Management of Transverse Root Fractures

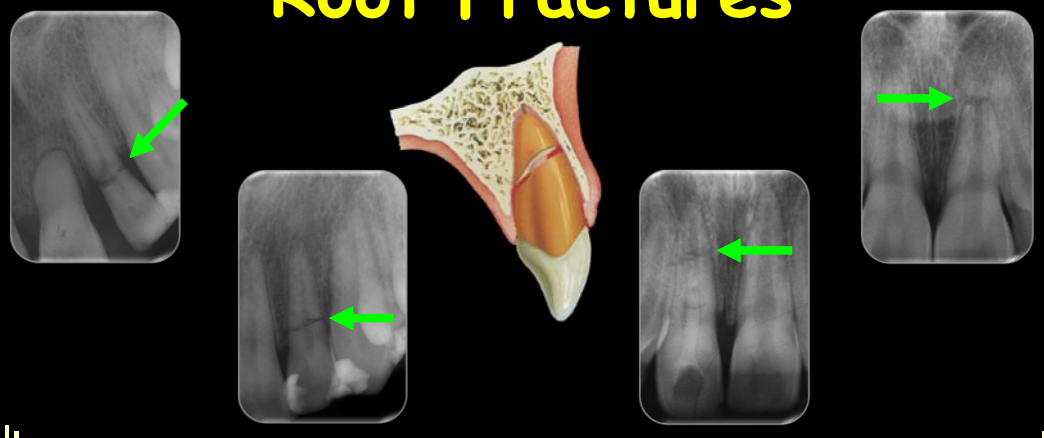
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Winthrop Professor of Clinical Dentistry
UWA Dental School
The University of Western Australia

ORAL HEALTH CENTRE

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Management of Transverse Root Fractures

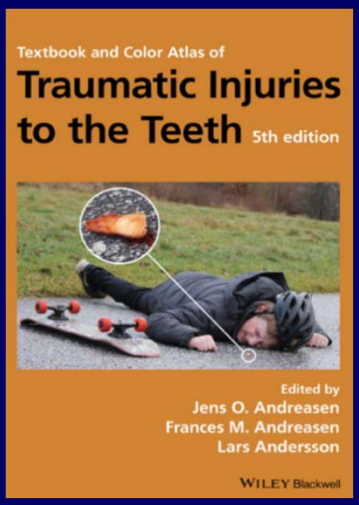


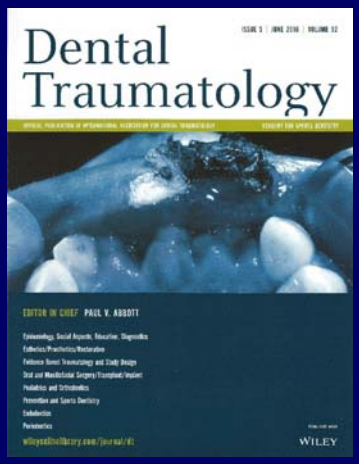
2

References









3

References



Dent Traumatol
2019; 35: 333-347



J Endod
2019; 45: S13-S27

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Outline



- Background information
- Classification of Root Fractures
- Diagnosis of Root Fractures
- Responses to Root Fractures
- Prognosis
- Management

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Transverse Root Fractures

- What I will NOT be discussing -
  - Crown:root fractures
    - → Vertical fractures



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Outline



- Background information
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Background



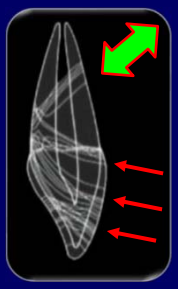
- Root Fractures
  - Defined as fractures involving dentine, cementum and pulp
- A relatively uncommon injury
  - Andreasen & Andreasen (2007)
    - → 0.5 - 7.0% of injuries to permanent teeth
    - → 2.0 - 4.0% of injuries in primary teeth
  - Stockwell (1988) - WA School Dental Service
    - → 0.4% of the injuries (6-12 year old children)
  - Lam, Abbott *et al* (2008) - Bunbury, WA
    - → 3.0% of the injuries (children and adults)

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Root Fractures

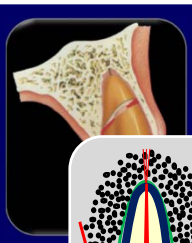


- Mechanism of injury
  - Usually a frontal impact
    - → Typically caused by fights and objects striking the teeth
  - Fracture can occur in different planes
    - → Depends on the direction and the distribution of the force
    - → More common to be oblique
      - Even though many say "horizontal" !!

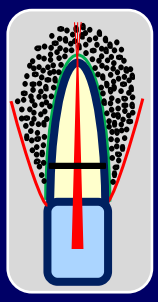


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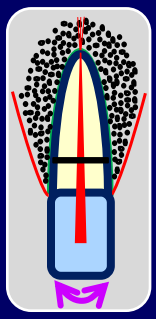
Root Fractures



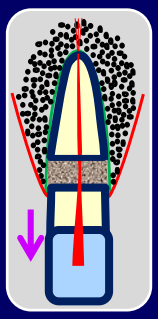
- Concurrent Injuries
  - The coronal fragment
    - → Concussion
    - → Subluxation
    - → Extrusion
    - → Lateral luxation
    - → Avulsion



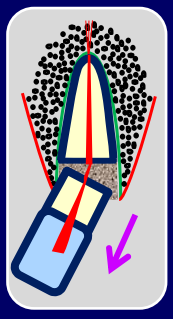
Concⁿ



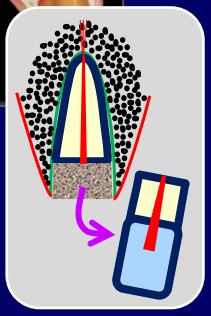
Subluxⁿ



Extrⁿ



Lat Luxⁿ



Avulⁿ

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Root Fractures

- Tissue damage / effects
  - Apical Fragment
    - → Neurovascular supply intact
      - Pulp is not damaged
    - → PDL is not damaged

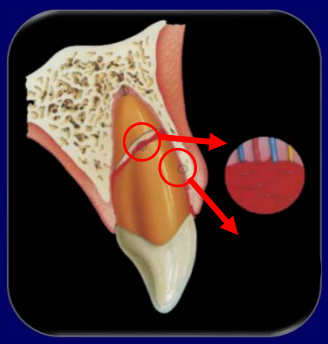


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Root Fractures

- Tissue damage / effects
  - Coronal Fragment
    - → Pulp is stretched or lacerated at the fracture line
    - → Rupture and / or compression of the PDL
    - → Root surface may be exposed
      - If coronal fragment is displaced

Amount of damage will depend on whether the coronal fragment is displaced and the extent of any displacement



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Outline

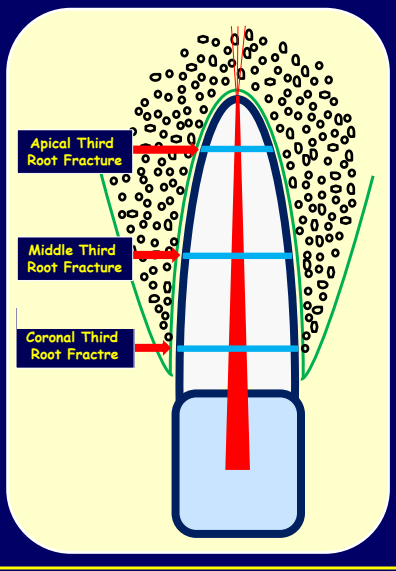


- Background information
- Classification of Root Fractures
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Root Fractures

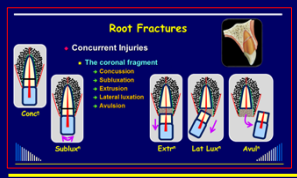
- Classified according to:
  - Position -
    - → Apical third
    - → Middle third
    - → Coronal third

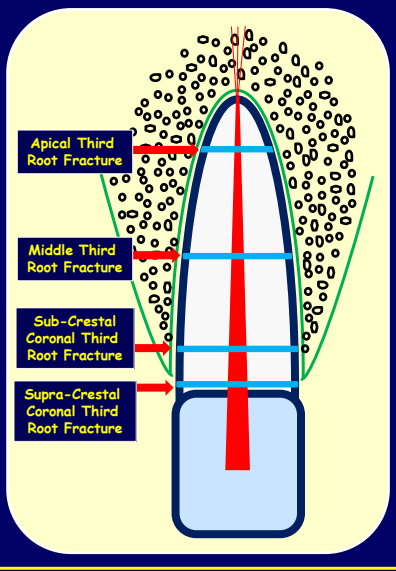


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Root Fractures

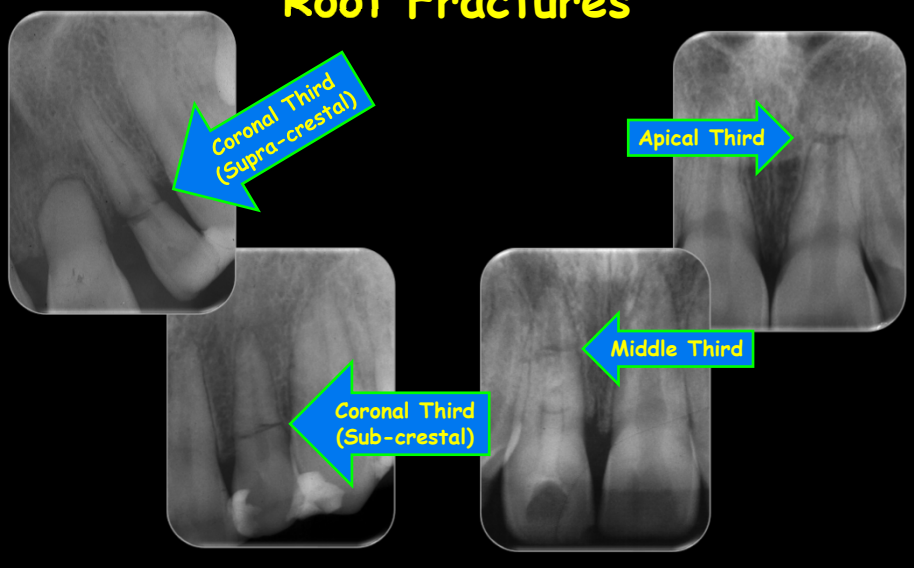
- Classified according to:
  - Position -
    - Apical third
    - Middle third
    - Coronal third
      - Sub-crestal
      - Supra-crestal
- + Coronal fragment injury -
  - Concussion, Subluxation, Extrusion, Lateral Luxation or Avulsion





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Root Fractures



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Outline



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Diagnosis of Root Fractures

- History - as for all trauma cases
- Clinical - as for all trauma cases
  - Special things to note:
    - Coronal segment may be mobile or displaced
    - May be bleeding from the gingival sulcus
    - May have crown discolouration (red or grey)
    - May be tender to percussion

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Pulp Sensibility Tests



- Usually initially negative for root fractures
  - Except when there is no, or only minor, displacement of the coronal fragment
- Pulp tests are important to help assess the risk of healing complications
  - Positive initial pulp test responses indicate a significantly reduced risk of pulp necrosis later
- Essential to perform at the emergency visit
  - *Time is NO EXCUSE for not doing these tests !!!*

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Pulp Sensibility Tests



- Initial Pulp Test results are necessary to assess the pulp status at subsequent review appointments
  - Based on changes in how the pulp responds

Immediate Post-Trauma	Review 1	Review 2
+	+	+
+	+	-
+	-	+
-	+	+
-	-	+
-	-	-

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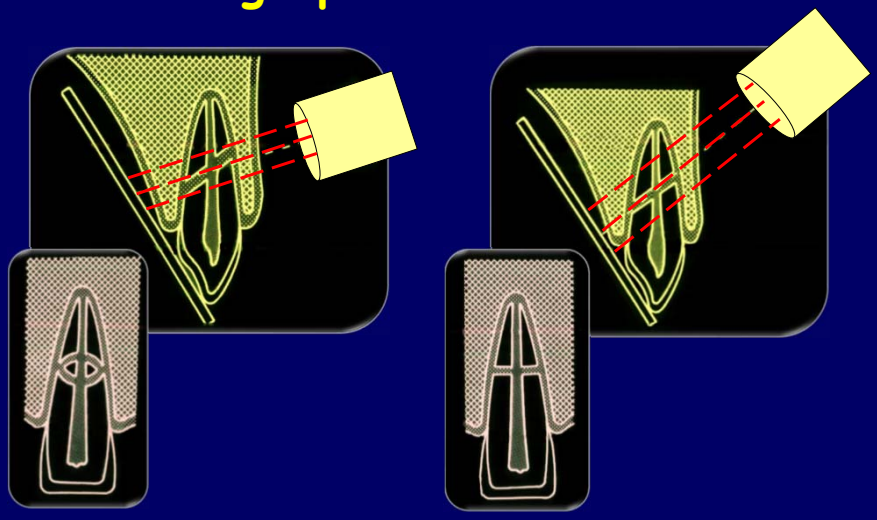
Radiographic Examination

- Radiographs are essential to reveal root fractures
- Minimum radiographs for typical trauma incident:
  - 3 x periapical radiographs
  - 1 x occlusal radiograph
  - 1 - 2 PA's of the opposing arch
  - Consider other views – vertical tube shifts

➔ To diagnose all injuries and to assess the healing at reviews

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Radiographic Examination



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Radiographic Examination

- Occlusal radiograph
  - Best for apical third and middle third root fractures
- Bisecting angle periapical radiograph
  - Best for coronal third root fractures
- NOTE: Some root fractures not evident initially
  - But become more obvious at review appointments - due to haemorrhage or granulation tissue in the fracture line
- ALSO: CBCT not needed and not of practical value for root fractures
  - Radiographs reveal sufficient detail for initial management

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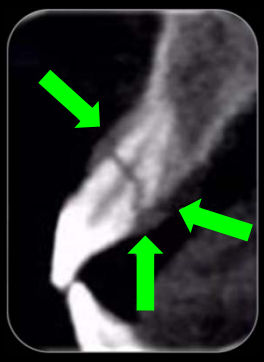
Radiographic Examination



- ALSO: CBCT not needed and not of practical value for root fractures
  - Radiographs reveal sufficient detail for initial management

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Radiographic Examination



- CBCT images - have revealed the likelihood of fractures of the alveolar socket wall being associated with root fractures

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Outline

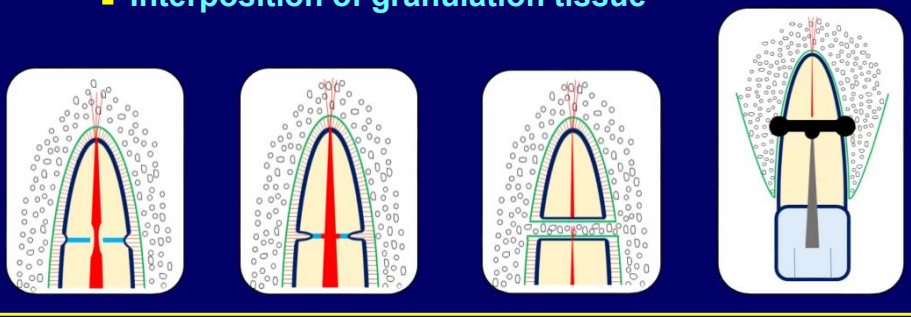


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Responses to Root Fractures

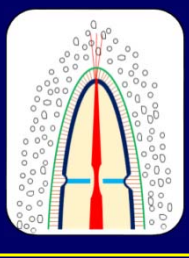
- Four typical responses:
  - Healing with calcified tissue
  - Interposition of connective tissue
  - Interposition of bone and connective tissue
  - Interposition of granulation tissue



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Responses to Root Fractures

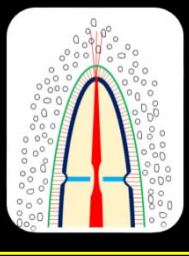
- Four typical responses:
  - Healing with calcified tissue
    - → Most likely when no, or little, displacement of the coronal fragment
    - → "Internal repair" - dentine
      - May be some osteodentine or cementum
    - → Usually have rounding of peripheral fracture edges
    - → Usually get Pulp Canal Calcification over time

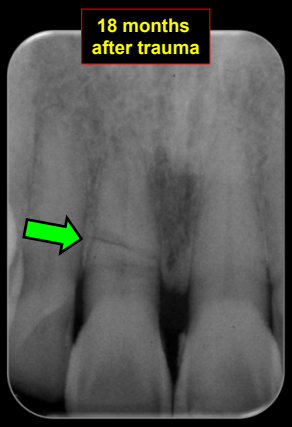


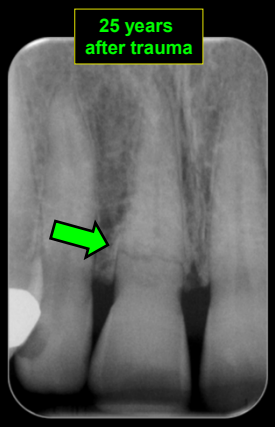
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Responses to Root Fractures

- Four typical responses:
  - Healing with calcified tissue







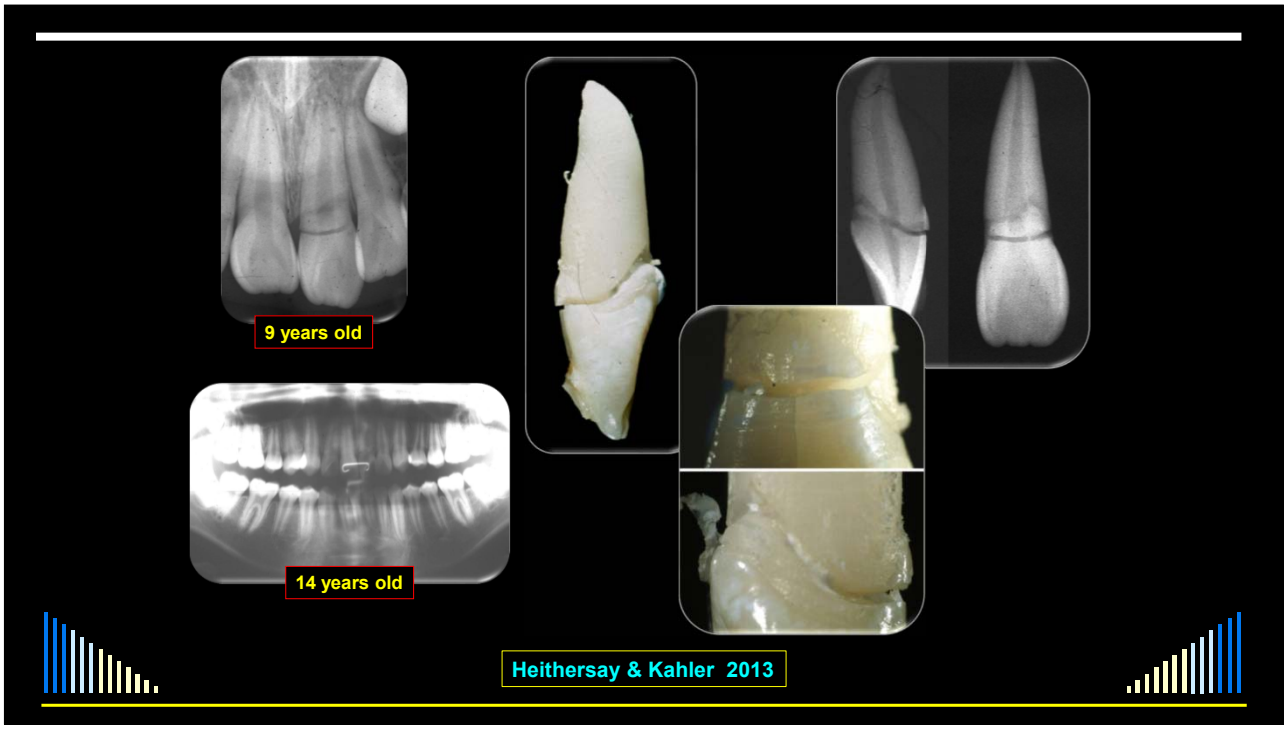
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Healing responses following transverse root fracture: a historical review and case reports showing healing with (a) calcified tissue and (b) dense fibrous connective tissue

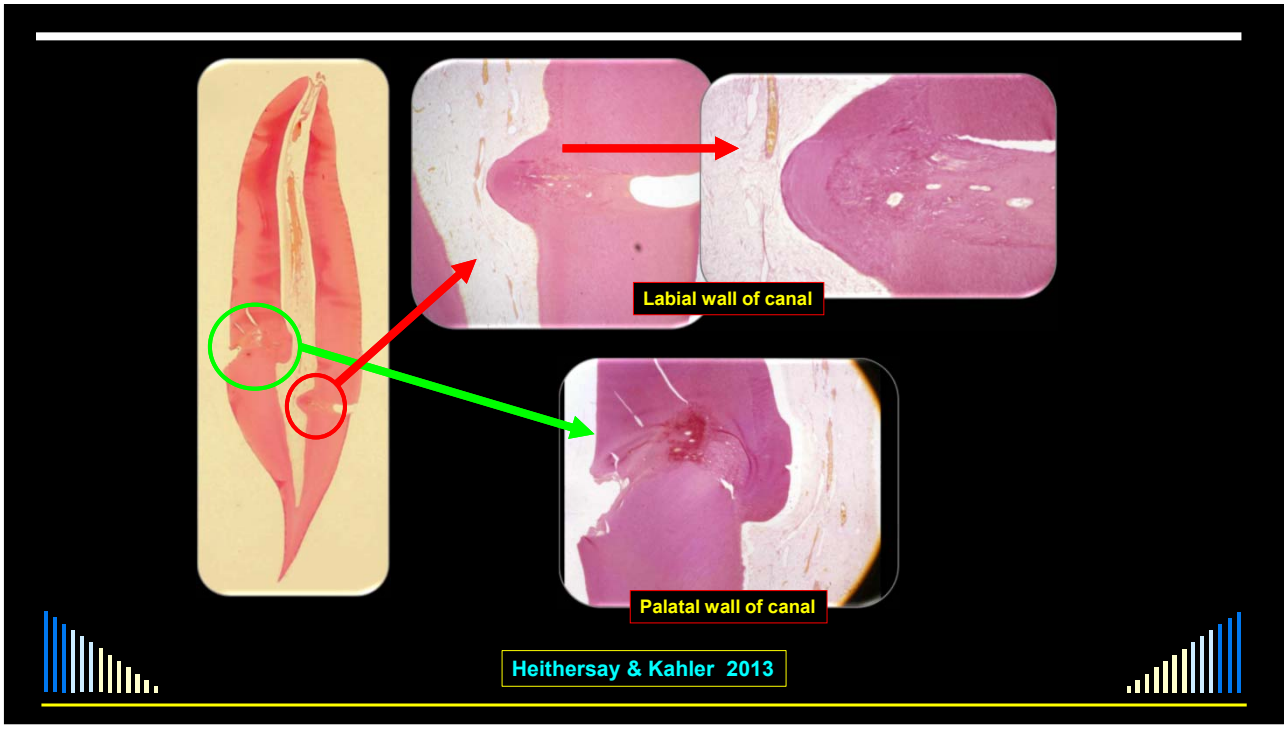
Geoffrey S. Heithersay AO, Bill Kahler

Dent Traumatol 2013; 29: 253-265

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9 years old
14 years old
Heithersay & Kahler 2013

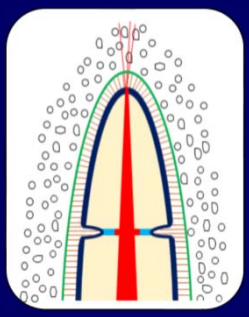
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Labial wall of canal
Palatal wall of canal
Heithersay & Kahler 2013

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Responses to Root Fractures

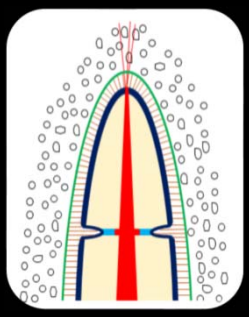
- Four typical responses:
  - Interposition of connective tissue
    - → Most likely when the coronal fragment is displaced
    - → Pulp is severely stretched or severed completely
      - May repair / revascularize if no bacteria present
    - → PDL cells dominate healing in the fracture line
      - Hence, connective tissue repair
    - → Usually get Pulp Canal Calcification over time



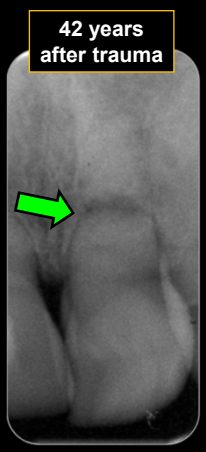
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Responses to Root Fractures

- Four typical responses:
  - Interposition of connective tissue



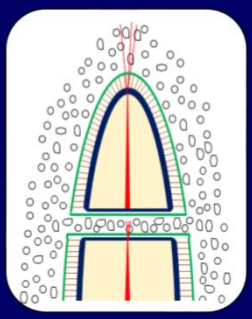




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Responses to Root Fractures

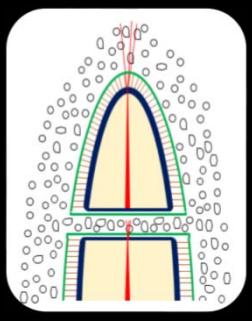
- Four typical responses:
  - Interposition of bone and connective tissue
    - If fracture occurs before completion of alveolar growth
      - No union between fragments for this to occur
    - The coronal fragment erupts normally
    - The apical fragment remains in the same position
    - Usually have rounding of peripheral fracture edges
    - Usually get Pulp Canal Calcification over time



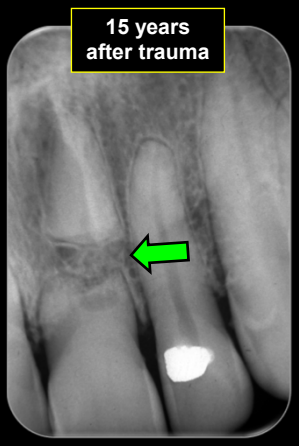
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Responses to Root Fractures

- Four typical responses:
  - Interposition of bone and connective tissue



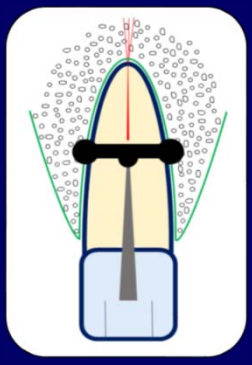




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Responses to Root Fractures

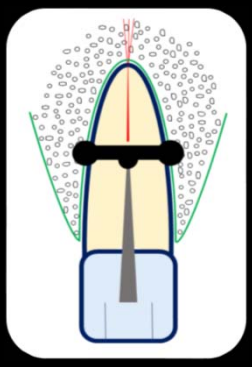
- Four typical responses:
  - Interposition of granulation tissue
    - If the pulp in the coronal fragment necroses and becomes infected
      - Granulation tissue forms in the fracture line in response to the infection
        - Similar to apical periodontitis from an infected root canal system
      - No union between fragments
      - May be some inflammatory resorption leading to widening of the foramen at the fracture line
    - The pulp in the apical fragment remains normal and usually has Pulp Canal Calcification over time
    - Usually have rounding of peripheral fracture edges

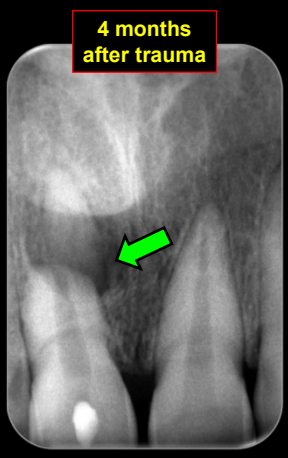


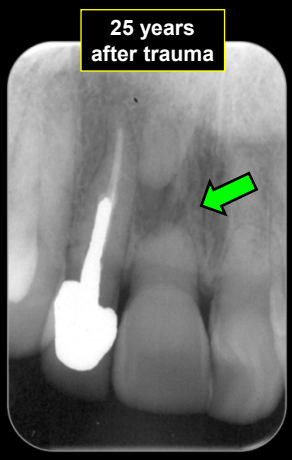
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Responses to Root Fractures

- Four typical responses:
  - Interposition of granulation tissue



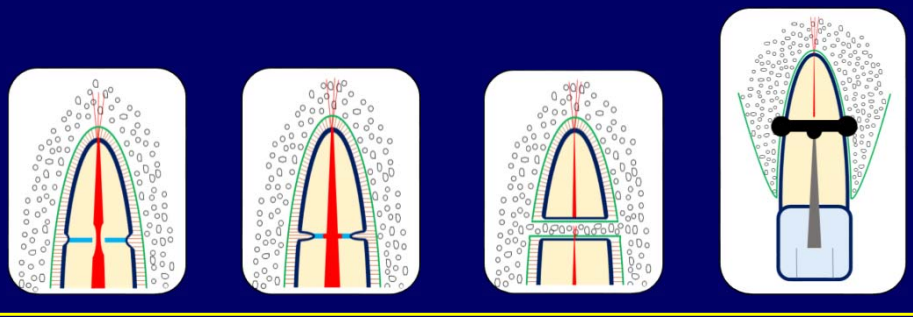




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Responses to Root Fractures

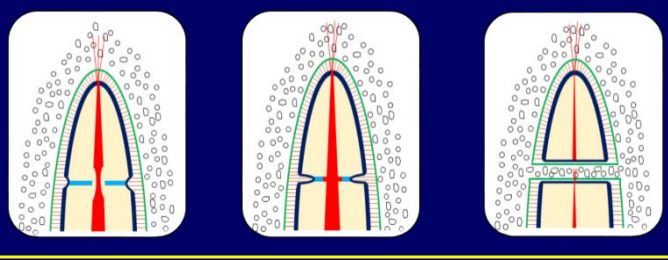
- Pulp responses after root fractures
  - Apical fragment - the pulp usually survives and remains normal
    - → Usually develops pulp canal calcification over time



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Responses to Root Fractures

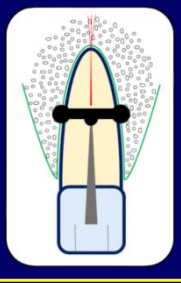
- Pulp responses after root fractures
  - Apical fragment - the pulp usually survives and remains normal
    - → Usually develops pulp canal calcification
  - Coronal fragment
    - → Pulp may recover / revascularise
      - ✪ Typically then get pulp canal calcification



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Responses to Root Fractures

- Pulp responses after root fractures
  - Apical fragment - the pulp usually survives and remains normal
    - → Usually develops pulp canal calcification
  - Coronal fragment
    - → Pulp may recover / revascularise
      - Typically then get pulp canal calcification
    - → OR may get pulp necrosis and infection of the root canal system
      - Inflammation in the fracture line
        - i.e. Granulation tissue



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Responses to Root Fractures

- Pulp responses after root fractures
  - 15 studies from 1930 - 2004
    - → No. of teeth in each study ranged from 18 - 400
    - → Pulp necrosis in each study ranged from 4% - 55%
    - → Total : 1017 teeth
      - 274 had pulp necrosis = 26.9%
  - *Hence - the prognosis for pulp healing after root fracture is very good !!!*

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Responses to Root Fractures

- Pulp responses after root fractures
  - Many factors affect the pulp response
    - → Age
    - → Stage of root development
      - Size of pulp lumen at the fracture line
    - → Mobility of the coronal fragment
    - → Displacement of the coronal fragment
    - → Diastasis between fragments
      - i.e. whether the pulp was stretched or ruptured at the fracture line
    - → The treatment provided

- *Hence, it is difficult / impossible to generalise !*

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Outline



- Background information
- Classification of Root Fractures
- Diagnosis of Root Fractures
- Responses to Root Fractures
- **Prognosis**
- Management

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Prognosis after Root Fracture

- Incompletely Developed Teeth - 13 teeth
  - NO teeth were lost
  - NO cases with external resorption or ankylosis
  - NO cases with bone loss
  - NO cases of pulp necrosis over 10 years
  - Pulp canal calcification (note: cumulative no's)
    - → 38.5% (4 teeth) after 1 year
    - → 55.1% (6 teeth) after 3 years
    - → 82.1% (9 teeth) after 10 years

- Hence - the prognosis for incompletely developed teeth after root fracture is very good !!!

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Prognosis after Root Fracture

- Fully Developed Teeth
  - Uncommon problems after root fracture
    - → Bone loss
      - Coronal third fractures - 18.8% after 10 years
      - Middle third fractures - 6% after 10 years
      - Apical third fractures - NIL
    - → Surface resorption - NIL
    - → Inflammatory root resorption - NIL
    - → Ankylosis and replacement resorption
      - 2.5% of middle third fractures after 10 years
      - NIL for apical and coronal third fractures

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Prognosis after Root Fracture

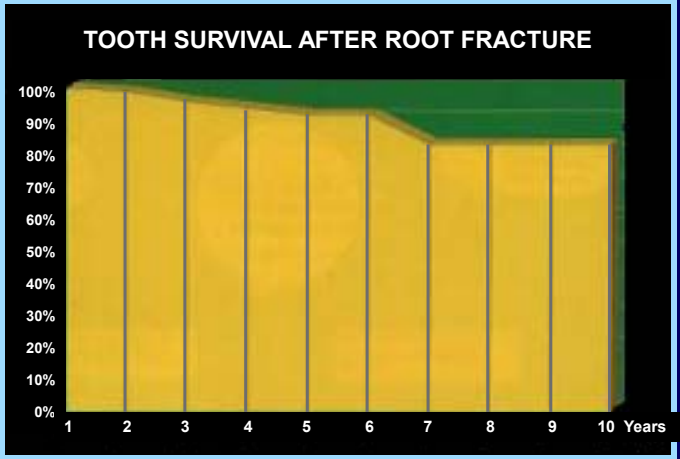
- Fully Developed Teeth

	No. of Years	Apical Third Root Fracture	Middle Third Root Fracture	Coronal Third Root Fracture
No. of Teeth		13	46	16
Tooth Loss	1	0	2	1
	3	1	3	1
	10	1	4	5

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47

Prognosis after Root Fracture



Andreasen *et al* 2007

48

Prognosis after Root Fracture

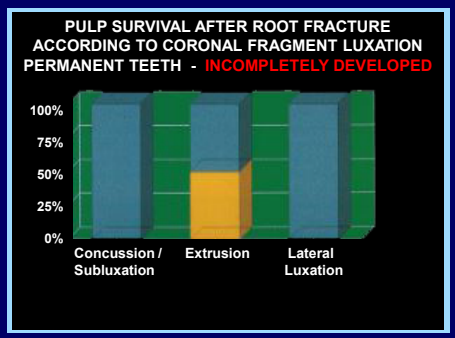
- Fully Developed Teeth

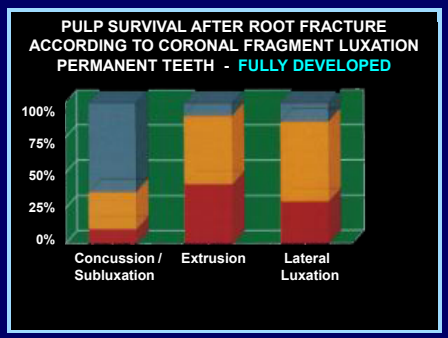
	No. of Years	Apical Third Root Fracture	Middle Third Root Fracture	Coronal Third Root Fracture
No. of Teeth		13	46	16
Tooth Loss	1	0	2	1
	3	1	3	1
	10	1	4	5
Pulp Necrosis & Infection of RCS	1	2	12	5
	3	3	14	5
	10	3	14	5

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Prognosis after Root Fracture





Tissue Responses

Hard Tissue | Connective Tissue | Granulation Tissue

Andreasen *et al* 1989

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Prognosis after Root Fracture

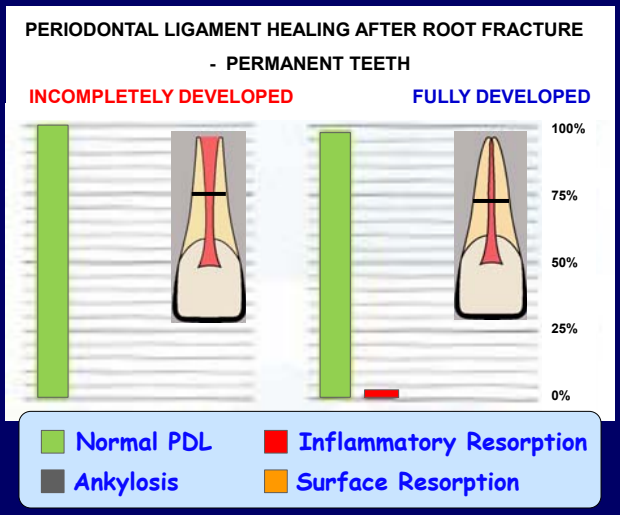
- Fully Developed Teeth

	No. of Years	Apical Third Root Fracture	Middle Third Root Fracture	Coronal Third Root Fracture
No. of Teeth		13	46	16
Tooth Loss	1	0	2	1
	3	1	3	1
	10	1	4	5
Pulp Necrosis & Infection of RCS	1	2	12	5
	3	3	14	5
	10	3	14	5
Pulp Canal Calcification	1	2	16	2
	3	5	24	4
	10	9	25	9

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Prognosis after Root Fracture



From: Andreasen *et al* 2011

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Outline

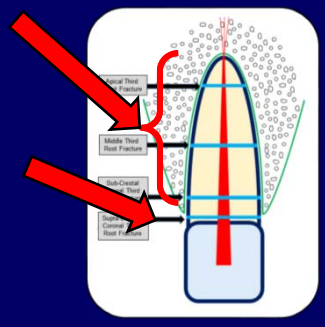


- Background information
- Classification of Root Fractures
- Diagnosis of Root Fractures
- Responses to Root Fractures
- Prognosis
- Management

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Management of Root Fractures

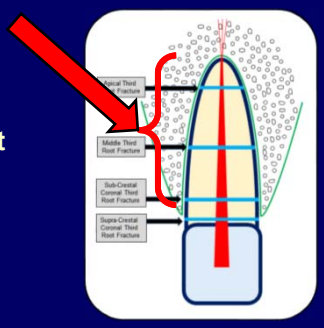
- Initial management depends on fracture position
  - Apical, middle, & coronal sub-crestal fractures
    - manage conservatively
  - *Critical case* - supra-crestal fracture in the coronal third



54

Management of Root Fractures

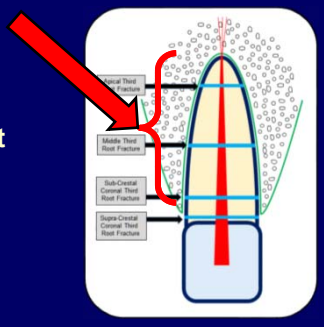
- Initial management depends on fracture position
  - Apical, middle, & coronal sub-crestal fractures
    - manage conservatively
      - → Reposition coronal fragment
        - if displaced
      - → Stabilise with wire/composite splint
      - → Review - PDL and pulp healing



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Management of Root Fractures

- Initial management depends on fracture position
  - Apical, middle, & coronal sub-crestal fractures
    - manage conservatively
      - → Reposition coronal fragment
        - if displaced
      - → Stabilise with wire/composite splint
        - For 1 – 3 months
        - The more coronal the fracture, the longer the splinting period



56

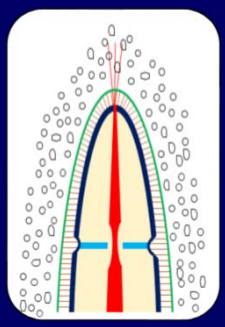
Management of Root Fractures



57

Management of Root Fractures

- Initial management depends on fracture position
  - Apical, middle, & coronal sub-crestal fractures
    - manage conservatively

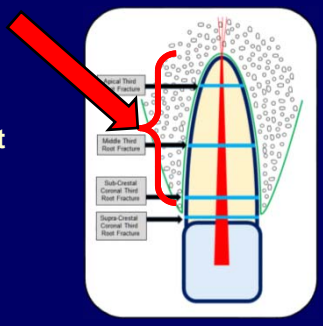


- AIM: to stabilise the fragments to provide the ideal environment for healing with calcified tissue
  - i.e. internal dentine repair
- Healing is less likely if the fragments are moving
- Only one time / opportunity for this repair
  - If repair does not occur, then cannot try again with further splinting
- There is no harm in splinting for longer periods compared to short periods

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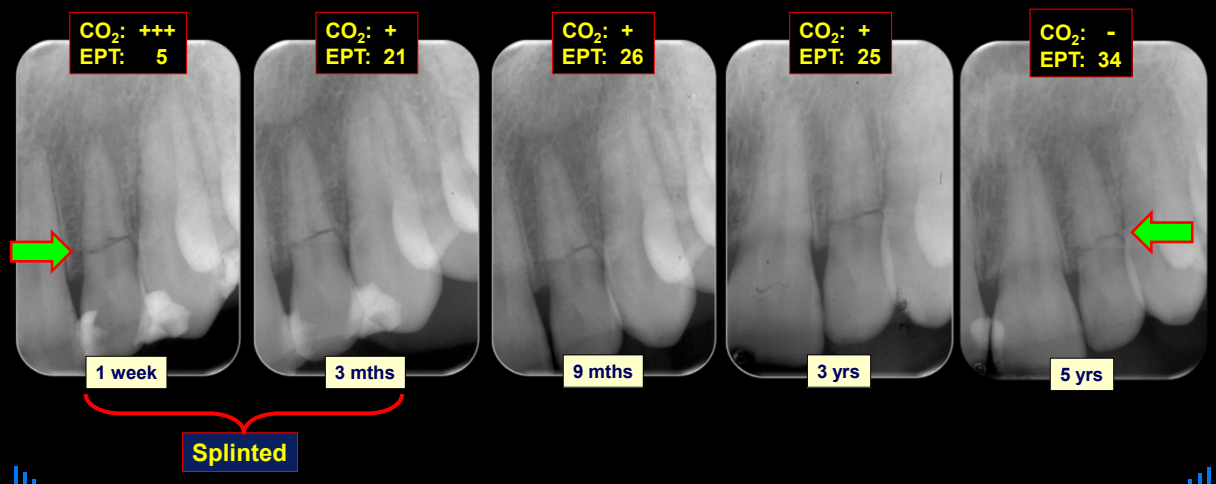
Management of Root Fractures

- Initial management depends on fracture position
  - Apical, middle, & coronal sub-crestal fractures
    - manage conservatively
      - → Reposition coronal fragment
        - if displaced
      - → Stabilise with wire/composite splint
      - → Review pulp and PDL healing over time
        - If no signs of pulp necrosis - continue to review for as long as possible

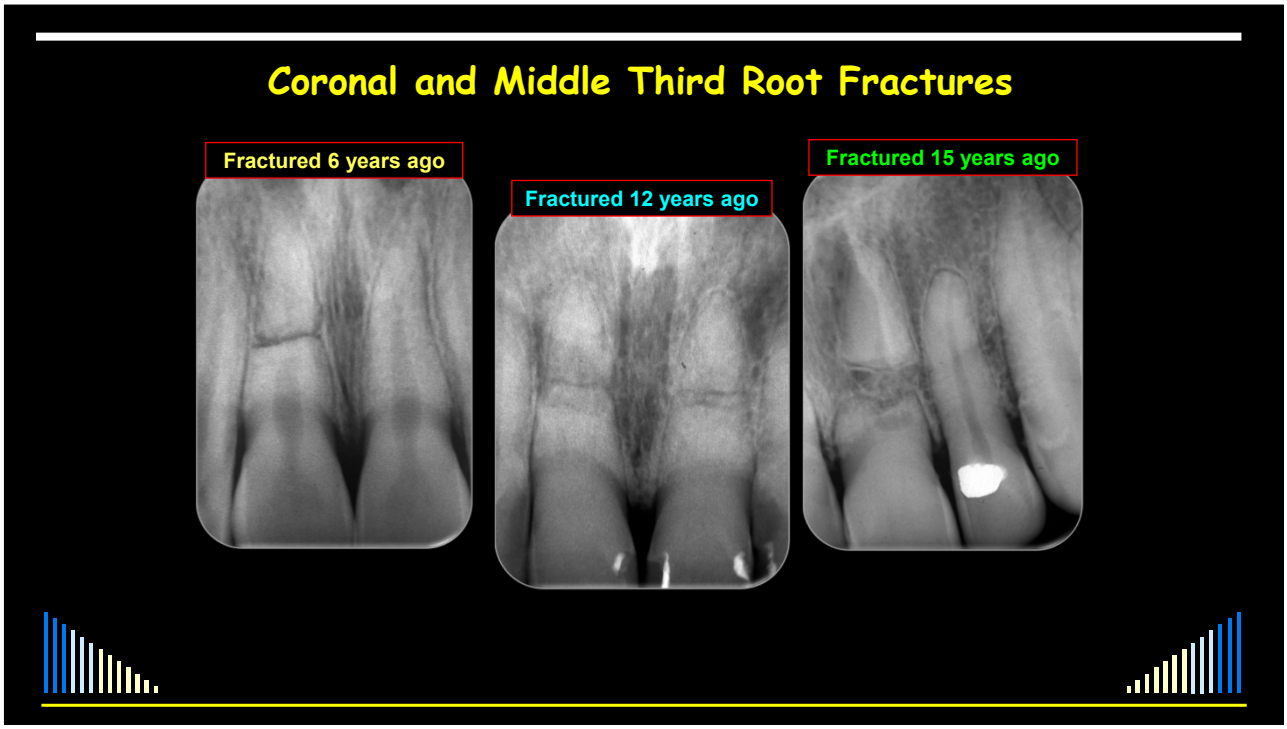


59

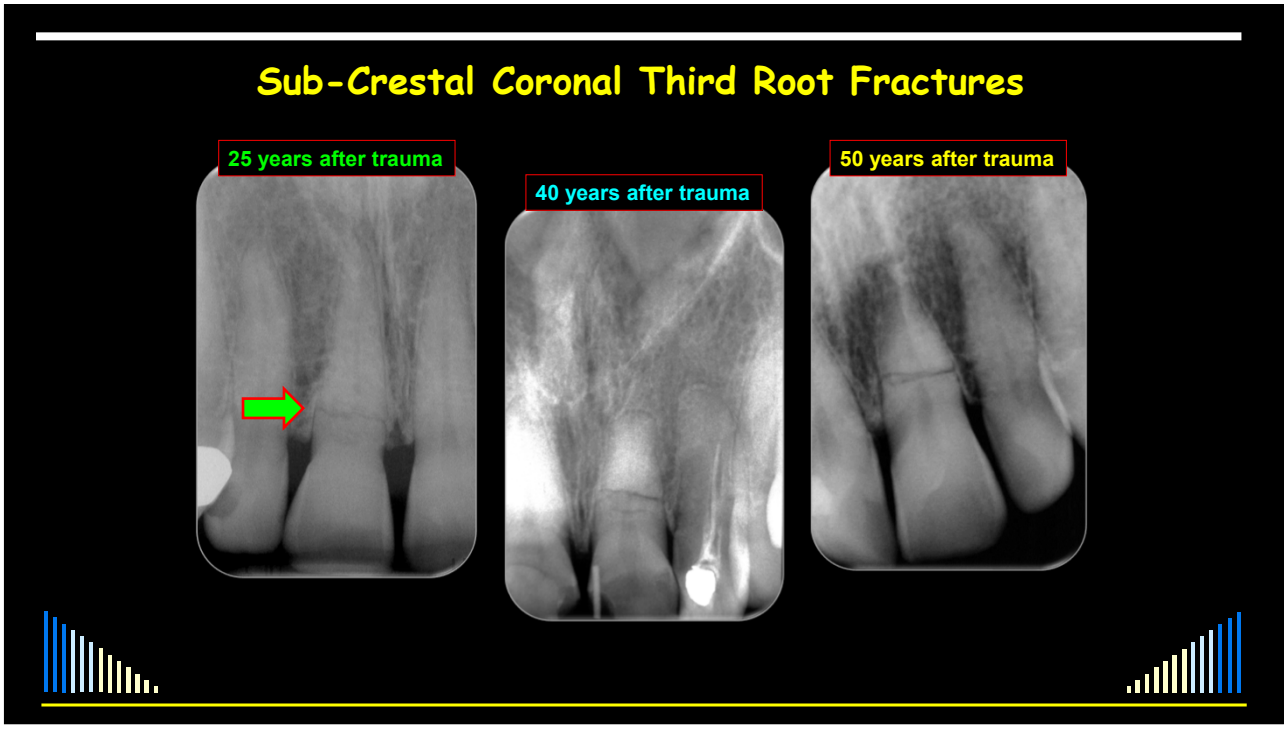
Sub-Crestal Coronal Third Root Fracture



60


Coronal and Middle Third Root Fractures
Fractured 6 years ago
Fractured 12 years ago
Fractured 15 years ago

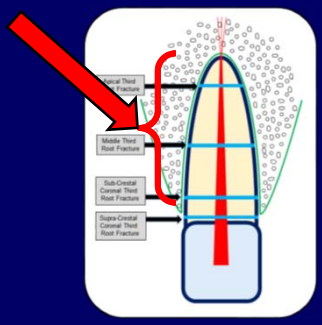
61


Sub-Crestal Coronal Third Root Fractures
25 years after trauma
40 years after trauma
50 years after trauma

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Management of Root Fractures

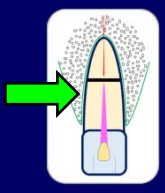
- Initial management depends on fracture position
  - Apical, middle, & coronal sub-crestal fractures
    - manage conservatively
      - → Reposition coronal fragment
        - if displaced
      - → Stabilise with wire/composite splint
      - → Review pulp and PDL healing over time
        - If no signs of pulp necrosis - review for as long as possible
        - If the pulp necroses and becomes infected - several options are available



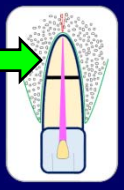
63

Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures

- Root Canal Treatment
  - coronal fragment only

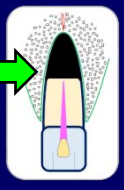


- Root Canal Treatment
  - coronal and apical fragments



- Root Canal Treatment
  - coronal fragment

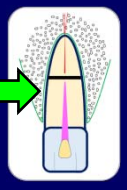
PLUS surgical removal
  - apical fragment



64

Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures

- Root Canal Treatment
  - coronal fragment only



  - Preferred / simplest method with predictably favourable outcomes
  - If necrosis + infection occurs early ➔ hence, the foramen at the fracture line is usually wide open
    - ➔ Need "apexification" - e.g. with $Ca(OH)_2$
    - ➔ Or place a "plug" - e.g. with MTA

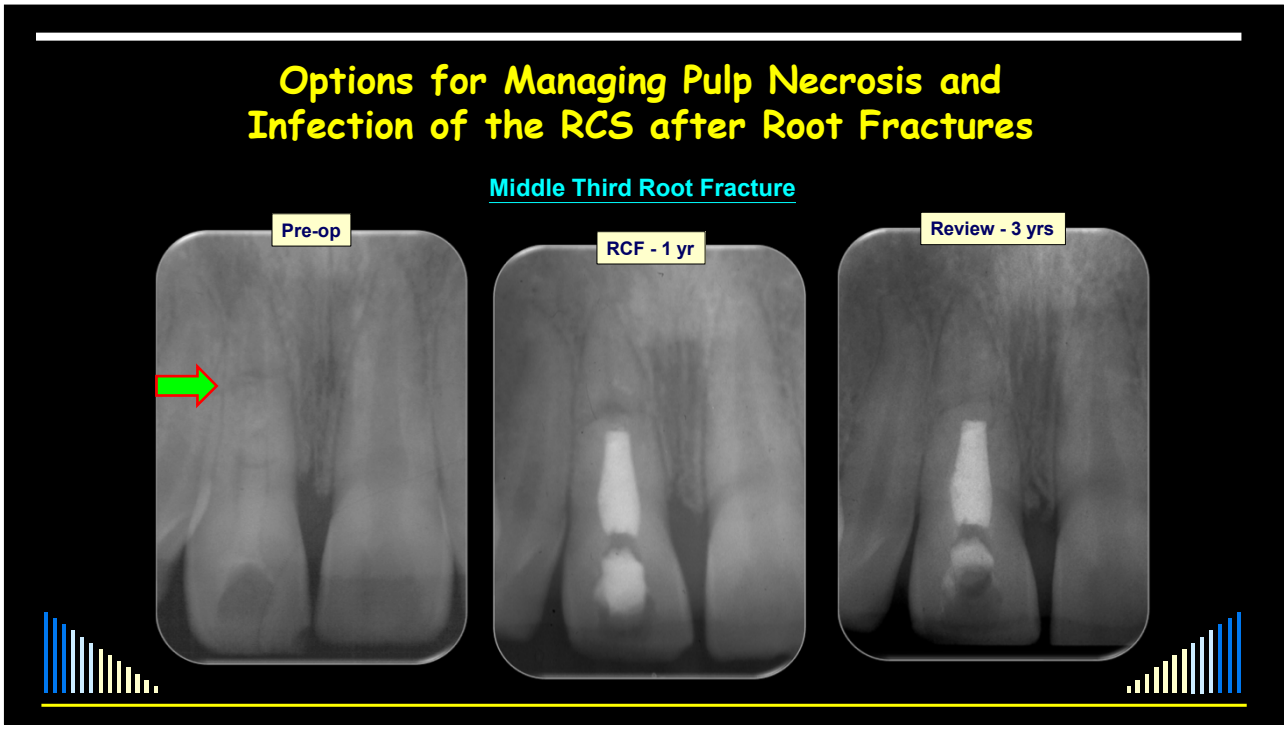
65

Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures

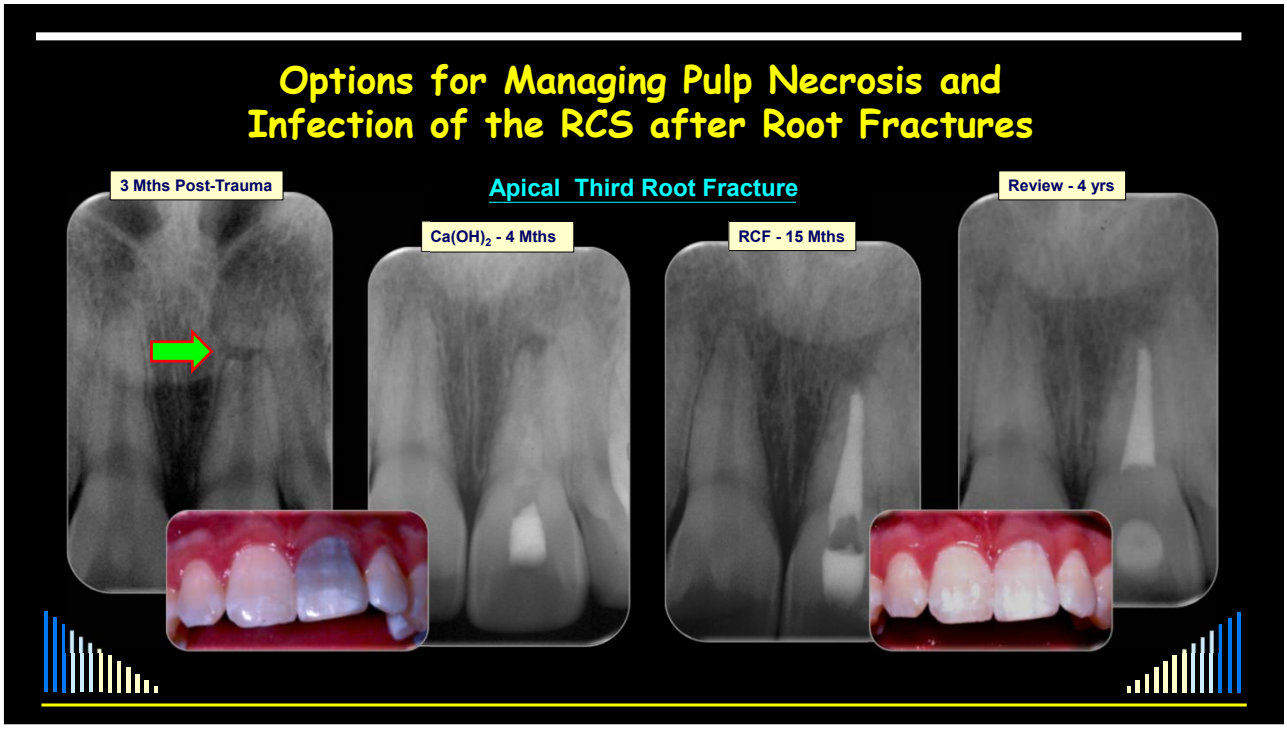
Middle Third Root Fracture



66


Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures
Middle Third Root Fracture
Pre-op
RCF - 1 yr
Review - 3 yrs

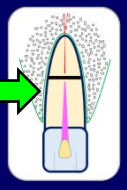
67


Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures
3 Mths Post-Trauma
Apical Third Root Fracture
Ca(OH)2 - 4 Mths
RCF - 15 Mths
Review - 4 yrs

68

Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures

- Root Canal Treatment
  - coronal fragment only



  - Preferred / simplest method with predictably favourable outcomes
  - If necrosis + infection occurs early → hence, the foramen at the fracture line is usually wide open
    - → Need "apexification" - e.g. with $Ca(OH)_2$
    - → Or place a "plug" - e.g. with MTA
  - If necrosis and infection occur later → PCC has usually narrowed the canal and opening
    - → Can do routine root canal treatment

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Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures

11, 21: Root Fractures when 8 years old - 1969



11: Infected RCS + "apical" periodontitis in fracture line - 1994 (i.e. 25 years later)



11: WL - 1994



11: RCF - 1994

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Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures

11, 21: Root Fractures when 8 years old - 1969



11: Infected RCS + "apical" periodontitis in fracture line - 1994 (i.e. 25 years later)



Review: 2003

(34 yrs post-trauma; 9 yrs since 11 RCF)



Review: 2011

(42 yrs post-trauma; 17 yrs since 11 RCF)

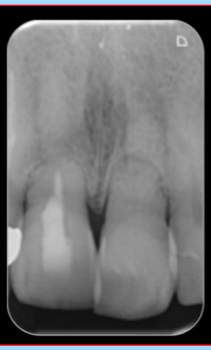
71

Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures

11, 21: Root Fractures when 8 years old - 1969



11: Infected RCS + "apical" periodontitis in fracture line - 1994 (i.e. 25 years later)



Review: 2014

(45 yrs post-trauma; 20 yrs since 11 RCF)



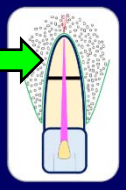
Review: 2016

(47 yrs post-trauma; 22 yrs since 11 RCF)

72

Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures

- Root Canal Treatment
  - coronal and apical fragments
- Not usually needed / recommended
  - Only when the entire root canal is infected or develops irreversible pulpitis



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Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures

From: M. Cvek - Fig. 22.23 – Andreasen 4th Edn 2007

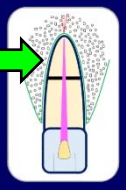


The 21 root fracture healed initially but the tooth developed Irreversible Pulpitis due to caries 5 years after the injury

74

Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures

- Root Canal Treatment
  - coronal and apical fragments

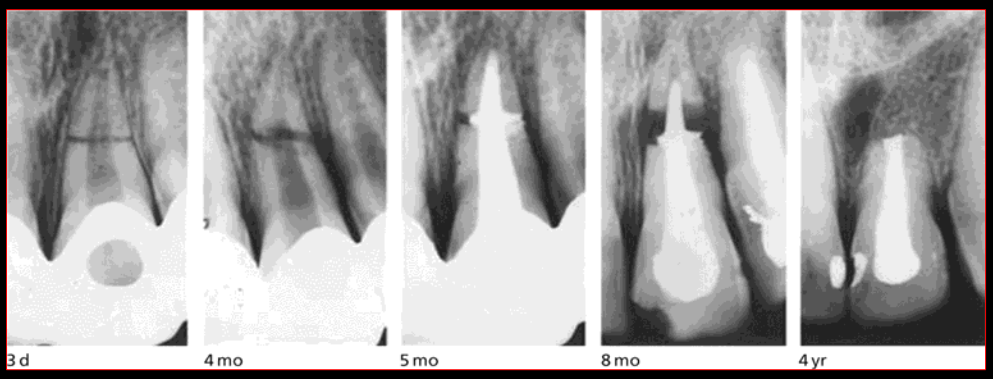


- Not usually needed / recommended
  - Only when the entire root canal is infected
  - Difficulties controlling debris, bacteria, tissue, materials, etc. at the fracture line
    - → May be extruded → can cause inflammation, delayed healing, foreign body reaction, etc.
- Generally has a poor prognosis
  - Surgery may be needed to remove apical fragment and excess materials

75

Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures

From: M. Cvek - Fig. 22.22 – Andreasen 4th Edn 2007

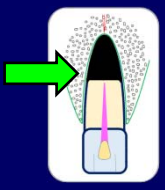


76

Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures

- Root Canal Treatment
  - coronal fragment

  PLUS surgical removal
  - apical fragment



- Rarely required
  - Since the apical fragment is not usually affected by the trauma and rarely develops pulp necrosis
  - Most cases are due to treatment problems after extrusion of materials into fracture site

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Options for Managing Pulp Necrosis and Infection of the RCS after Root Fractures

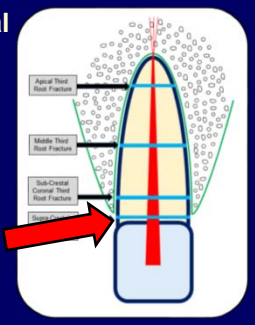
From: M. Cvek - Fig. 22.20 – Andreasen 4th Edn 2007



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Management of Root Fractures

- Initial management depends on fracture position
  - Critical case - supra-crestal fracture in the coronal third
    - ➔ Must decide whether to retain or remove the coronal fragment or even the entire tooth



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Complicated Crown:Root Fractures

- Initial management is very similar to managing a supra-crestal root fracture in the coronal third
  - Since the fracture extends into the coronal third of the root
  - Margins are sub-gingival
  - Likely to have lost a significant amount (or all) of the tooth's crown
    - ➢ Or the crown will be loose / detached so it cannot be retained

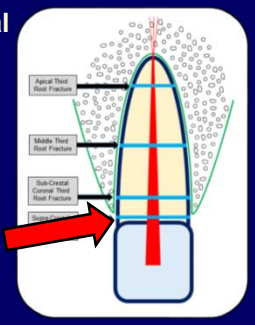




80

Management of Root Fractures

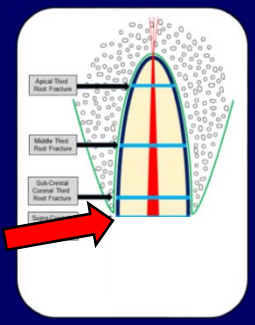
- Initial management depends on fracture position
  - Critical case - supra-crestal fracture in the coronal third
    - → Must decide whether to retain or remove the coronal fragment or even the entire tooth
    - → Options:
      - Remove coronal fragment and do Root Canal Treatment - followed by:
        - Post, crown
        - Crown lengthening surgery, post, crown
        - Orthodontic extrusion ± periodontal surgery, post, crown
      - Extract entire tooth and replace with prosthesis



81

Management of Root Fractures

- Options:
  - Remove coronal fragment and do Root Canal Treatment - followed by:
    - → Post, crown

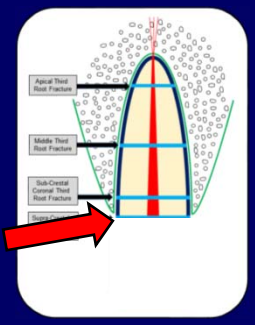


- Usually difficult or not feasible
  - Depends on whether an adequate restoration can be placed without compromising the gingivae
  - Depends largely on the position of the fracture

82

Management of Root Fractures

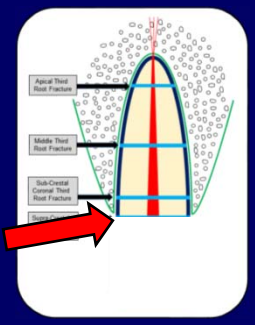
- Options:
  - Remove coronal fragment and do Root Canal Treatment - followed by:
    - → Post, crown
    - → Crown lengthening surgery, post, crown
      - Is possible in some cases
      - Depends on whether an adequate restoration can be placed without compromising the gingivae
      - Can surgery be done without compromising the adjacent teeth and the aesthetics
      - Depends largely on the position of the fracture → especially depth on the labial -v- palatal



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Management of Root Fractures

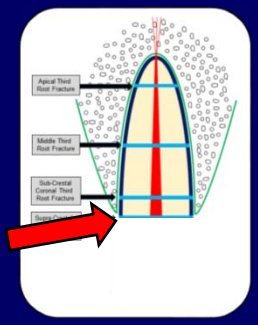
- Options:
  - Remove coronal fragment and do Root Canal Treatment - followed by:
    - → Post, crown
    - → Crown lengthening surgery, post, crown
    - → Orthodontic extrusion ± periodontal surgery, post, crown
      - Several factors to consider



84

Management of Root Fractures

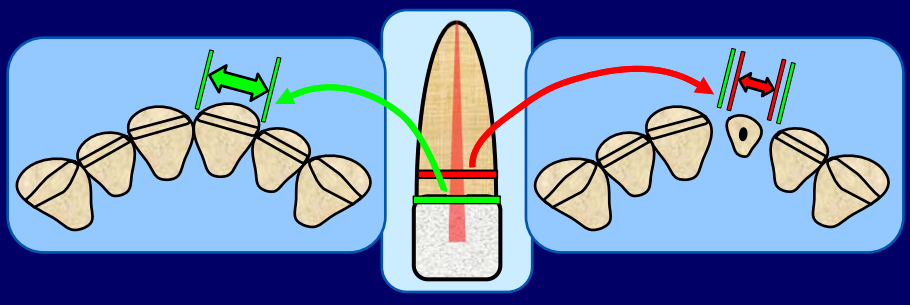
- Ortho. extrusion ± periodontal surgery, post, crown
  - Several factors to consider - esp:
    - Length of root / Length of crown
    - Emergence profile
      - → Width of root / Width of crown
    - Amount & strength of remaining tooth structure
      - → Ferrule
    - Occlusion
    - Aesthetics
    - Periodontal condition
    - Parafunctional habits
    - etc, etc.



85

Management of Root Fractures

- Ortho. extrusion ± periodontal surgery, post, crown
  - Several factors to consider - esp:
    - Length of root / Length of crown
    - Emergence profile
      - → Width of root / Width of crown



86

Management of Root Fractures

- Ortho. extrusion ± periodontal surgery, post, crown


1 week


RCF

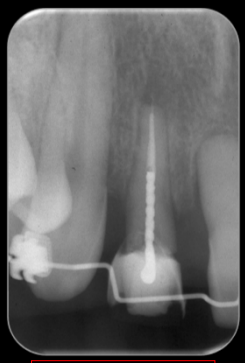

Extrusion

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Management of Root Fractures

- Ortho. extrusion ± periodontal surgery, post, crown


1 week


6 weeks Extrusion


3 months Retention

88

Management of Root Fractures

- Ortho. extrusion ± periodontal surgery, post, crown



Heithersay GS. Combined endodontic-orthodontic treatment of transverse root fractures in the region of the alveolar crest. *Oral Surg Oral Med Oral Pathol* 1973; 36: 404-415.

Courtesy of Prof. Geoffrey Heithersay AO

89

Management of Root Fractures

- Ortho. extrusion ± periodontal surgery, post, crown



Courtesy of Prof. Geoffrey Heithersay AO

90

Complicated Crown:Root Fractures

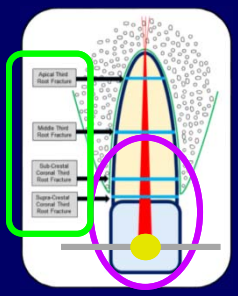


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  - Since the fracture extends into the coronal third of the root
  - Margins are sub-gingival
  - Likely to have lost a significant amount (or all) of the tooth's crown
    - Or the crown will be loose / detached so it cannot be retained

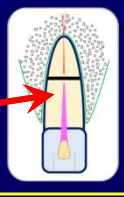


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Summary



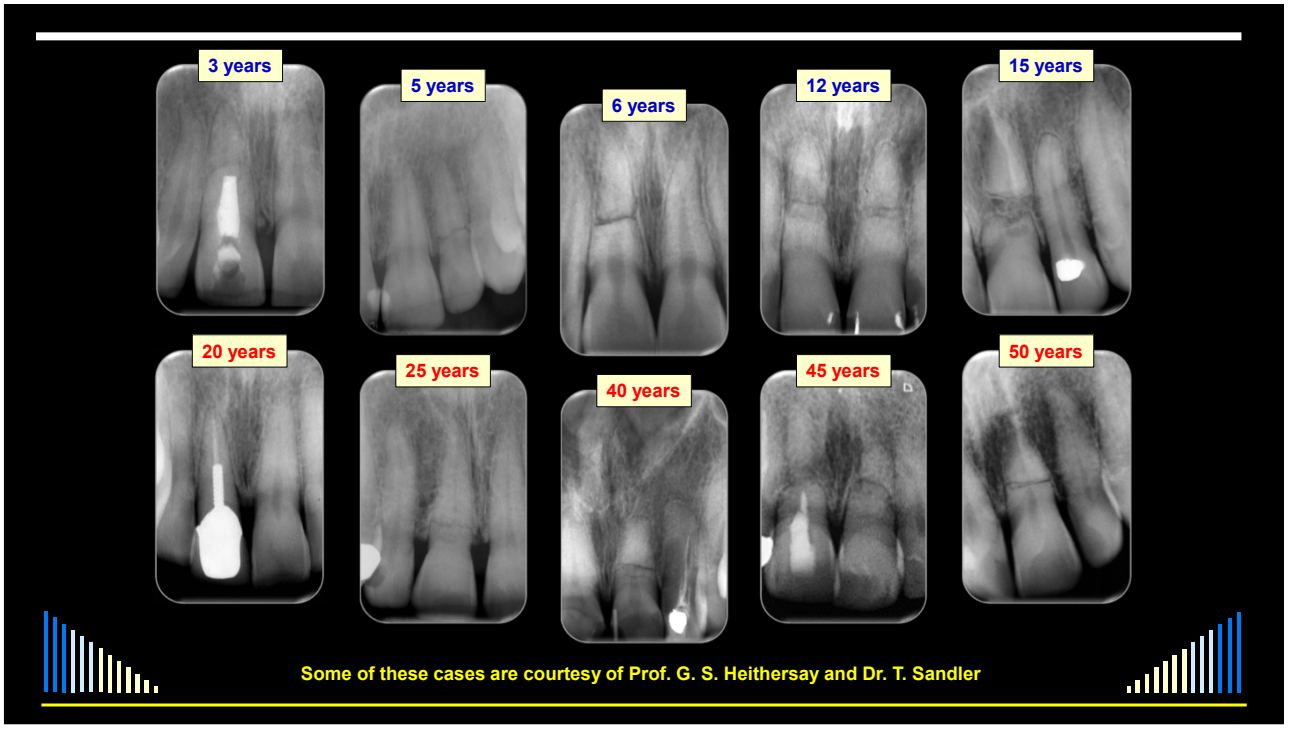
- Root fractures have a good prognosis
  - Depends on whether coronal fragment is displaced
  - Depends on level of fracture - supra-crestal fractures in the coronal third of the root have the least predictable prognosis
- Emergency management is simple
  - Reposition / Stabilise (splint) / Review
- Healing responses:
  - Hard tissue, or connective tissue, or bone & connective tissue
- Most pulps survive
  - Do NOT commence RCT at emergency appointment
    - → Wait and reassess over time
  - RCT only if the pulp in the coronal fragment necroses and becomes infected - only about 27% of cases
    - → Then only do RCT to the fracture line



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Some Cases to Illustrate ...

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