Pulpal changes following trauma.
When is it necessary to undertake RCT?

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Outline

• Pulpal changes following trauma:
  • Pulpal inflammation.
  • Pulp necrosis: with or without INFECTION.
  • Tertiary dentine formation: localised or generalised.
  • Internal resorption: surface, inflammatory & replacement.
• Applied pulp biology.
• When is it necessary to start RCT?

Dentine-pulp complex

DYNAMIC TISSUE that responds to PHYSICAL, MICROBIAL and CHEMICAL irritation in several ways to decrease the irritation.

The physical confinement of the pulp, its high incidence of sensory nerve innervation and the rich microcirculatory components make the dental pulp a UNIQUE TISSUE.
Causes of pulpal pathology:

<table>
<thead>
<tr>
<th>PHYSICAL</th>
<th>Direct / accidental trauma.</th>
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<tbody>
<tr>
<td></td>
<td>Bruxism.</td>
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<td></td>
<td>Orthodontics.</td>
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<tr>
<td>MICROBIAL</td>
<td>Caries.</td>
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<tr>
<td>IATROGENIC</td>
<td>Cavity preparation / restorative preparations.</td>
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<td>CHEMICAL</td>
<td>Restorative materials.</td>
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<td></td>
<td>Erosion.</td>
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Dentine-pulp complex: responds to spectrum of traumatic events

Exposed dentine due to UNCOMPPLICATED CROWN FRACTURE with subsequent bacterial invasion into the tubules.

Sterile exposure during a ROOT FRACTURE - pulp exposed to the periodontal ligament via the fracture line.

Pulp may become partly or totally severed and sometimes crushed at the apical foramen in LUXATION INJURIES.

Directly exposed to bacterial contamination following COMPLICATED CROWN FRACTURE.

Pulp may become partly or totally severed and sometimes crushed at the apical foramen in LUXATION INJURIES.

Pulpal changes following trauma

- PULPAL INFLAMMATION
- INTERNAL RESORPTION
- NECROSIS with or without INFECTION
- TERTIARY DENTINE formation

Pulpal Inflammation

- Reversible Inflammation
  - Pulp vitality but localised area of inflammation that can reasonably be expected to heal after conservative treatment.
  - Pain only present on stimulation (i.e. cold)
  - Pain ceases once stimulation is removed.

- Irreversible Inflammation
  - Pulp vitality but severely inflamed and unlikely to heal after conservative treatment.
  - Spontaneous pain.
  - Pain to thermal change with tendency to linger as dull ache after stimulus is removed.

Pulpal Inflammation

15-year-old male
Several crown fractures to upper anterior teeth
22 uncomplicated crown fractures
Emergency management by GDP - GIC seals
Endodontic referral - one week post trauma

Courtesy of Dr Anika Soori
Pulpal Inflammation

Diagnosis (22): Irreversible pulpitis, associated with normal apical tissues.

Treatment (22): Non-surgical endodontic therapy & review.

Pulp Necrosis

14-year old male. Direct trauma - football injury (24/02/12)
Mouthguard was worn.

Tooth 12: Mild luxation injury (Subluxation)
- No symptoms.
- No TTP.
- Positive response to CO
- No discoloration.
- PA: WNL

Tooth 11: Moderate luxation injury (extrusive luxation)
- "Constant throbbing ache".
- Very TTP.
- Negative response to pulp testing.
- Light grey discoloration.
- PA: Increase in apical PDL space.

Dx: Pulp necrosis with infection and symptomatic apical periodontitis.
Tx: NS RCT

Pulp Necrosis (WITH INFECTION)

Complete RUPTURE of the neurovascular supply to the pulp and severance of PDL fibres.

Disruption to blood flow.

Vascular stasis.

Hypoxia and ischaemia.

Tissue NECROSIS.

Bacterial ingress - INFECTION.

Andreasen et al. (2007)

Pulp Necrosis: With or without infection

- Necrosis with or without INFECTION

INTERNAL RESORPTION

PULPAL INFLAMMATION

Dentine-pulp complex

Localized or generalized TERTIARY DENTINE formation

Pulpal changes following trauma


Dx: Pulp necrosis with infection and symptomatic apical periodontitis.
Tx: NS RCT
Pulpal changes following trauma

**PULPAL INFLAMMATION**

**NECROSIS** with or without INFECTION

**INTERNAL RESORPTION**

**Dentine-pulp complex**

**Localized or generalized TERTIARY DENTINE formation**

**Primary Dentine**
- Formed by the odontoblasts during the development of the tooth.
- Occurs until the completion of root formation.
- Both form along entire pulp-dentine border

**Secondary Dentine**
- Laid down after completion of root formation in increments throughout life.
- Results in gradual but progressive asymmetrical loss of endodontic volume

**Tertiary Dentine**
- Secreted by odontoblasts / odontoblast-like cells in response to external stimuli / injury.
- Localized or Generalized

**Localised Tertiary Dentine**
- Localized (focal deposition) tertiary dentine:
  - Complicated crown fractures & vital pulp therapy - 'Cvek' pulpotomy/direct pulp capping with the intention of achieving dentine bridge formation - represents reparative dentine formation.
  - Preservation of a vital, non-inflamed pulp, biologically walled off by a continuous hard tissue barrier.

**Cvek 1982**: pulps of monkey incisors were exposed by either crown fractures or grinding

Pulpal changes are often characterised by a proliferative response and associated with only superficial inflammation, extending no more than 2mm from the exposure site.

- Localised Tertiary Dentine
  - 16-year old female
  - 22 - complicated crown fracture
  - No luxation injury

Courtesy of Dr Artika Soma
Pulpal Inflammation

Pre-op 6-months 12-months

Brannstrom et al. 1979 Andreasen et al. 2007

Histological response

MTA Ca(OH)$_2$

Dentine bridge is inconsistent & porous.
Ca(OH)$_2$ does not adhere to dentinal walls.
Sealing ability is poor.

Provides a good protective barrier against microleakage.
No tunnel defects.

C/O: "discoloured front tooth"
Hx: 21- Impact trauma when patient was younger.
No Symptoms.
CO$_2$ negative, but EPT positive.
No periapical radiolucency.

C/O: "discoloured front tooth"
Hx: 11- Impact trauma when patient was younger.
No Symptoms.
CO$_2$ negative, but EPT positive.
No periapical radiolucency.

Dentine bridge is inconsistent & porous.
Ca(OH)$_2$ does not adhere to dentinal walls.
Sealing ability is poor.

Poor antibacterial properties.
Pulp Canal Obliteration (PCO)

- Response to injury of the neurovascular supply to the pulp:
  - Leads to an accelerated hard tissue deposition (reactory dentine) along pulp canal wall - i.e. survival of existing odontoblasts.
  - Common sequela in all types of luxation injuries that include displacement.
  - Recognised radiographically as early as 3-months after injury but most often detected after 1-year.

PCO - Colour change

Darker hue, loss of translucency and yellow appearance of the crown.

Tooth discolouration is of limited diagnostic value - not reliable indicator for pulp or periapical pathology. Robertson et al. 1996

Not all PCO cases undergo colour change.

PCO - Radiographic findings

With periapical pathology

Without periapical pathology

Pulp Canal Obliteration (PCO)

Pulpal necrosis and periapical disease are not a common complication

<table>
<thead>
<tr>
<th>Study</th>
<th>Ob period (yr)</th>
<th>No. of units Studied (teeth)</th>
<th>No. of teeth with PCO</th>
<th>No. of teeth with pulpal necrosis (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andreasen 1970</td>
<td>3.6</td>
<td>189</td>
<td>42</td>
<td>7</td>
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<tr>
<td>Johansen &amp; Hedegard 1975</td>
<td></td>
<td>76</td>
<td>76</td>
<td>16</td>
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<tr>
<td>Jacobsen &amp; Kerekes 1977</td>
<td>16</td>
<td>122</td>
<td>122</td>
<td>13</td>
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<tr>
<td>Andreasen et al. 1987</td>
<td>3.6</td>
<td>96</td>
<td>96</td>
<td>1</td>
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<tr>
<td>Robertson et al. 1996</td>
<td>16</td>
<td>82</td>
<td>82</td>
<td>8.5</td>
</tr>
<tr>
<td>Ogino et al. 2009</td>
<td>276</td>
<td>276</td>
<td>276</td>
<td>27.2</td>
</tr>
</tbody>
</table>

Apparent RADIOGRAPHIC DIAMETER does not always correspond to its true HISTOLOGICAL WIDTH. Kukl & Wilson 1996
Generally accepted that pulp sensibility tests are unreliable.

- CO\textsubscript{2} and EPT.
- Progressive decrease in the response to thermal and electrical pulp testing as PCO becomes more pronounced.
- Robertson et al. 1996: 40% of the teeth (n=82) although not responding to EPT were clinically and radiographically within normal limits.

Absence of a positive response does not in itself indicate pulp necrosis.

**Sympathetic and/or PA pathology**
- No discolouration
- No clinical or radiographic signs of infection

**Discolouration and/or aesthetic concerns**
- Partial coverage restoration
- Microlux bleaching
- Satisfactory result

**Baseline**
- Elective RCT
- Discolouration and/or aesthetic concerns
- Vital bleaching
- Non-vital bleaching

**Option 1**
- Satisfactory result
- Unsatisfactory result

**Option 2**
- Monitor

**Baseline**
- 16 days
- 33 days

**PCO - External bleaching**

**Baseline**

**16 days**

**3 weeks**

**3 weeks**

**PCO**

**Symptomatic and/or PA pathology**

**Discolouration and/or aesthetic concerns**

**Partial coverage restoration**

**Microlux bleaching**

**Satisfactory result**

**Monitor**

**Baseline**

**3 weeks**

**5 weeks**

**Courtesy of Dr. Bruce Matis**

**Courtesy of Dr. Janice Kan**
OPERATIVE CHALLENGES IN CASES OF PCO

- Root Perforations
- Instrument Fracture
- Structure Loss

PULPAL CHANGES FOLLOWING TRAUMA

- Pulpal Inflammation
- Pulpal Necrosis with or without Infection
- Internal Resorption
- Dentine-pulp complex

If in doubt: REFER
Take PA

ULTRASONICS & PULP BURS

TIPS

Operating microscope

Labial perforation

September 2012

Courtesy of Dr. Anika Saro
Internal Resorption

- **SURFACE RESORPTION**
- **INFLAMMATORY RESORPTION**
- **REPLACEMENT RESORPTION**

**Internal Inflammatory Resorption**

30-year old female. Hx: direct trauma L1 - lateral luxation-type injury.
No symptoms. Negative response to CO₂.

**Courtesy of Dr Artika Soma**

**Internal Inflammatory Resorption**

- Clinically:
  - May or may not be symptomatic.
  - Mixed response to pulp testing: early stages may be positive - vital apical portion.

- Radiographically:
  - Oval-shaped enlargement within the pulp chamber.
  - Shift PA.
  - CBCT.

**Heithersay 2007**

**Internal Inflammatory Resorption**

**APICALLY**
- Revascularisation front - vital pulp tissue

**Necrotic & Infected front**

Progression depends on interaction between necrotic and vital pulp tissue at their interface.

**CORONALLY**
- Necrotic & Infected front

**Internal Inflammatory Resorption**

**Courtesy of Dr Artika Soma**

**Internal Inflammatory Resorption**

**Courtesy of Dr Luke Moloney**
Internal Inflammatory Resorption

'Internal tunnelling resorption'
- Pulp undergoes metaplastic changes and dentine is resorbed and replaced by bone-like hard tissue.
- Not due to presence of bacteria.
- Generally asymptomatic.
- Often only recognised during radiographic examination.
  - Irregular enlargement of pulp space that is filled with bone-like hard tissue.
  - Periapical changes often not present.

Perforating lesion

When is it necessary to undertake RCT

ALWAYS INDICATED
- When Pulp is predictably necrosed and INFECTED

STRICT MONITORING INDICATED
- Pulp necrosis and INFECTION is highly probable but NOT INEVITABLE

LESS STRICT MONITORING INDICATED
- Pulp necrosis and INFECTION are unlikely

Closed Apex

Abbott & Yu 2007

Andreasen et al. ‘Dental Trauma Guide’ 2010

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Open Apex
When is it necessary to undertake RCT

**ALWAYS INDICATED**

- When Pulp is predictably NECROSED and INFECTED

**STRICT MONITORING INDICATED**

- Pulp necrosis and INFECTION is highly probable but NOT INEVITABLE

**LESS STRICT MONITORING INDICATED**

- Pulp necrosis and INFECTION are unlikely

Closed Apex:

Open Apex:

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**Two major factors impact on the potential for pulpal healing following luxation injuries:**

- **TYPE OF LUXATION INJURY** - Extent of damage to the complex.
- **STAGE OF ROOT DEVELOPMENT** - Capacity of the complex to repair.

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**Transient Apical Breakdown (TAB)**

Temporary radiographic changes in the region of the apical foramen:

- **Mild** - moderate luxation injuries.
- **Mature teeth**

Partial or total disruption to vascular supply - Ischaemic changes in the pulp

Wound healing response.

Resorption of hard tissue (dentine, cementum and bone).

Increase in PDL space / diameter of apical foramen.

Gain space to accommodate ingress of greater vascular network into the root canal to aid in the healing process.
Transient Apical Breakdown (TAB)

1-month post trauma - 11 palatally luxated (Heithersay 2007)

1-year post trauma - 11 palatally luxated: Positive pulp testing (EPT)


04/10/11 Tooth 21: de-attachment of orthodontic bracket - extrusive luxation.
Symptomatic.
CO₂ negative.
Mild grey discoloration.
PA: widening of PDL space present apically.

Dx 21: Symptomatic AP with necrotic and infected root canal system.

October 2011 March 2012 October 2012

22 CO₂ - 22: CO₂ - 22: EPT +

Tooth 22: no major displacement - concussion.
No Symptoms.
No TTP.
CO₂ negative.
No discoloration.
PA: widening of PDL space present apically.
Decision was made to strictly monitor this tooth.

Transient Apical Breakdown (TAB)

Associated colour change.
Unreliable pulp testing
Associated with PCO.
Transient process - 1-year.

1-year post trauma - 11 palatally luxated (Heithersay 2007)
Transient Apical Breakdown (TAB)

12 year old male
Subluxation 11 Three weeks prior
No symptoms but discoloured 11
CO2 negative, EPT positive

Courtesy of Dr Luke Moloney

3 weeks later
Colour resolved
Pulp canal obliteration

Courtesy of Dr Luke Moloney

Horizontal Root Fracture

Pulp in apical portion of root usually remains vital.

Both pulpal and PDL damage coronally.

Healing mostly depends upon the integrity of the pulp at the level of the fracture.

Hard tissue healing

- Minimal displacement of the coronal fragment (pulp may only be slightly stretched at the level of the fracture site).
- Fracture healing with ingrowth of cells originating from the apical half of the pulp ensures hard tissue union of the fracture.
- Cannot be diagnosed radiographically earlier than 3-months after injury.

Andreasen et al. 2007

Andreasen & Hjorting-Hansen 1967
**Horizontal Root Fracture**

*Connective tissue healing*

- The pulp is ruptured or severely stretched at the level of the fracture following displacement of the coronal fragment.
- Healing is dominated by ingrowth of cells originating from the periodontal ligament.
- Results in interposition of connective tissue between the fragments.

Andreasen et al. 2007

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**Interposition of bone and connective tissue**

Interposition of a bony bridge and connective tissue between the apical and coronal fragments, with a normal PDL surrounding both fragments.

Andreasen & Hjorting-Hansen 1967

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**Non-healing due to infection**

- Inflamed granulation tissue between the fragments.
- Coronal portion - necrotic & infected. Apical portion - usually contains vital pulp tissue.
- Widening of the fracture line, loss of lamina dura and rarefaction of the alveolar bone bone corresponding to the fracture line.

Andreasen et al. 2004

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Total pulp canal obliteration of the root canal in both fragments is a common finding.
Horizontal Root Fractures - 'predictors of healing'

Time of injury 8-year old male
Direct trauma - playground sporting injury (August 2007)
Emergency management at RDHM
Continued care under paediatric specialist
Endodontic referral - September 2011

11: EPT + 21: EPT + 12: CO₂ + 22: CO₂ +

17-year old male
Hx: accidental hockey stick injury to the face (13-years old)
Significant displacement of lower anterior teeth

Courtesy of Dr. Ennio Rebellato
Summary

- Dentine-Pulp complex is a DYNAMIC tissue with a significant capacity to heal.
- Pulpal changes following trauma can include: (i) Pulpal inflammation; (ii) Pulpal necrosis (with or without INFECTION); (iii) Tertiary dentine formation and (iv) Internal resorption.
- Whether the inflammation will progress to pulp necrosis, or resolve with a repair/reparative response, may be influenced by clinical treatment procedures.

Summary

- When deciding whether to undertake endodontic therapy:
  - Perform endodontic therapy on teeth where pulpal necrosis and INFECTION is inevitable following the traumatic injury.
  - For cases where pulp necrosis and INFECTION is highly probable but not inevitable:
    - Undertake the appropriate emergency management.
    - Take good baseline records and maintain strict and structured reviews.
    - If in doubt contact an endodontist for advice or refer.