Traumatic Dental Injuries & Root Resorption – implications in endodontics

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The relationship between traumatic dental injuries and root resorption

Traumatic dental injuries

Root resorption

Traumatic dental injuries

I. Crown fractures
II. Luxations
III. Avulsions
IV. Root fractures

Traumatic Dental Injuries

"For every force (action), there is an equal and opposite force (reaction)."

Root resorption

I. External root resorption
II. Cervical root resorption
III. Internal root resorption
Timing of emergency dental treatment

Acute priority: root fractures, lateral/extrusive luxations, avulsions – tx required within hrs
Subacute priority: complicated crown fractures, intrusions, concussions, subluxations – tx can be delayed several hrs
Delayed priority: uncomplicated crown fractures – tx can be delayed beyond 24hrs

Andreasen, et al. Dent Trauma, 2002
Baklund & Andreasen, Endod Topics, 2004

Crown fractures

I. Enamel only
II. Enamel-dentin fractures
III. Complicated crown fractures
IV. Crown-root fractures

Treatment options:
- D'Angelo AJ, et al.
- Dent Traumatol 2012

Enamel only and Enamel-dentin fractures – Restore and monitor

Complicated crown fractures – assess pulpal vitality / root development

- Preserve vital, non-inflamed pulp.
- Concomitant luxation injury may compromise blood supply.

Complicated crown fractures

Tx options
I. Pulp cap
II. Shallow pulpotomy (Cvek)
III. Coronal (complete) pulpotomy
IV. Root canal therapy


Complicated crown fractures

I. Pulp cap – small exposures tx’ed within 24 hrs.
II. Pulpotomy – larger exposures or longer elapsed times before treatment is initiated.
III. Root canal therapy – severely inflamed pulps with mature roots.

Cvek, 1994
The Çvek pulpotomy

- Çvek, M J Endod. 1978
- Çvek, M J Endod. 1983

Healing frequencies in complicated crown fracture cases

- Pulp capping: Ravni, Scand J Dent Res. 1992 86%
- Fuks et al. Ped Dent. 1982 81%
- Çvek pulpotomy: Çvek, J Endod. 1978 96%
- Fuks et al. Endod Dent Trauma. 1987 94%
- Cervical pulpotomy: Geiber et al, Br Dent J. 1988 75%
- Pulpectomy/RCT: multiple studies 90%

Crown-root fractures

- Complex injuries
- Remove the mobile coronal segment
- Restore if possible
- Crown lengthening pin
- Surgical or orthodontic extrusion
- Pulpotomy or RCT pin

Luxations

I. Concussions/subluxations
II. Lateral luxations
III. Intrusive luxations
IV. Extrusive luxations

Luxations - treatment principles

- Reposition the tooth
- Splint / stabilize the tooth
- Vitality testing
- Follow up and treat as needed

Two common pulpal responses after luxation injuries

1. Pulp necrosis
2. Calcific metamorphosis

Andreasen JO, Andreasen FM. Textbook on Traumatic Injuries

Andreasen et al. Endod Dent Trauma, 1987
Luxation injuries

- Pulp necrosis or calcific metamorphosis

**Extrusive and lateral luxations** of mature roots:
- 55-60% develop pulp necrosis within 1 year.
- If an open apex, only 5% become necrotic.
  but 35% experience pulp canal obliteration.

**Intrusions** mature roots – 85% develop pulp necrosis.
open apex – 50% develop pulp necrosis.

(Dentaltraumaguide.org)

Luxation injuries

What is the likelihood of dental pulp remaining vital following luxation injuries?

- Concussions: 97%
- Subluxations: 94%
- Extrusive luxations: 74%
- Lateral luxations: 42%
- Intrusive luxations: 15%

Andreasen & Pedersen, Endod Dent Trauma, 1985

Luxation injuries

What is the prognosis for luxated teeth with necrotic pulps that are treated with CaOH and obturated with GP?

- Mature teeth: 94%
- Immature teeth: 96%

Cvek, Endod Dent Trauma, 1992

Intrusive luxations

- Maximum damage to pulp and PDL
- Can reposition surgically, orthodontically or allow to re-erupt on their own
- Long term prognosis often unfavorable

Avulsion injuries

Surgically repositioned and splinted case

Courtesy of Dr. Lena Holz

Andreasen JO, Andreasen FM. Textbook on Traumatic Injuries
Avulsion injuries - critical factors in management
- Time out of the socket
- Extraoral storage medium
- Stage of root maturation

Andreasen, Endod Dent Trauma, 1995

Avulsion injuries - extraoral storage media
- Saline, saliva
- Milk
- HBSS, Viaspan
- Gatorade
- Egg albumin
- Pedialyte
- Coconut water

Note: Water is NOT good because it is hypotonic!

Milk is Good!
- Physiologically good osmolarity for teeth.
- pH is in a physiological range.
- Can provide some nutrients to the cells.
- Pasteurized milk has a low bacterial count.
- Is readily available in many cases.


Avulsion injuries - consequences
- Attachment damage
- Pulpal necrosis and bacterial ingress
- Root resorption – inflammatory & replacement

Avulsion injuries
- case report 1
- 15 yr old male avulsed #8 –
  #8 replanted within 25 minutes

Courtesy – Dr. Jerald Smith

Avulsion injuries
- case report 2
- Avulsed #8 on Xmas eve -
  kept in milk for 4 hours prior to reimplantation.
Avulsion injuries
- replantations with an open apex

- Incidence of revascularization.  
  18% - Kling et al. Endod Dent Trauma, 1996  
  18% - Cvek et al. Endod Dent Trauma, 1990  
  34% - Andreasen et al. Endod Dent Trauma, 1995  
- 5 min soak in doxycycline solution doubles the chance of revascularization occurring.  
  - Cvek et al. Endod Dent Trauma, 1990  
- Risk: immature roots can resorb quickly.

Avulsion injuries
- systemic antibiotics/vaccines

- Amoxicillin at time of replantation  
  - no inflammatory resorption  
  - Hammarstrom et al. Endod Dent Trauma, 1996  
- Tetracycline could be an alternative for pts > 12 y/o  
  anti-resorptive properties  
  - Sei-Lim et al. Endod Dent Trauma, 1998  
- Note: ensure tetanus vaccine is current  
  - Andreasen

Horizontal root fractures

These can be sub-classified on the basis of:
- Location of fracture line  
  (cervical, middle, apical)  
- Extent of fracture (partial or complete)  
- Number of fracture lines  
  (simple, multiple, comminuted)  
- Position of coronal segment  
  (displaced or non-displaced)

Horizontal root fractures

- Teeth must be repositioned & stabilized  
- Rigid or flexible splint – 4 weeks to 4 months  
- RCT / CaOH tx of coronal segment if pathosis develops

(Courtesy Dr. Cyrus Ardalan)
**Horizontal root fractures**
- four modes of healing
  - Healing with calcified tissue
  - Interposition of connective tissue
  - Interposition of bone & connective tissue
  - Interposition of granulation tissue
  (Andreasen & Hjorting-Hansen, 1967)

**Horizontal root fractures**
- incidence of pulp necrosis
  - Pulp necrosis occurs about 25% of the time.
  - Typically occurs only in the coronal segment.
  - Prognosis when treating the coronal segment while unknown appears good.
    Cvek, Odont Revy, 1974

**Case report: Trampoline accident 4 days earlier, tooth splinted that day. Tooth #8 non-responsive to cold.**

On Dec 1, tooth #8 responded to cold testing!

(Courtesy Dr. Laura Garden)

**Case report: History of trauma 3 months earlier, root fracture stabilized and splint removed 2 weeks later. Patient presents now with pain on biting down on #9.**

(Courtesy Dr. Nick Schroeder)

**Splinting teeth - rationale**
- Maintain position and function
  Diangelis et al, Dent Trauma 2012
- Remove in 7-10 days
  Andreasen, Acta Odontol Scand 1975
  Nesfield et al, Oral Surg 1982
- Should allow physiological movement
  Antrim et al, J Endod 1982

**Splinting teeth - technique principles**
- Passive placement
- Stabilize teeth in position
- Easy to make/place
- Does not interfere with occlusion
- Allows endodontic access
- Allows good oral hygiene
- Easily removed

(Neaverth & Goerg, J Am Dent Assoc 1980)
What about orthodontics after trauma?

- There is no consensus on how long to wait!

Krodjian et al. J Orthod 2008 – suggests waiting 3 months (after minor injuries) and up to 1 year (after severe injuries) before starting ortho tx (based on empirical information only).
Pereira et al. Dent Trauma 2012 – waiting 15-30 days is sufficient after minor injuries (rat model).

Potential complications following traumatic dental injuries:
- Pulp necrosis
- PCO
- Resorption
  - ex. inflammatory
  - replacement
  - cervical invasive
  - internal

Take home points regarding traumatic dental injuries:
- Get a good history of the traumatic event!
- Young pulps have a great capacity to heal. A non-responsive pulp does not imply pulp necrosis.
- Infection related resorption progresses very rapidly in immature teeth!
- Endo tx is NOT a 1st priority in root fracture cases.
- Multiple injuries to a tooth decrease the prognosis.
- Every traumatic injury is its own individual injury!

One common sequelae to many of the more significant dental injuries..............
Root Resorption

I. Historical Background
II. Mechanisms of resorption
III. External root resorption
IV. Cervical root resorption
V. Internal root resorption

1894 – Gaskill
Case report of internal resorption w/ a pink spot

1930 – Gottlieb & Orbán
Described internal root resorption

1951 – Henry & Weinman
Histological study of extracted teeth
> 90% showed some type of evidence related to external root resorption

1966 – Andreasen & Hjorting-Hansen
Studies with replanted teeth defined 3 types of external resorption:
- surface
- inflammatory
- replacement

1979 – Harrington & Natkin
First described post-bleaching cervical resorption
1981 – Al Frank
First described extracanal invasive resorption

Heithersay -
Invasive Cervical Root Resorption
Quintessence Int 1999,
Endo Topics 2004

1982 – Present
Many reports/studies on root resorption since 1982

Primary vs. nonpermanent teeth, it is pathologic.

Hammarstrom, 1985
Selzer (Endodontology ed 2), 1988

Root Resorption
How does root resorption take place?
- Responsible cells: odontoclasts / osteoclasts
- Osteoclasts are attracted to specific proteins present on calcium salt crystals in mineralized tissues such as bone and dentin.
- Under normal circumstances, the mineralized tissues of permanent teeth are resistant to resorption.

H. Mechanisms of resorption
Two things that need to happen before root resorption can occur:

A. Loss/alteration of protective layer around dentin
B. Inflammation present next to the dentinal surface

A. Protective layers against resorption — what are they?

Cementum and pre-dentin:
- Both are unmineralized layers
- Both are resistant to the resorptive process

Odontoclasts are considered a variant of the osteoclast. A vast amount of our knowledge regarding these cells comes from studies of bone physiology and pathology.

Osteoclasts will not adhere to NOR resorb unmineralized matrix

B. Inflammation
- Has both destructive and reparative phases.
- Resorption occurs during the destructive phase.
Inflammation

Destructive phase
- acidic environment
- cell death
- will continue as long as stimulus is present

Paul Abbott describes the "resorption triad":
1. Breakdown of barriers
2. Continued stimulation
3. Blood supply

Four general types of stimuli that can lead to external root resorption

- Pressure-induced damage
- Microbial infection of the RC space
- Suicidal infection
- Chemical damage secondary to bleaching

Heithersay, Endod Topics, 2004
Patel et al, Dent Update, 2007

Inflammation

When inflammation is ongoing and exposed dentin is present – root resorption can occur.

Management considerations:

1. What type of resorption is present?
2. Is the resorption self-limiting?
   If progressive:
3. What is the best direction of management?
4. What is the short/long term prognosis?
5. If extraction is indicated, when should it be done?
External root resorption:
--- A physiologic or pathologic process resulting in the loss of dentin or cementum which initially begins in the periodontium and affects the external or lateral surfaces of a tooth.

--- AAE Glossary of Terms
- Apical/lateral root resorption
- Cervical root resorption

Apical/lateral root resorption

1. Surface
2. Inflammatory
3. Replacement

(Andreasen, 1966)

1. Surface Resorption
- Henry & Weinman's study?
- Transient stimulus followed by cemental healing
- Not seen radiographically

2. Inflammatory Resorption
- Pulpal bacteria / infection
- Sulcular bacteria
- Pressure - impacted teeth, ortho tx
- Two types - apical & lateral

3. Replacement Resorption
- "Ankylosis"
- Trauma most common etiology
- Bone replacing tooth structure

In osseous replacement resorption, bone is undergoing a normal physiological process. Dentin has now become part of this normal bone remodeling process and is being replaced by bone, thus making this essentially untreatable.
Treatment principles for external root resorption

Apical/lateral inflammatory root resorption – remove the etiology!
There are both preventive and interceptive strategies.
Both involve the use of CaOH –

- It is antibacterial.
  Brystom et al, Endod Dent Trauma, 1989
- It influences the pH in dentin.
  Transtad et al, J Endod, 1981
  Nervich et al, J Endod, 1993
- It possibly stimulates repair on the root surface.

Preventive strategies - avulsion injuries
Factors to consider in avulsion cases:
1. Time out of the mouth
2. Storage media used
3. Damage to the root
4. Splintering
5. Timing of root canal treatment

Preventive strategies - avulsion injuries
Timing of root canal treatment in avulsion cases
1. Avoid immediate use of CaOH
2. Avoid immediate RCT
3. Avoid extra-oral RCT
Each of these have been shown to cause further damage to the PDL thus increasing the risk of ankylosis occurring
4. Use of Ledermix – Bryson et al, Dent Trauma, 2002

Ledermix paste -- an alternative?
1% triamcinolone (corticosteroid)
3% demeclocycline (broad spectrum Ab)
Bryson, et al. 2002

Ledermix paste
- Potential alternative to CaOH
- can be placed immediately
- can cause crown discoloration
- is presently not FDA approved in the U.S.
Avulsion injury – (preventive strategy)
- case: hit in mouth by bad-hop grounder which avulsed #8, luxated #9 five weeks earlier.

Luxation injury – (interceptive strategy)
- CaOH therapy
- RCT
- 24/2-43
- #9
- Boating accident one year earlier – luxation injuries of both #6,7
- 1-28-94
- Obturated
- 6-22-95
- 28 mos. recall

Luxation injuries – (interceptive strategy)
- CaOH therapy
- RCT
- Prognosis
- Cvek. 1974, 1992

Apical resorption – (interceptive strategy)
- Pre-tx film
- New month recall

Replacement resorption
- RCT ()
- CaOH (?)
- Prognosis (?)

Replacement resorption
- Treatment principles in adults: Can maintain in the absence of symptoms, however the root will gradually resorb away as it is replaced with bone ultimately resulting with the crown of the tooth fracturing away from the ridge.
In kids, two principles to consider:
1. Tooth preservation phase
2. Ridge preservation phase

The tooth preservation phase:
If you can preserve these teeth beyond the individual's growth phase, consider it a success!

Hypothesis: if inflammation can be minimized, could replacement resorption then be reduced? Could RCT be beneficial? Ledermix paste?

The ridge preservation phase:
If the tooth becomes in infraposition of 2mm or more, the tooth will not erupt and the ridge will not grow!

Treatment – Decoronation
Goal: to preserve a good osseous ridge for implant placement after the growth phase is complete!
Bone will not grow on enamel, thus one of the goals of decoronation is to remove the enamel.
Malmgren et al. Scan J Dent Res. 1984

Summary of treatment principles –
1. Inflammatory root resorption is very treatable – remove the etiology!
2. Replacement resorption is a result of normal cells performing their normal function, thus is not treatable, but can/should be managed.
3. Replacement resorption can be a rapid or very slow progressive process.

IV. Cervical root resorption
Cervical root resorption (aka)

1. Post-bleaching resorption
2. Invasive cervical resorption
3. Extracanal invasive resorption
4. Sub-epithelial external inflammatory resorption
5. And other related terms

Invasive cervical root resorption

- Typically asymptomatic
- Histologically similar to other inflammatory resorption defects.
- Pulp tissue typically plays no role in process.
- Cervical region of the root is invaded by fibrovascular/histo-ossous tissue from the PDL.

Heathersay, Endo Topics, 2004

Post-bleaching resorption

- Harrington & Natkin, J Endod 1979 (case series of 4 cases)
- younger patients
- history of trauma
- history of RCT & N-V bleaching

Southan, 1967
- reported 5-10% incidence where enamel and cementum do NOT meet in cervical area

Gap  Flush  Overlap
- cervical region prone to resorption

Invasive Cervical Root Resorption

Heathersay – 2004
Endo Topics 2004:7:73-82

(Good summary article.)

Pre-disposing factors to cervical resorption:

Orthodontics
Trauma
Bleaching
Surgery
No identifiable factor

Heathersay, Quintessence Int, 1999
**Potential predisposing factors to ICR**


29 premolars orthodontically tipped buccally for 8 weeks => 27 of 29 showed clear signs of buccal cervical resorption.

18 contralateral premolars served as controls – no ortho tx => only 1 of 18 showed buccal cervical resorption.

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**Llamas-Carreras et al., Int Endo J. 2010**

Compared root resorption in endo-treated teeth vs their contralateral teeth with vital pulps during orthodontic treatment.

No significant differences were found.

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**Other proposed etiologic factors:**

- Playing wind instruments?
  (Gursel, 2011)

- Contact with cats?
  - Feline herpes virus
  (von Arx, 2009)

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**If long standing, granulation tissue in the dentin can be seen undermining enamel – “pink tooth”**

*Often misdiagnosed as internal resorption!*

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**Asymptomatic tooth #11 referred for evaluation for internal root resorption**

They proposed a 3 stage mechanism of ECR:
1) an initiation stage
2) a resorption stage and
3) a repair stage.

Mavridou provided several illustrations as they continued to expand on the complex nature of cervical resorption.

Treatment options for cervical resorption:
1. RCT / internal repair
2. Surgical repair
3. Combined RCT / surgical tx
4. Orthodontic extrusion
5. Do nothing – observe

Frank & Torabinejad, 1998
Heithersay, 1999

1. RCT / internal repair

2. Surgical repair

3. Combined RCT / surgical tx
4. Orthodontic extrusion (& repair)

The concept here ——
extrude the entry point(s) above bone
and restore the resorptive defect.

Tx recommendation for
Heithersay Class I & II cases:
1. Reflecting a flap starts by disrupting the
   blood supply to the area.
2. Clean out both the tooth and bony defects,
   consider use of tri-chloroacetic acid (TCA).
3. Restore the tooth.
4. Monitor tooth vitality post-op

Tx recommendation for
Heithersay Class III & IV cases:

⇒ Use of Trichloroacetic acid.
Heithersay, 1999 — non-surgical tx using
a topical application of 90% aqueous solution
of trichloroacetic acid for 1-2 minutes.

Theory is that this causes coagulation necrosis
which deactivates the resorptive tissues

Prognosis after treatment:
Following 3 year recalls:
Class I & II lesions 100%
Class III lesions 78%
Class IV lesions 12%
Heithersay, Endod Topics, 2004

5. Do nothing & follow

Summary of treatment principles
for cervical resorption –
1. Stop the continuation of the process.
2. Restore unprotected root surface
   with restorative material.
3. When extensive, long term prognosis
   is questionable.
The use of CBCT in root resorption cases

Chenca, et al. 2007, Dental Traumatology – discussed and illustrated clinical applications of cone beam computed tomography for the diagnosis and treatment planning of root resorption.

The use of CBCT in root resorption cases

Can help in planning the treatment/management of resorption cases, but it is not always necessary for diagnosis!

– CBCT had better sensitivity than PA films.

(CBCT and extracanal invasive resorption)


(CBCT and external inflammatory resorption)

Case: 61 y/o female referred to evaluate #21, sensitivity noted to brushing in area.

(Courtesy Dr. Eshwar Aradi)

IV. Internal root resorption
Internal root resorption
- described in 1930 by Gottlieb & Orban
- rare in permanent teeth

Gaskill, 1894 and Mummery, 1920
Both presented case reports of “internal resorption” showing pink spots.
In retrospect, it may have been that both of these cases were cervical external resorption in origin.

Internal Root Resorption

Nice review articles by:
Estimated prevalence: 0.01-1%

- usually asymptomatic
- oval shaped enlargement of pulp space
- part of pulp tissue must be vital

Radiographic features to distinguish internal from external root resorption
- Change angles of films, lesion stays centered
- “normal” canal shape not visible thru defect

Treatment of internal root resorption:
BCT
Clean, shape and obturate the canal space.
(Courtesy Dr. Husain Karashi)