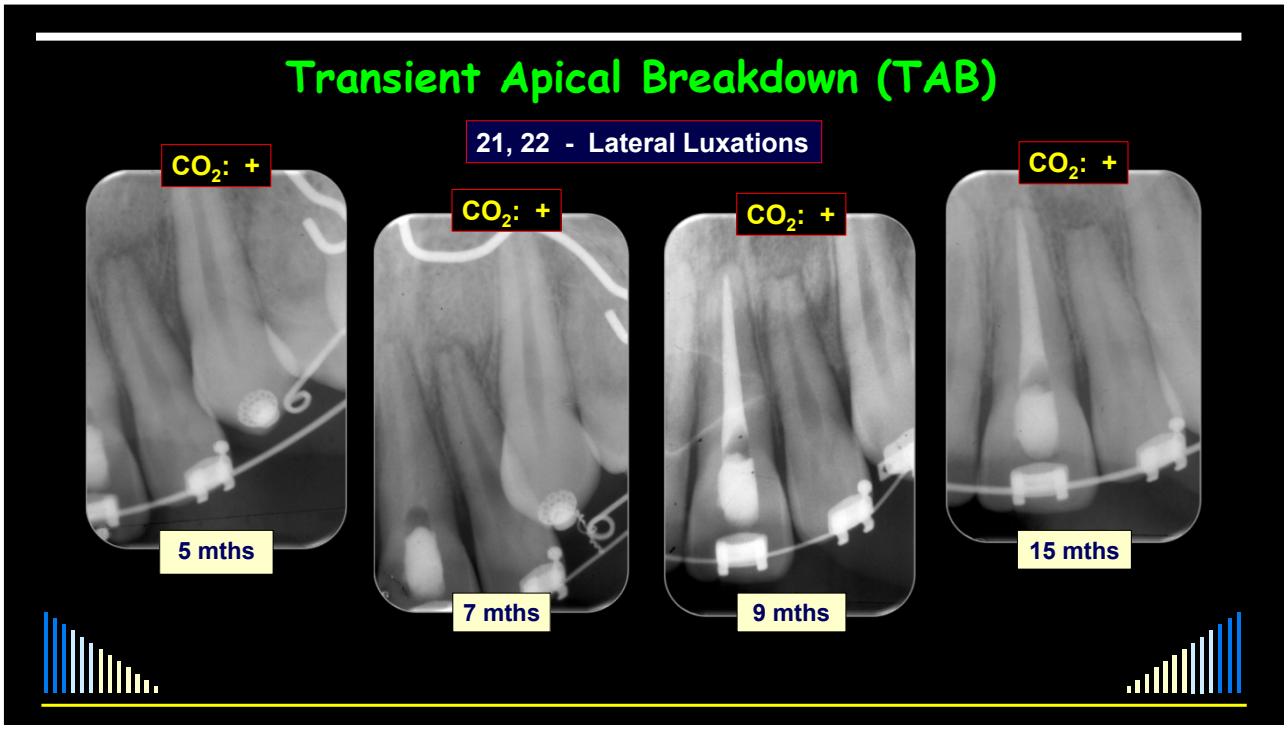
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Transient Apical Breakdown (TAB)

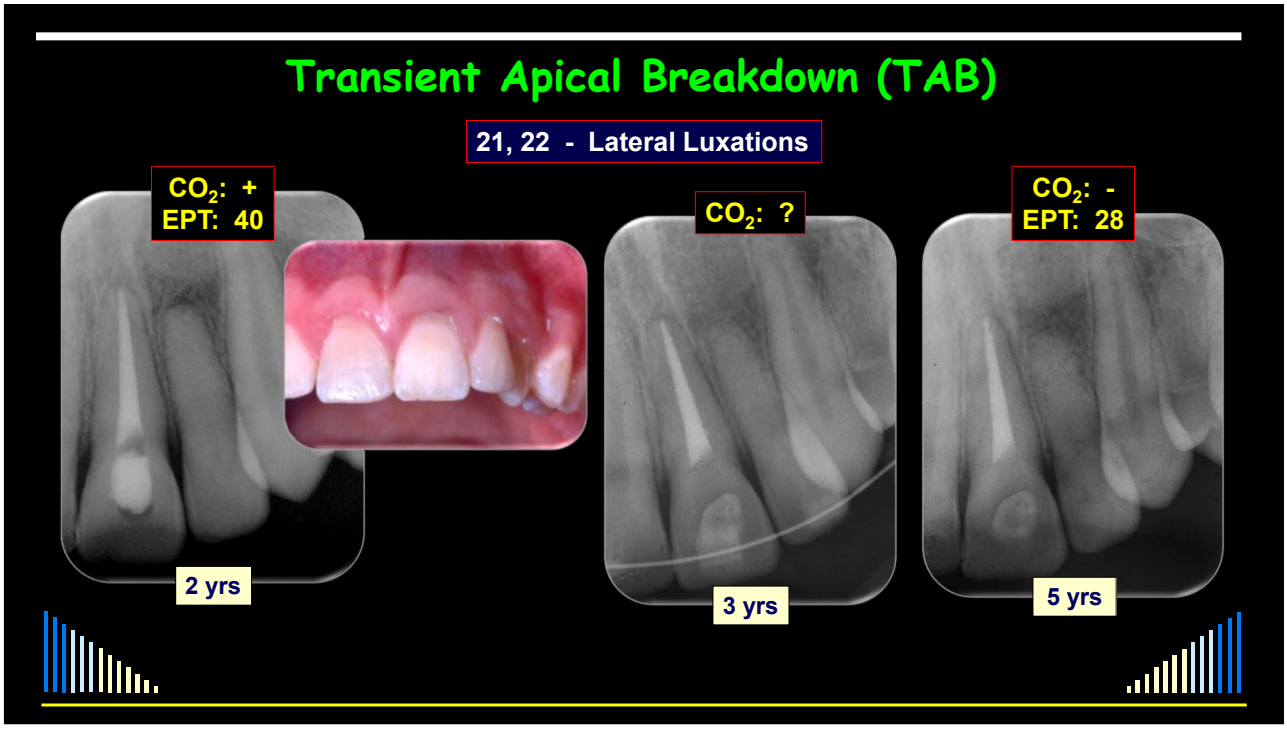
21, 22 - Lateral Luxations



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Transient Apical Breakdown (TAB)
21, 22 - Lateral Luxations
CO_2: +
5 mths
CO_2: +
7 mths
CO_2: +
9 mths
CO_2: +
15 mths

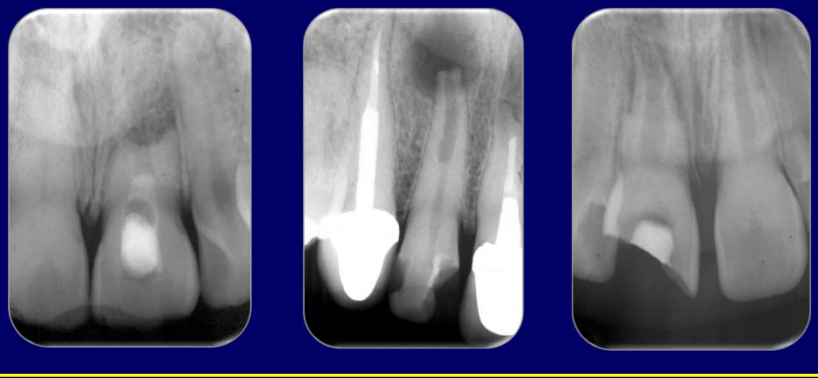
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Transient Apical Breakdown (TAB)
21, 22 - Lateral Luxations
CO_2: +
EPT: 40
2 yrs
CO_2: ?
3 yrs
CO_2: -
EPT: 28
5 yrs

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Peri-Radicular Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Fibrous healing
- ☑ Transient Apical Breakdown (TAB)
- × Cessation of root development
- × Disturbances to root development



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Peri-Radicular Responses to Trauma

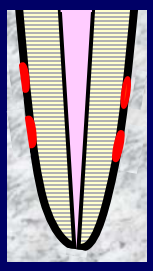
- ☑ Recovery and return to a normal state
- ☑ Fibrous healing
- ☑ Transient Apical Breakdown (TAB)
- × Cessation of root development
- × Disturbances to root development
- × Bone resorption
  - Marginal (crestal)
  - Apical
  - Lateral



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Peri-Radicular Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Fibrous healing
- ☑ Transient Apical Breakdown (TAB)
- × Cessation of root development
- × Disturbances to root development
- × Bone resorption
  - Marginal (crestal)
  - Apical
  - Lateral
- × External resorption
  - Surface



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Peri-Radicular Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Fibrous healing
- ☑ Transient Apical Breakdown (TAB)
- × Cessation of root development
- × Disturbances to root development
- × Bone resorption
  - Marginal (crestal)
  - Apical
  - Lateral
- × External resorption
  - Surface
  - Inflammatory



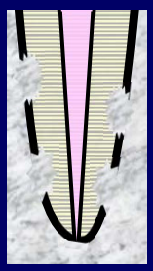


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Peri-Radicular Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Fibrous healing
- ☑ Transient Apical Breakdown (TAB)
- × Cessation of root development
- × Disturbances to root development
- × Bone resorption
  - Marginal (crestal)
  - Apical
  - Lateral
- × External resorption
  - Surface
  - Inflammatory
  - Replacement





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Peri-Radicular Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Fibrous healing
- ☑ Transient Apical Breakdown (TAB)
- × Cessation of root development
- × Disturbances to root development
- × Bone resorption
  - Marginal (crestal)
  - Apical
  - Lateral
- × External resorption
  - Surface
  - Inflammatory
  - Replacement
  - Invasive





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Peri-Radicular Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Fibrous healing
- ☑ Transient Apical Breakdown (TAB)
- × Cessation of root development
- × Disturbances to root development
- × Bone resorption
  - Marginal (crestal)
  - Apical
  - Lateral
- × External resorption
  - Surface
  - Inflammatory
  - Replacement
  - Invasive
- ◆ Ankylosis
  - With root resorption
  - Without root resorption

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Peri-Radicular Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Fibrous healing
- ☑ Transient Apical Breakdown (TAB)
- × Cessation of root development
- × Disturbances to root development
- × Bone resorption
  - Marginal (crestal)
  - Apical
  - Lateral
- × External resorption
  - Surface
  - Inflammatory
  - Replacement
  - Invasive
- ◆ Ankylosis
  - With root resorption
  - Without root resorption

+ Combinations of various responses
  - Simultaneously
  - Sequentially over time

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Peri-Radicular Responses to Trauma



External Inflammatory & Replacement Resorption



External Inflammatory Resorption & Bone Resorption



External Invasive & Replacement Resorption

- Combinations of various responses
  - Simultaneously
  - Sequentially over time

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Soft Tissue Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Fibrous healing - scar





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Soft Tissue Responses to Trauma

- ☑ Recovery and return to a normal state
- ☑ Fibrous healing - scar
- × Loss of attachment



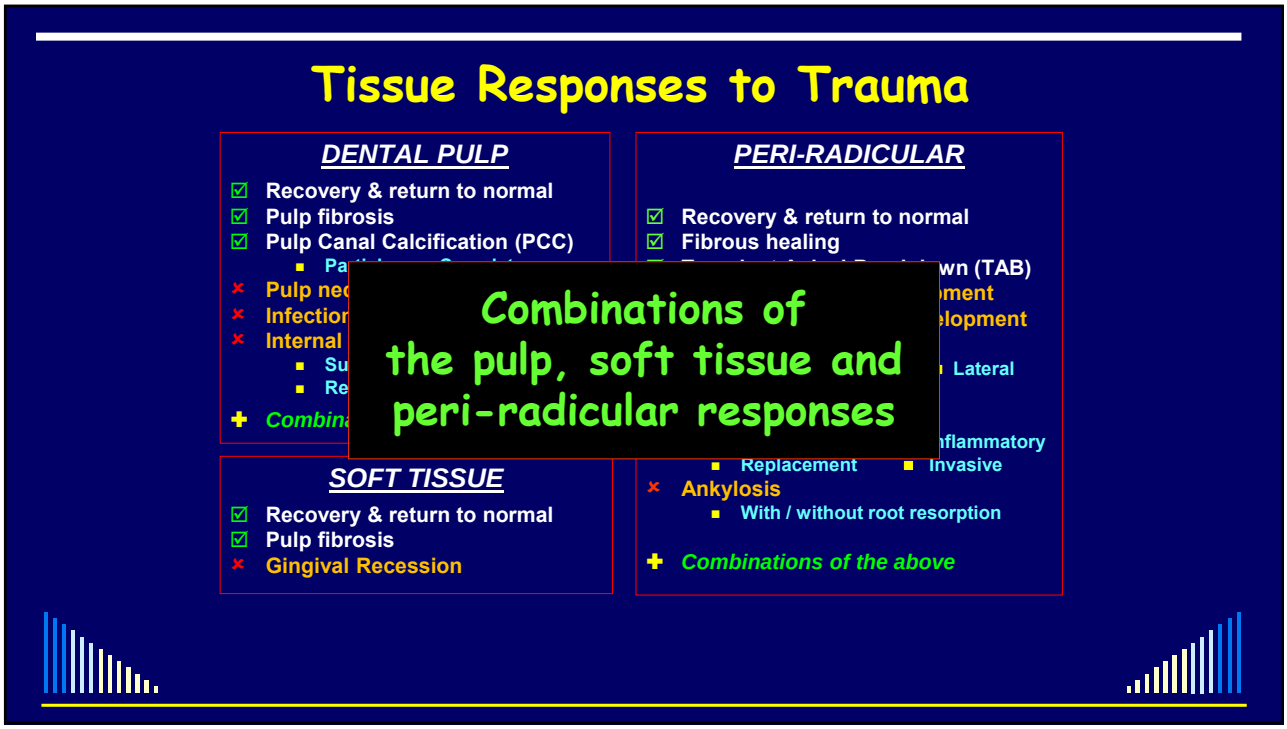
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Soft Tissue Responses to Trauma

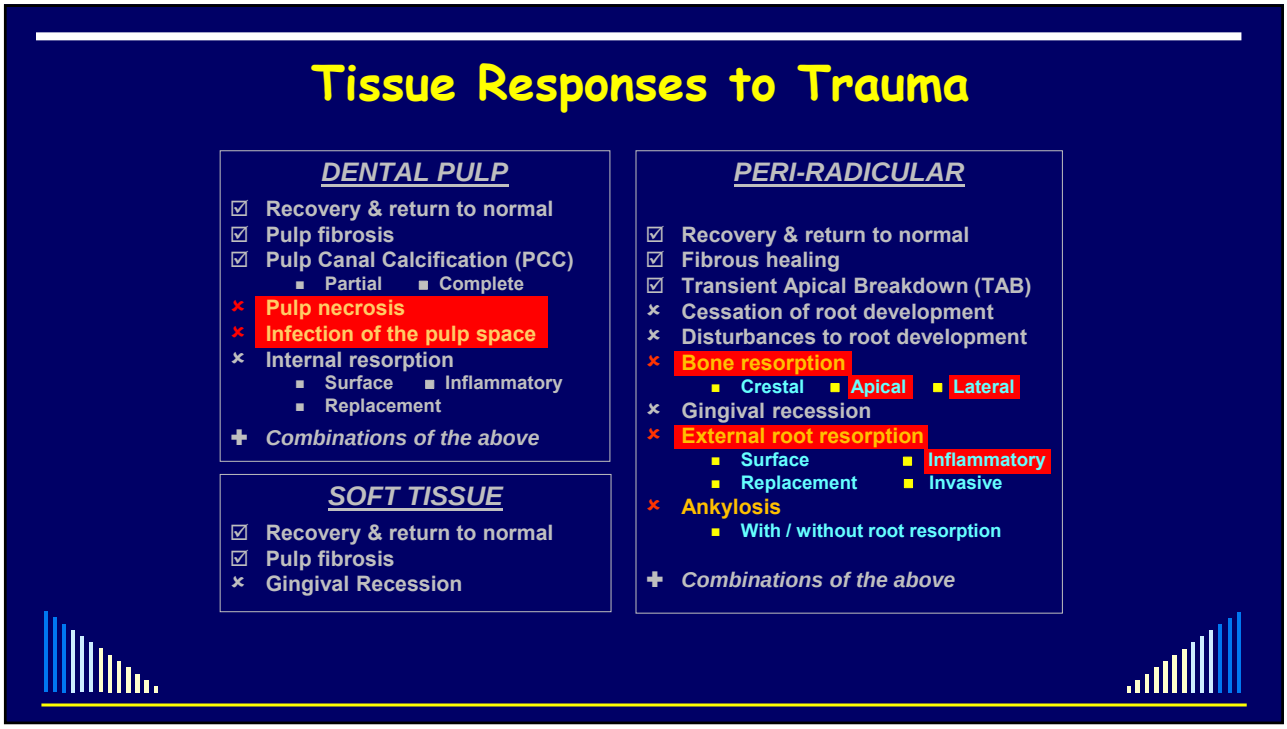
- ☑ Recovery and return to a normal state
- ☑ Fibrous healing - scar
- × Loss of attachment
- × Gingival recession



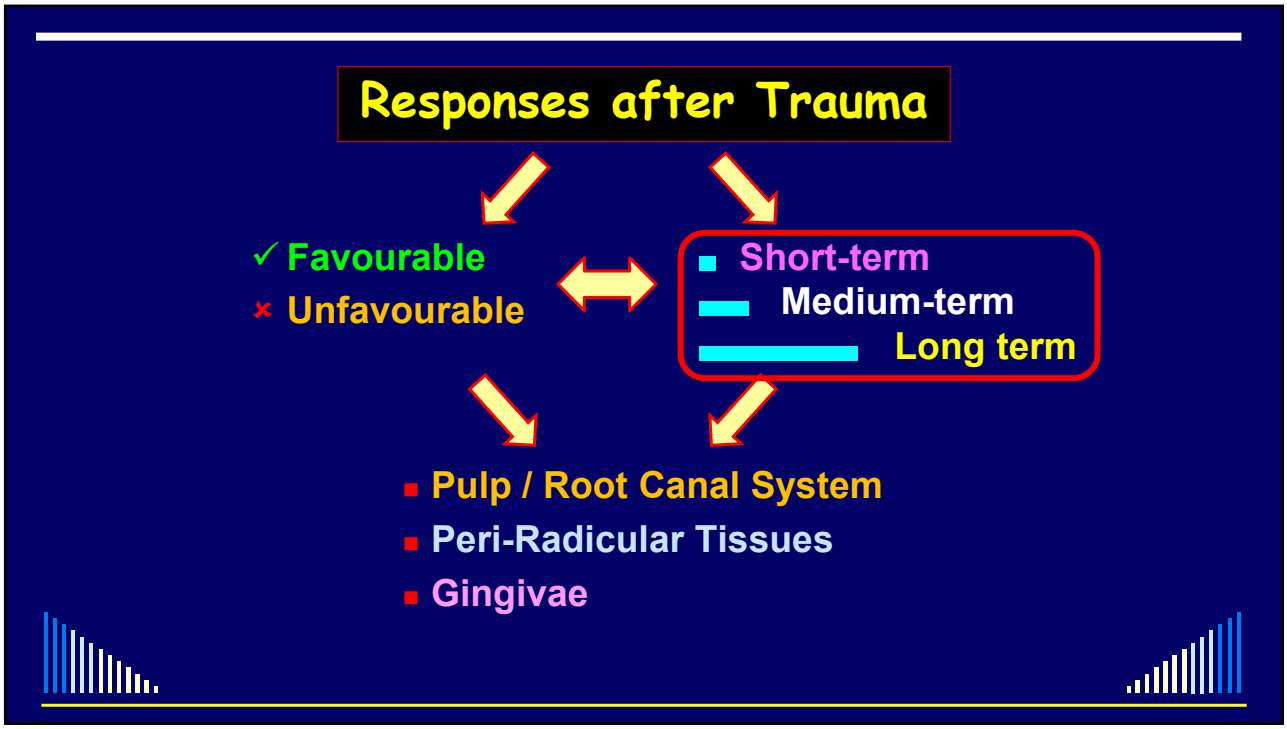
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Tissue Responses to Trauma
DENTAL PULP
Recovery & return to normal
Pulp fibrosis
Pulp Canal Calcification (PCC)
Pulp nec
Infectio
Internal
Combina
SOFT TISSUE
Recovery & return to normal
Pulp fibrosis
Gingival Recession
PERI-RADICULAR
Recovery & return to normal
Fibrous healing
wn (TAB)
ment
elopment
Lateral
flammatory
Replacement
Invasive
Ankylosis
With / without root resorption
Combinations of the above
Combinations of the pulp, soft tissue and peri-radicular responses

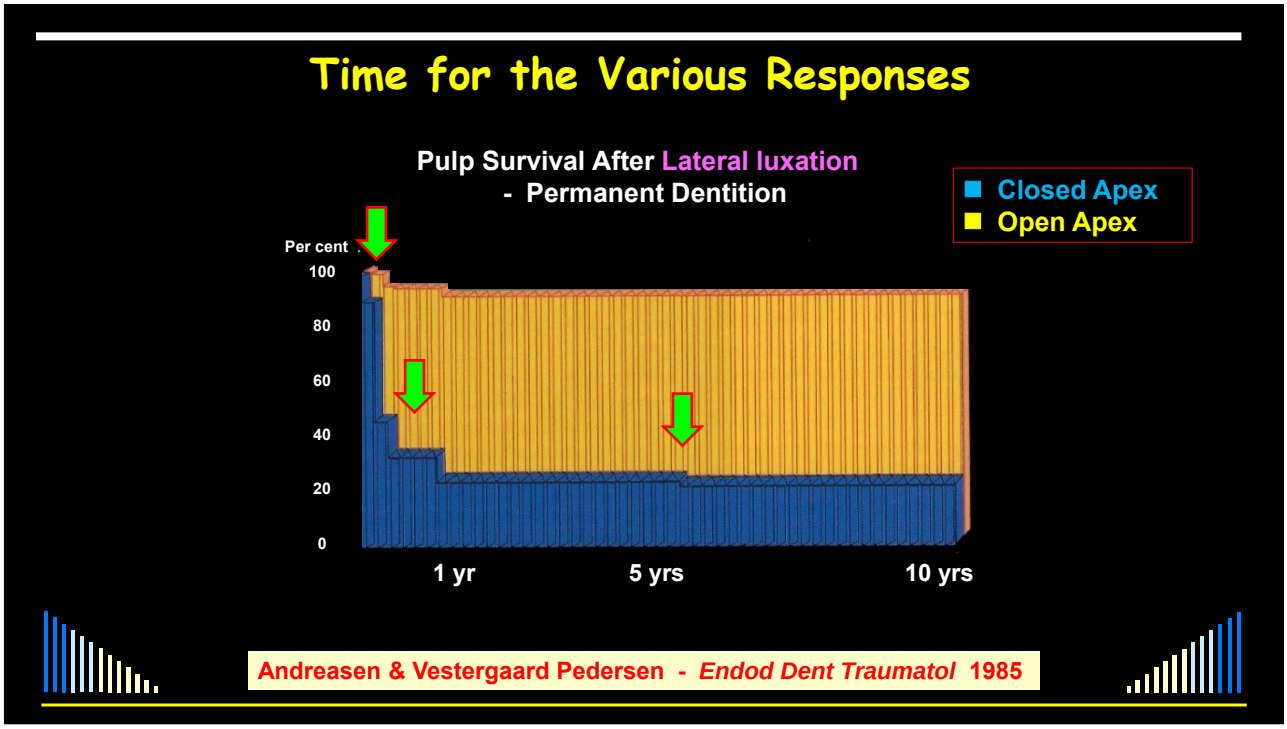
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Tissue Responses to Trauma
DENTAL PULP
Recovery & return to normal
Pulp fibrosis
Pulp Canal Calcification (PCC)
Partial
Complete
Pulp necrosis
Infection of the pulp space
Internal resorption
Surface
Inflammatory
Replacement
Combinations of the above
SOFT TISSUE
Recovery & return to normal
Pulp fibrosis
Gingival Recession
PERI-RADICULAR
Recovery & return to normal
Fibrous healing
Transient Apical Breakdown (TAB)
Cessation of root development
Disturbances to root development
Bone resorption
Crestal
Apical
Lateral
Gingival recession
External root resorption
Surface
Inflammatory
Replacement
Invasive
Ankylosis
With / without root resorption
Combinations of the above

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Responses after Trauma
✓ Favourable
× Unfavourable
Short-term
Medium-term
Long term
Pulp / Root Canal System
Peri-Radicular Tissues
Gingivae

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Time for the Various Responses
Pulp Survival After Lateral luxation
- Permanent Dentition
Closed Apex
Open Apex
Per cent
100
80
60
40
20
0
1 yr
5 yrs
10 yrs
Andreasen & Vestergaard Pedersen - Endod Dent Traumatol 1985

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Time for the Various Responses

- No clear definition in the literature
- ***MY*** definitions:
  - Short-term ➔ up to 3 months
  - Medium-term ➔ 3 months to 1 year
  - Long-term ➔ more than 1 year

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Short-term (up to 3 months) Responses

DENTAL PULP

- ☑ Recovery & return to normal
- ☑ Pulp fibrosis
- ☑ Pulp Canal Calcification (PCC)
  - Partial
  - Complete
- × Pulp necrosis
- × Infection of the pulp space
- × Internal resorption
  - Surface
  - Inflammatory
  - Replacement
- ✚ *Combinations of the above*

SOFT TISSUE

- ☑ Recovery & return to normal
- ☑ Pulp fibrosis - scar
- × Gingival Recession

PERI-RADICULAR

- ☑ Recovery & return to normal
- ☑ Fibrous healing
- ☑ Transient Apical Breakdown (TAB)
- × Cessation of root development
- × Disturbances to root development
- × Bone resorption
  - Crestal
  - Apical
  - Lateral
- × Gingival recession
- × External root resorption
  - Surface
  - Inflammatory
  - Replacement
  - Invasive
- × Ankylosis
  - With / without root resorption
- ✚ *Combinations of the above*

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Medium-term (3 months to 1 year) Responses

DENTAL PULP

- ☑ Recovery & return to normal
- ☑ Pulp fibrosis
- ☑ Pulp Canal Calcification (PCC)
  - Partial
  - Complete
- × Pulp necrosis
- × Infection of the pulp space
- × Internal resorption
  - Surface
  - Inflammatory
  - Replacement
- ✚ *Combinations of the above*

SOFT TISSUE

- ☑ Recovery & return to normal
- ☑ Pulp fibrosis - scar
- × Gingival Recession

PERI-RADICULAR

- ☑ Recovery & return to normal
- ☑ Fibrous healing
- ☑ Transient Apical Breakdown (TAB)
- × Cessation of root development
- × Disturbances to root development
- × Bone resorption
  - Crestal
  - Apical
  - Lateral
- × Gingival recession
- × External root resorption
  - Surface
  - Inflammatory
  - Replacement
  - Invasive
- × Ankylosis
  - With / without root resorption
- ✚ *Combinations of the above*

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Long-term (more than 1 year) Responses

DENTAL PULP

- ☑ Recovery & return to normal
- ☑ Pulp fibrosis
- ☑ Pulp Canal Calcification (PCC)
  - Partial
  - Complete
- × Pulp necrosis
- × Infection of the pulp space
- × Internal resorption
  - Surface
  - Inflammatory
  - Replacement
- ✚ *Combinations of the above*

SOFT TISSUE

- ☑ Recovery & return to normal
- ☑ Pulp fibrosis
- × Gingival Recession

PERI-RADICULAR

- ☑ Recovery & return to normal
- ☑ Fibrous healing
- ☑ Transient Apical Breakdown (TAB)
- × Cessation of root development
- × Disturbances to root development
- × Bone resorption
  - Crestal
  - Apical
  - Lateral
- × Gingival recession
- × External root resorption
  - Surface
  - Inflammatory
  - Replacement
  - Invasive
- × Ankylosis
  - With / without root resorption
- ✚ *Combinations of the above*

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Outline

- Introduction
- Potential consequences of trauma
- Tissue responses to trauma
  - Pulp
  - Peri-radicular tissues
  - Gingiva and oral mucosa
- Factors that affect healing

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Factors Affecting Healing after Trauma

Mechanical Factors

Biological Factors

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Factors Affecting Healing after Trauma

Mechanical Factors

1. Direct or Indirect trauma
2. Energy of impact - Mass and Velocity
   - NB: $E = mc^2$
3. Resiliency of the impacting object
4. Shape of the impacting object
5. Direction of the impacting force

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Factors Affecting Healing after Trauma

Mechanical Factors

- These factors will determine the:
  - Types of injuries
  - Severity of injuries
    - → Affect healing responses
- Obtain a thorough history about how the accident occurred
  - Helps predict the injuries that are likely to be present

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Factors Affecting Healing after Trauma

Biological Factors

1. Stage of root development
2. Extent of pulp involvement
3. Degree of displacement of tooth
4. Concurrent injuries to the same tooth

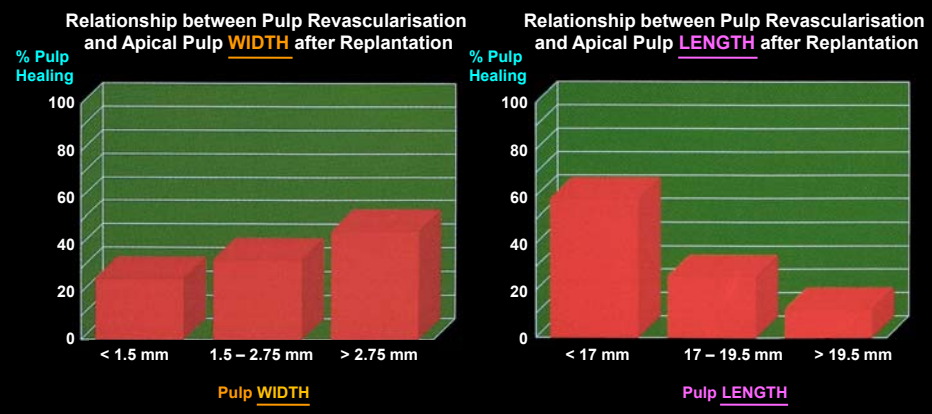
➔ **MUST ALL be assessed after trauma**

↳ Via: the history
clinical examination
pulp sensibility tests
radiographs, etc.

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Factors Affecting Healing after Trauma

Incompletely Developed Teeth



Andreasen et al 1992

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Incompletely Developed Teeth

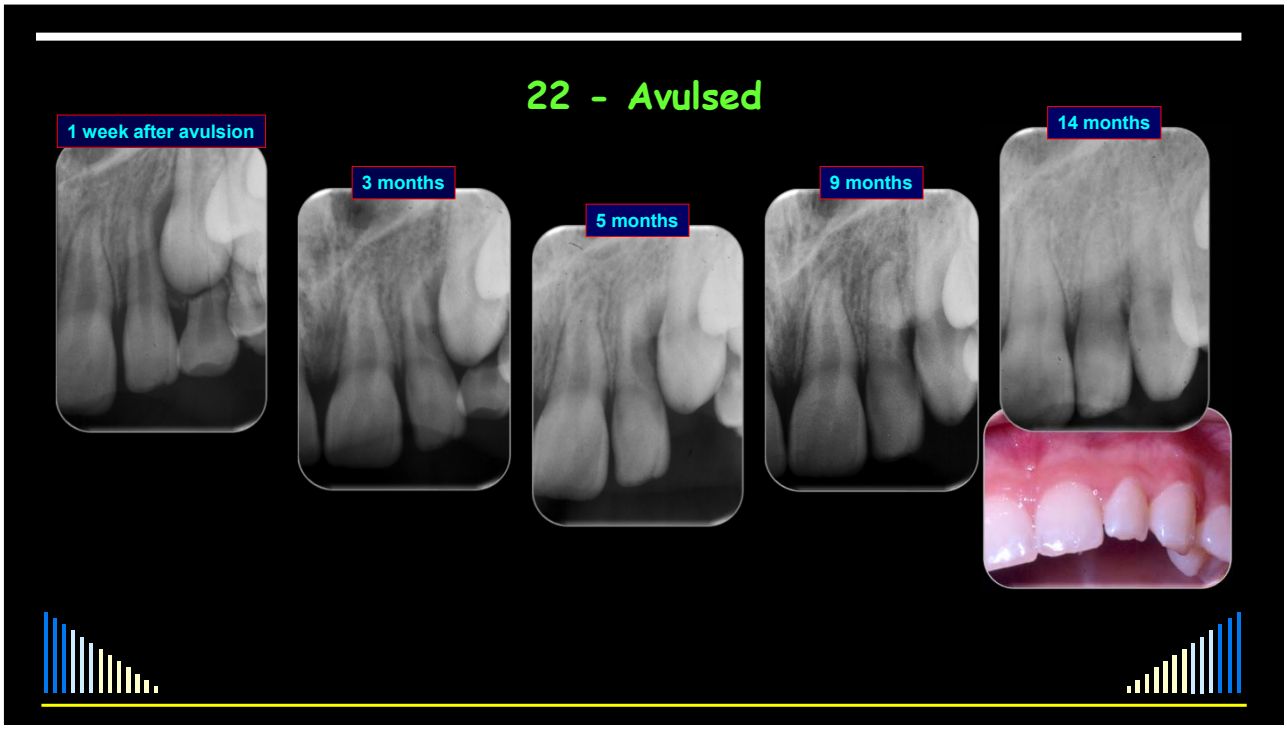
- AIM: Always wait for pulp revascularisation
  - Allows further root development
  - Improves long-term prognosis of tooth
- Prognostic factor: 0.7mm apical diameter
  - Andreasen FM *et al* - *EDT* 1986

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Incompletely Developed Teeth

- AIM: Always wait for pulp revascularisation
- MANAGEMENT:
  - Reposition and stabilise
  - Reassess regularly over time - with:
    - → Pulp sensibility tests - CO_2 and electric tests
    - → Radiographs - especially look for:
      - Further root development
      - Pulp canal calcification

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Incompletely Developed Teeth

- Endodontics - *ONLY IF* very definite signs of pulp necrosis AND infection - e.g.:
  - Inflammatory root resorption
  - Periapical radiolucency
  - Draining sinus
  - Swelling
  - Pain, etc

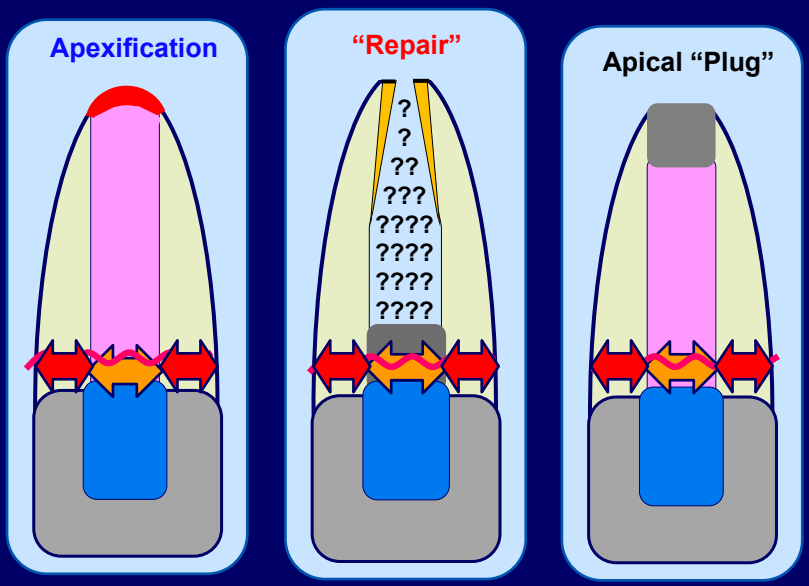
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Incompletely Developed Teeth

- Endodontics - *ONLY IF* very definite signs of pulp necrosis AND infection
  - Then: need *APEXIFICATION*
  - *Or other procedures - such as:*
    - *An "Apical Plug"*
    - *A "Repair" procedure*
      - *Commonly / ?? incorrectly called "regeneration"*

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Managing Infected RCS's in Incompletely Developed Teeth



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Radiographic and clinical outcomes of the treatment of immature permanent teeth by revascularization or apexification: a pilot retrospective cohort study.

Alobaid et al - J Endod 2014; 40: 1063-1070

- Compared $Ca(OH)_2$ Apexification, MTA "Apical Plugs" and "Repair" procedures
- Combined the $Ca(OH)_2$ Apexification and MTA "Apical Plugs" - due to small numbers
- No significant difference between groups for root length or width after treatment
- "Repair" was not superior to apexification

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Radiographic and clinical outcomes of the treatment of immature permanent teeth by revascularization or apexification: a pilot retrospective cohort study.

Alobaid et al - J Endod 2014; 40: 1063-1070

	$Ca(OH)_2$ Apexification + MTA "Apical Plug"	"Repair" Procedure ("Regeneration")
No. of Teeth + Av. Follow-up Time	12 - Av. 22 mths	19 - Av. 15 mths
Survival	12 (100%)	18 (95%)
"Clinical Success" (NOTE: not defined)	12 (100%)	15 (78%)
"Adverse Events"	1 (11%)	8 (42%)

- *"Adverse Events"*
  - "Repair" *group* - Re-infection (3), Staining (2), Re-traumatized (1) Fracture (1), Pain (1)
  - "Apexification" group - Re-traumatized (1)

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Can We Regrow Pulps?

Abbott PV.

Californian Dental Association Journal

2018; 46: 240 - 259.





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<u>BUT</u> - Teeth with Incomplete Root Development need early and regular follow-up

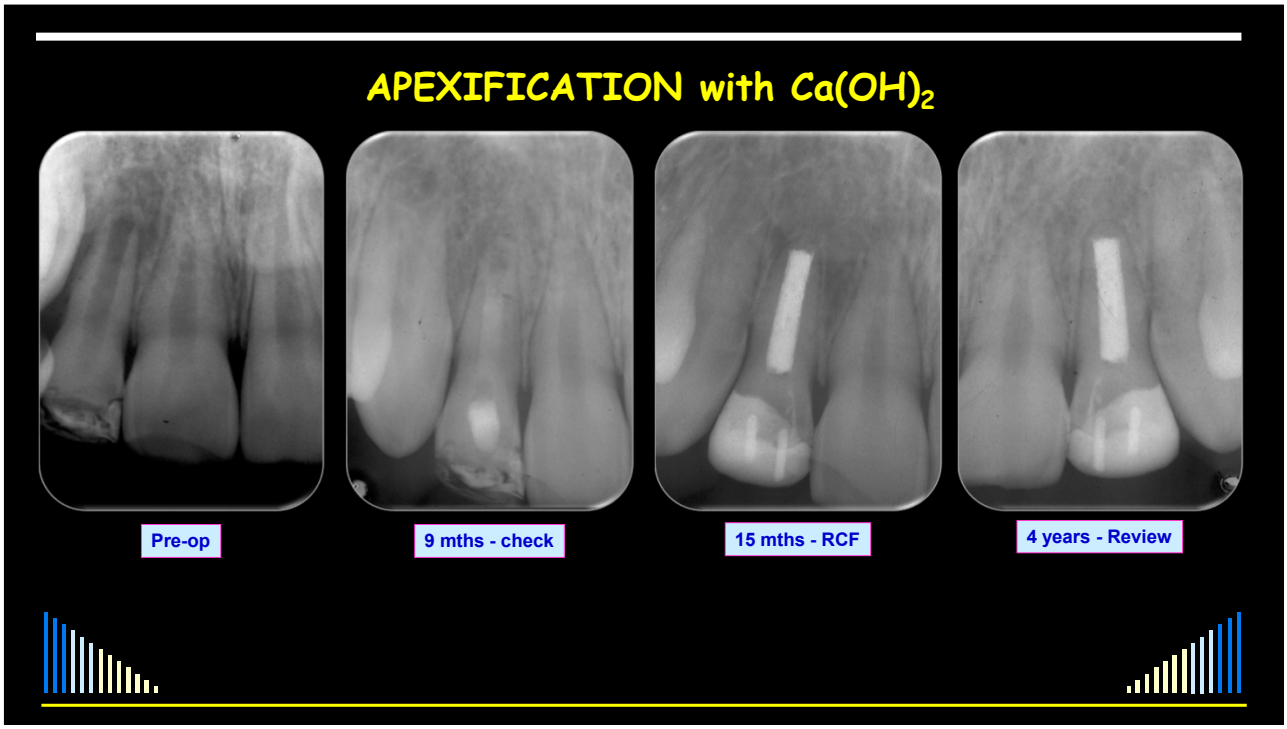
- Especially in the first few months after luxation / avulsion
- Monitor for signs of External Inflammatory Resorption
- As this resorption can develop and progress rapidly!!



11 - Avulsion
21 - Intrusion
12, 22 - Lat. Luxation



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Factors Affecting Healing after Trauma

Degree of Displacement

PROGNOSIS:

➔ *For BOTH pulp and peri-radicular tissue healing*

- Concussion ➡ Best
- Subluxation
- Extrusion
- Lateral Luxation
- Intrusion
- Avulsion

Worst

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Relationship between:

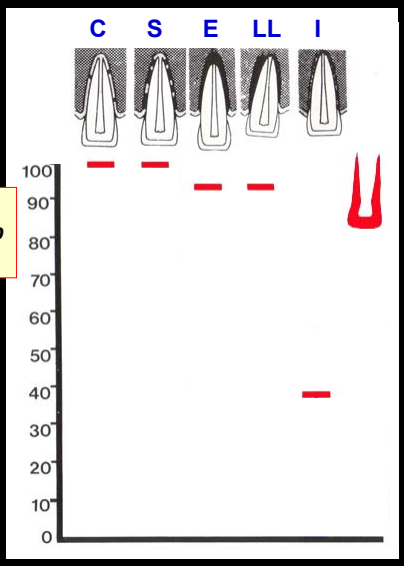
- **Luxation injury**
- **Pulp healing**
- **Stage of development**

(Andreasen 1989)

+ AVULSION

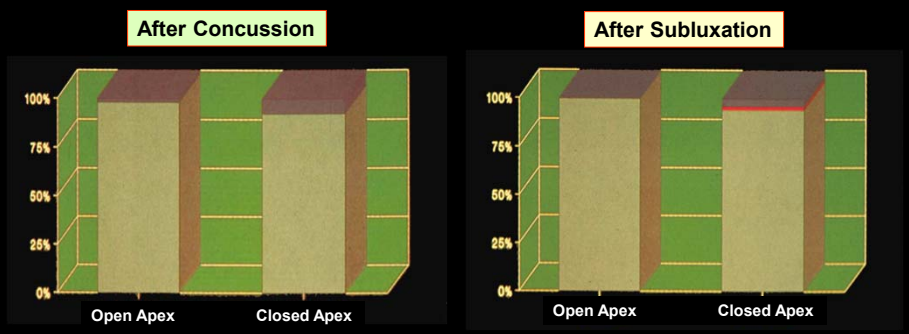
- **Immature - 34% of pulps survived**
- **Mature - NO pulps survived**

Andreasen et al - 1995



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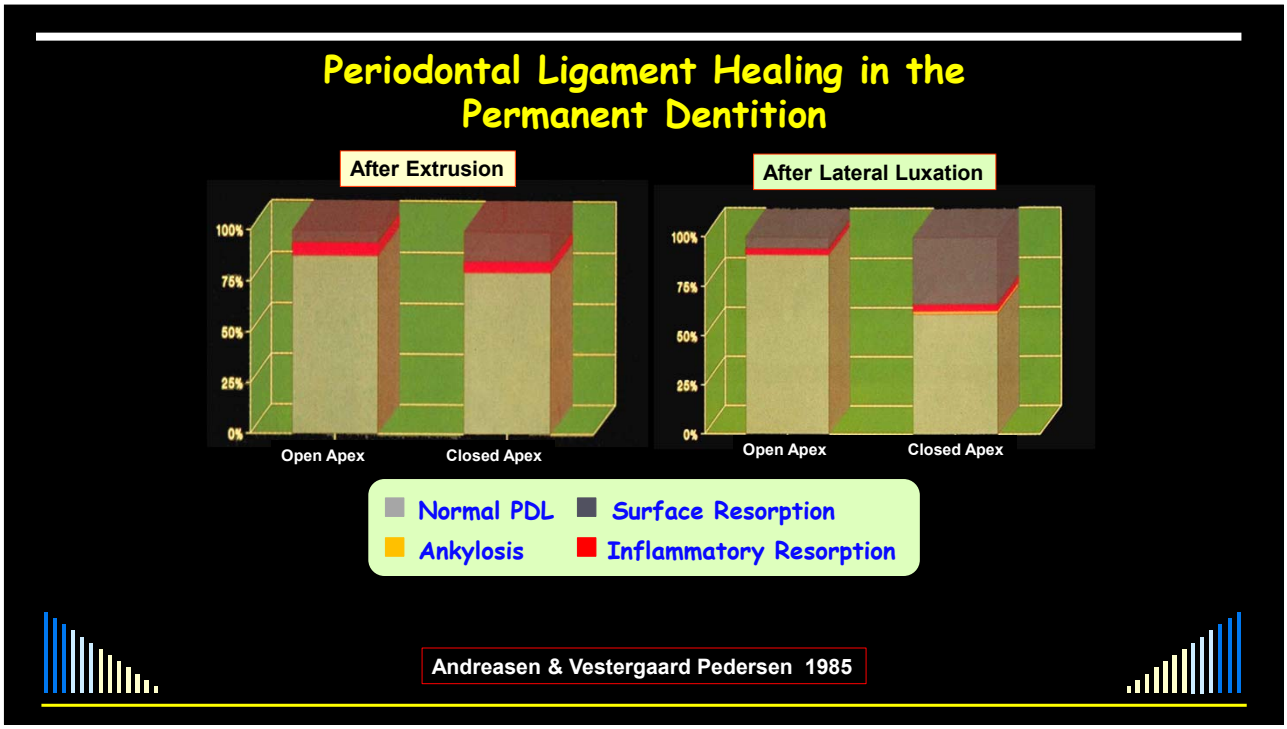
Periodontal Ligament Healing in the Permanent Dentition



Andreasen & Vestergaard Pedersen 1985

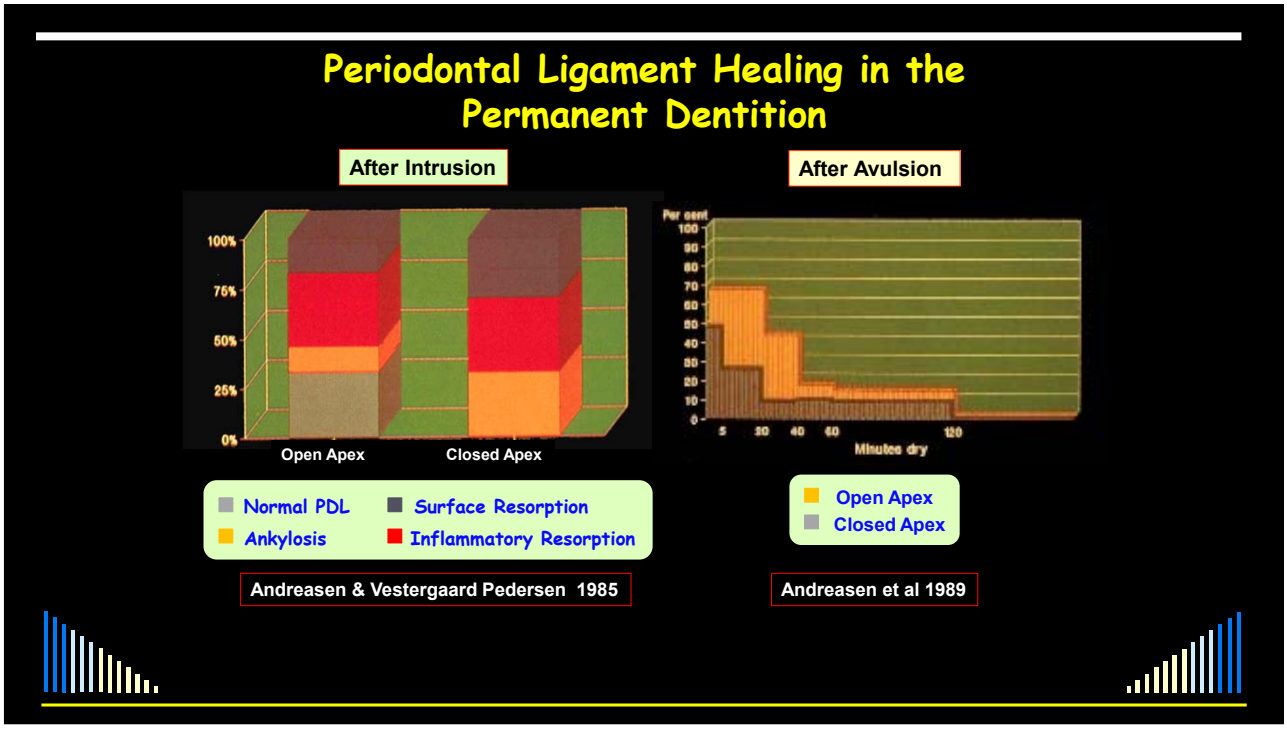
74

Periodontal Ligament Healing in the Permanent Dentition



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Periodontal Ligament Healing in the Permanent Dentition



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Factors Affecting Healing after Trauma

Extent of Pulp Involvement

KEY FACTORS:

- How likely is pulp necrosis?
- Can bacteria enter the root canal system?

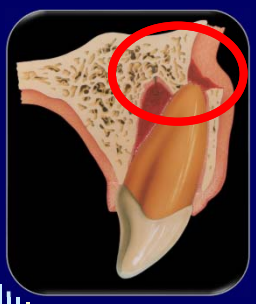
77

Factors Affecting Healing after Trauma

Extent of Pulp Involvement

KEY FACTORS:

- How likely is pulp necrosis?
  - Depends on the type of injury
    - → Luxations, avulsions , root fractures
      - Can severe the blood supply apically or at fracture line
      - Depends on the ability to revascularise



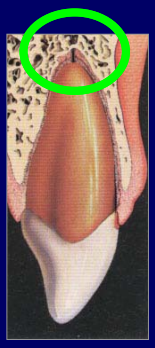


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Factors Affecting Healing after Trauma

Extent of Pulp Involvement

KEY FACTORS:



- How likely is pulp necrosis?
  - Depends on the type of injury
    - → Subluxation, concussion, crown fractures
      - Apical blood supply will be intact
      - Depends on the ability to resist bacterial invasion
      - AND whether any pathway(s) for bacteria to enter the tooth



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Factors Affecting Healing after Trauma

Extent of Pulp Involvement

KEY FACTORS:



- Can bacteria enter the root canal system?
  - Bacterial Pathways:
    - → Infractions
    - → Uncomplicated Crown Fractures
      - dentine exposed
    - → Complicated Crown Fractures
      - pulp exposed
  - Depends on the pulp's ability to resist the bacterial invasion

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Factors Affecting Healing after Trauma

Concurrent Injuries to the Same Tooth

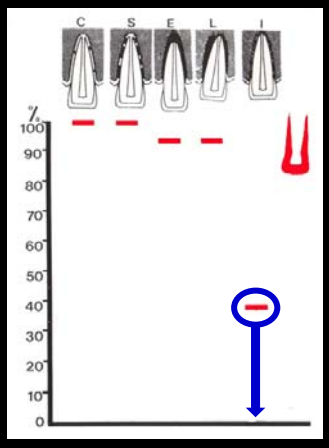
- Often have concurrent injuries to one tooth
  - → Esp. Luxations and Crown Fractures
- More damage to the tissues
- Will affect the outcome of treatment and the overall long-term prognosis

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PULP SURVIVAL AFTER CROWN FRACTURE

TEETH WITH OPEN APICES





Andreasen *et al* 1989, 1992

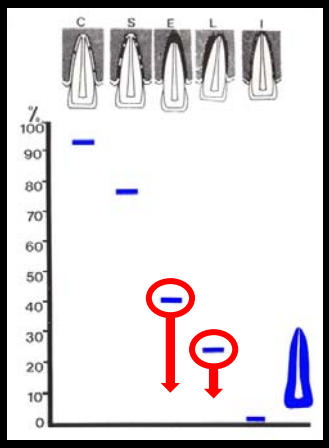
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PULP SURVIVAL AFTER CROWN FRACTURE

TEETH WITH CLOSED APICES



PCC Pulp Survival Pulp Necrosis



Andreasen *et al* 1989, 1992

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Factors Affecting Healing after Trauma

Mechanical Factors

1. Direct or Indirect trauma
2. Energy of impact (Mass & Velocity)
3. Resiliency of impacting object
4. Shape of impacting object
5. Direction of impacting force

Biological Factors

1. Stage of root development
2. Extent of pulp involvement
3. Degree of displacement
4. Concurrent injuries to the same tooth

*** ALL these factors be assessed for each injury

↳ Via: the history, clinical examination
pulp sensibility tests, radiographs, etc.

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Outline

- Introduction
- Potential consequences of trauma
- Tissue responses to trauma
  - Pulp
  - Peri-radicular tissues
  - Gingiva and oral mucosa
- Factors that affect healing

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Summary

- Be available to manage trauma - i.e. ASAP !!!
- Understand the injuries - the mechanisms and damage
- Understand ALL the potential tissue responses
- Understand the factors that affect the tissue responses
- Follow up your cases
  - To ensure:
    - Pulp healing
    - Peri-radicular healing
    - Gingival and oral mucosa healing
  - To manage any problems that develop

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