Management of Dental Injuries in Children

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Limitations of trauma research
- Ethical: Patients can’t be randomized to “trauma” and “no trauma” groups
- Animal models: limited clinical applicability to humans
- Retrospective case series studies
  - Individual case reports
- Randomized post-injury treatment interventions
- Comparability of injuries studied


Guidelines for Treatment
- **International Association of Dental Traumatology**
  Guidelines for the evaluation and management of traumatic dental injuries. Dental Traumatol 2012;28
  - I. Fractures and luxations of permanent teeth
  - II. Avulsion of permanent teeth
  - III. Primary teeth
- **American Association of Endodontists**
  Recommended guidelines for the treatment of traumatic injuries. Chicago: AAE; 2013
  www.AAE.org

HISTORY:
- Patients name, Age, Sex, Address, and Phone Number
- Medical History and Assessment of General Health

TETANUS PROTECTION PROTOCOL
- Immunization completed plus booster within 5 years - no treatment
- Greater than ten years since immunization - toxoid
- Between 5 & 10 years since immunization and dirty wound - toxoid
- No history of immunization and dirty wound - toxoid and antitoxin

http://www.health.state.mn.us/divs/idepc/diseases/tetanus/hcp/tetwdmgmt.html
WHEN did the accident occur?
WHERE did the accident occur?
HOW did the accident occur?

RULE OUT:
- Child Abuse
- CNS Injury

Child Abuse
- Annual US estimate – 1.5 million cases
- Ratio of nonreported to reported = 100:1
- 40-60% Abusers were abused as children
- High rates with special needs patients
- Most prevalent in age group 0-24 months

Diagnostic Evaluation for Abuse
Red Flags in the History:
- Injury incompatible with child’s developmental abilities
- Absent, changing, or evolving history
- Delay in seeking medical care
- Triggering event that precipitates loss of control in caregiver
- Family crisis or stress
- Prior history of abuse in caregiver

Bruising and Location
Non-Intentional
- Forehead
- Vertex of chin
- Elbows
- Knees/Shins

Intentional
- Ears
- Neck
- Upper arms/legs

Child Abuse
- Bruising:
  - If bruising is seen in a non-ambulatory child or in non-prominent soft tissue locations on the body - consideration should be given to abuse or some other underlying condition
- Bites:
  - Patterns of bites vary in tooth shape, arch impression and intercuspid distance depending on whether the bite was inflicted by a child (<30 mm) or an adult
- Dentists are mandated reporters

CENTRAL NERVOUS SYSTEM INJURY


Signs of Increased Intracranial Pressure

- DIZZINESS
- NAUSEA
- VOMITING
- HEADACHE
- LETHARGY OR IRRITABILITY
- LOSS OF MEMORY
- PUPIL SIZE AND REACTION TO LIGHT
- LOSS OF CONSCIOUSNESS

RECORD SYMPTOMS REPORTED BY PATIENT

- Spontaneous Pain
- Reaction to Thermal Change
- Disturbances in Occlusion

CLINICAL EXAM

- RECORD:

  - Extraoral Wounds and Palpation of Facial Skeleton
  - Injuries to intraoral soft tissues

Chin Trauma correlated with:

- Posterior crown fractures
- Mandibular condylar fractures
- Cervical spine injury


Examine tooth crowns for fracture, pulp exposure, or color change

Record displacement of teeth

RECORD:

- Mobility of Teeth or Alveolar Fragments
- Sensitivity to Percussion
- Abnormalities in Occlusion
- Reaction to Vitality Tests
REACTION OF TEETH TO VITALITY TESTS

- A. Carbon Dioxide Snow
- B. Tetrafluoroethane (Endo Ice)
- C. Electric Vitalometers


RADIOGRAPHIC EVIDENCE OF PATHOLOGY

- 2 Weeks - Pulpal Necrosis
- 3 Weeks - Inflammatory Resorption (External and Internal)
- 6 Weeks - Replacement Resorption (Ankylosis)

COMMON REACTIONS OF TEETH TO TRAUMA

- PULPAL HYPEREMIA (PULPITIS)
- INTERNAL HEMORRHAGE
- PULP NECROSIS
- PULP CANAL OBLITERATION
- INFLAMMATORY RESORPTION . . .
  a) Internal  b) External
- REPLACEMENT RESORPTION (Ankylosis)

PULPAL HYPEREMIA (PULPITIS)
INTERNAL HEMORRHAGE

PULPAL CANAL OBLITERATION (PCO) - RESULTS

- PCO dependent on type of injury
- PCO dependent on stage of root development
- PN subsequent to PCO was uncommon (1%)
- PCO occurs later than PN (12 mos. vs 3mos)
- PCO increased with bands / resin fixation


- 276 teeth with PCO
- Measured color, EPT, mobility & percussion
- **Yellow discoloration in 67%**
- PA lesions and negative EPT in 33%
- Normal PA and EPT in 31%
- Small PA changes/high normal EPT in 36%

**Etiology**

- **Inflammatory resorption**
  - Surface resorption of cementum exposing dentinal tubules
  - Pulp necrosis
  - Toxic products from the pulp provoke an inflammatory response in the PDL

**Replacement Resorption**

- Direct union of bone and root
- Resorption of root - Replacement with bone
- Direct result of loss of vital PDL

**Primary Pulp Exposure TX options**

- Partial pulpotomy in immature incisor
- Pulpotomy when no resorption has begun
- Pulpectomy with resorbable paste – 20% deflections of succeeding permanent incisors
  - Coll et al. 1996, Flaitz et al. 1989
- Extraction


- Matched pairs carious vital primary incisors received either FC pulpotomy or CaOH RCT
- 74 teeth followed clinically and radiographically for up to 23 months
- Success in 89% of FC pulpotomies and 73% in RCT. No significant difference between.

**Subluxation (loosening)**

- An injury to the tooth-supporting structures with abnormal loosening, but without displacement of the tooth
Intrusive Luxation
(central dislocation)

- A displacement of the tooth into the alveolar bone.
- This injury is accompanied by comminution or fracture of the alveolar socket.

Injuries to Developing Teeth

- Discoloration of the enamel
- Enamel hypoplasia
- Crown or root dilaceration
- Arrested Development
- Sequestration of tooth germ
- Disturbance in eruption

Injury to developing successors

- 20% Assuncao, et al 2009
- 25% Sennhenn-Kirchner, et al 2006
- Mild hypoplasia most common (~75%)
- Most frequently following intrusions, then avulsions
- Children aged 1 – 3 years at greatest risk


Total spontaneous re-eruption: 40 – 60 %
Partial re-eruption: 40%
Pulp necrosis or root resorption: 50%
PCO: 50%
**Intrusive Luxation**

- Allow to reerupt if apex is displaced toward or through labial plate
- Extract if apex is displaced into developing tooth

International Association of Dental Traumatology. Guidelines for the evaluation and management of traumatic dental injuries. Dental Traumatol 2012:28;174-182

No evidence to support loss of space when primary anterior teeth are lost after primary canines erupt.

**Management of Traumatic Injuries to Young Permanent Teeth**

  - Remove dentin from coronal fragment before bonding
  - Rehydrate fragment in water for 30 minutes prior to bonding
  - Place chamfer on buccal and lingual surfaces after the fragment is bonded


**Treatment Alternatives in Class III Fractures of Permanent Teeth**

- DIRECT PULP CAP: small exposure, < 24 hours
- PARTIAL PULPOTOMY (CaOH or MTA) preferred tx; larger exposures, > 24 hours
- PULPECTOMY: closed apex


International Association of Dental Traumatology. Guidelines for the evaluation and management of traumatic dental injuries. Dental Traumatol 2007:23
**CALCIUM HYDROXIDE PARTIAL PULPOTOMY**

96% SUCCESS WITH PULPS EXPOSED 1 HOUR TO 90 DAYS


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**TECHNIQUE**

- 1) Gently Remove Dentin and Pulp to 1-2 mm
- 2) Use Copious Irrigation
- 3) Cover Pulp with CaOH

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**MTA Pulpotomy**


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**What does it contain?**

- Tricalcium silicate
- Dicalcium silicate
- Tricalcium aluminate
- Tetracalcium aluminoferrite
- Calcium sulfate
- Bismuth oxide

**So it is Portland Cement**

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**Indications**

- Pulp cap
- Pulpotomy
- Open apices
- Revascularization
- Perforations
- Resorptions
- Root-end

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**Why MTA?**

- Biocompatible
- Low cytotoxicity
- No mutagenicity
- Periodontal regeneration
- Cemental regeneration
- Pulpal regeneration
- Excellent seal
Pulpotomy

Clinical Procedures
- MTA
- moist pellet
- temp filling
- 1 week perm filling
- check vitality every 3 to 6 months

MTA partial pulpotomy

- Advantage
  - Good success rate

- Disadvantages
  - Cost
  - Re-entry
  - Discoloration
  - Material manipulation

Biodentine pulpotomy

- Martens L, et. al. Pulp management after traumatic injuries with a tricalcium silicate-based cement (Biodentine®): a report of two cases, up to 48 months followup. Eur Arch Paediatr Dent. 2015

Clinical Applications

1. DPC/IPC
2. Temporary Restorations
3. Liner/Base (Dentin replacement)
4. Pulpotomy and partial (Cvek) pulpotomy
5. Repair of root/pulpal floor perforations
6. Apexification
7. Retrograde Root Filling
8. Apexogenesis
9. Root resorption repair: internal/external

CRITERIA FOR SUCCESS

- 1) No clinical signs or symptoms
- 2) No radiographic pathology
- 3) Continued development of immature roots
- 4) Formation of calcific barriers
- 5) Sensitivity to electrical stimulation

NECROTIC IMMATURE TEETH

- Apexification: CaOH
- Apexification: MTA
- Apexogenesis: Revascularization
Disadvantages: CaOH Apexification

- Multiple visits over 8 – 16 months
- Must achieve hard barrier at apex
- Long term CaOH further weakens tooth
- High incidence of subsequent root fracture

Calcium hydroxide weakens dentin


Mineral Trioxide Aggregate (MTA)

- High pH (similar to CaOH)
- Exceptional sealing properties
- Hardens within hours enabling canal obturation


- ciprofloxacin
- metronidazole
- cefaclor

REVASCULARIZATION


REMANAGEMENT OF LUXATION INJURIES TO THE YOUNG PERMANENT DENTITION
**CONCUSSION**

- An injury to the tooth-supporting structures without abnormal loosening or displacement of the tooth but with marked reaction to percussion.

**Subluxation** (loosening)

- An injury to the tooth-supporting structures with abnormal loosening, but without displacement of the tooth.

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**Concussion Treatment:**

- Inform patient & parent about potential sequelae;
- Monitor

**Subluxation Tx:**

- Splint ??
- F/U in 2 weeks;
- Radiograph at 1 month

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**SPLINTS SHOULD:**

- 1) Be passive and atraumatic
- 2) Be durable
- 3) Be flexible
- 4) Allow for vitality testing and endodontic access
- 5) Be easy to apply and remove

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**Splinting**

- Use fish line/acid-etch resin; soft arch wire/resin; ortho brackets with passive arch wire; suture as last resort.
- Circumferential wire splints contraindicated

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Primate studies have demonstrated that rigid and/or prolonged splinting may lead to extensive PDL healing complications, like ankylosis and replacement resorption.


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**Splinting - Home Care**

- No biting on splinted teeth
- Soft diet
- Maintenance of good oral hygiene

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**Intrusive Luxation (central dislocation)**

- A displacement of the tooth into the alveolar bone.
- This injury is accompanied by comminution or fracture of the alveolar socket.

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**Intrusive Luxation Tx:**

**OPEN APEX**
- If < 7 mm allow spontaneous repositioning; ortho extrusion if no movement within 2-4 weeks
- If > 7 mm reposition surgically or orthodontically

**CLOSED APEX**
- < 3 mm allow spontaneous eruption; ortho extrusion or surgical reposition if no movement within 2-4 weeks
- 3 – 7 mm reposition orthodontically or surgically
- >7 mm reposition surgically & splint for 2 weeks

- Chlorhexidine mouthrinse
- Remove pulp & fill with CaOH < 2-3 weeks
- Complete endo fill in 1 - 2 months if no resorption
- Antibiotics not helpful

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**EXTRUSIVE LUXATION**

(Pерipheral dislocation, partial avulsion)

- A partial displacement of the tooth out of its socket.
Extrusive Luxation Tx:

- Reposition tooth ASAP; best prognosis if completed within 2 hours
- Light splint for 2 weeks
- Remove pulp & fill with CaOH within 7-14 days
- Chlorhexidine mouthrinse
- Complete endo fill in 1 - 2 months if no inflammatory resorption

Lateral Luxation

- A displacement of the tooth in a direction other than axially.
- This is accompanied by comminution or fracture of the alveolar socket.

Lateral Luxation Tx:

- Reposition tooth ASAP; best prognosis if completed within 2 hours
- Light splint for 3 - 4 weeks
- Remove pulp & fill with CaOH within 7-14 days
- Chlorhexidine mouthrinse
- Complete endo fill in 1 - 2 months if no inflammatory resorption

Treatment of the Avulsed Permanent Tooth

I. Management at site of injury
II. Transport media
III. Management in dental office
IV. Adjunctive drug therapy considerations
V. Endodontic treatment
VI. Restoration of the avulsed tooth

Management at Site of Injury

- Replant immediately, if possible. If contaminated, rinse.
- When cannot be replanted, place tooth in best transport medium available.

Recommended Storage Media

1. Socket (immediate replantation)
2. Cell culture medium
3. Milk
4. Physiologic saline
5. Saliva

Blomlof L. Milk and saliva as possible storage media for traumatically exarticulated teeth prior to replantation. Swed Dent J. 8:1-26, 1981


Management of the Avulsed Tooth

- Ultimate goal
  - PDL healing without root resorption
- Most critical factor
  - Maintaining an intact and viable PDL on the root surface

Managing Mature Tooth

Extraoral DRY Time < 1 Hour

- Objective is to maintain PDL cell vitality
- Place in HBSS during history & exam
- Handle by crown and gently replant
- Splint 1 – 2 weeks
- Remove pulp in 7-14 days
- Place CaOH
- Obturate canal in 2-4 weeks

• Knocked-Out Tooth

  Baby tooth – If something happens to any of a child’s primary teeth, or “baby teeth,” you should take your child to the dentist as soon as you can. If a tooth is completely out, do not try to reinsert it back in the socket. Although it is normal for children to lose primary teeth, an accident that damages a primary tooth could also harm the permanent “adult” tooth underneath.

  Adult tooth – A baby tooth should not be replanted back in the mouth, but a permanent tooth should. Hold the tooth by the crown, and if it is dirty, rinse the root with water. Do not soak the tooth or remove any attached bits of tissue. If possible, gently insert and hold the tooth in its socket with a clean wash cloth or gauze. If this isn’t possible, use a firmly closed, clean, non-slip, non-saline gauze with saliva or water. Take your child to the dentist as quickly as you can. Don’t forget to bring the tooth and any tooth pieces you find.
Management of Root Surface

- Objective is to maintain PDL cell vitality
- Keep moist in HBSS
- Do not handle root surface
- Gently remove persistent debris

Management of the Socket

- Gently aspirate without entering socket
- If clot present use saline irrigation
- Do not curette socket
- Do not vent socket
- If alveolar bone collapsed, use blunt instrument to reposition
- Manually compress bony plates after replantation

Management of Soft Tissues

Tightly suture any soft tissue lacerations, particularly in the cervical region

Splinting

- Use fish line/acid-etch resin; soft arch wire/resin; ortho brackets with passive arch wire; suture as last resort.
- Circumferential wire splints contraindicated
- Maintain splint 10-14 days; longer if tooth demonstrates excessive mobility

Splinting - Home Care

- No biting on splinted teeth
- Soft diet
- Maintenance of good oral hygiene

Antibiotics??

- Hammarstrom, L. et al., Endod Dent Traumatol 1986; parenteral antibiotics prior to extraction and immediately following replantation resulted in less inflammatory resorption in monkeys. Prevents bacterial invasion of the necrotic pulp and inflammatory resorption; route & timing
- Sae-Lim V. et al., Endod Dent Traumatol 1998; Tetracycline decreases root resorption by affecting the motility of the osteoclasts and reduces effectiveness of collagenase
- Cvek M. et al. Endod Dent Traumatol 1990; Soaking teeth in topical doxycycline prior to replantation enhances revascularization
Adjunctive Drug Therapy Considerations

- Systemic antibiotics:
  - If < 12 y/o pen v (250 mg/kg/d in 4 divided doses × 7 days)
  - If ≥ 12 y/o doxycycline (100 mg q 12 h first day, then 50 mg q 12 h days 2 – 10)
- Tetanus consultation within 24 hours
- Chlorhexidine mouth rinses
- NSAIDs to inhibit bone resorption & pain relief

Endodontic Treatment
Mature Tooth < 1 Hour DRY Time

- Remove pulp in 7-14 days
- Place CaOH
- Obtrurate canal in 2-4 weeks

PROGNOSIS IS BEST FOR REIMPLANTED TEETH IF:
- Extra-Oral period is minimal
- Periodontal ligament is not traumatized
- If not replanted the transport and soaking solution is HBSS
- Endo therapy is not done in the hand before reimplantation
- An appropriate splint is applied for 1 week
- CaOH pulpectomy is completed in 1 wk

Managing Avulsed Immature Tooth
Open Apex < 1 Hour DRY Time

- Objective is to revitalize severed pulp


Managing Avulsed Immature Tooth
Open Apex < 1 Hour DRY Time

- Best chance if replanted within 20 minutes - MUST be replanted within 60 minutes
- Soak in doxycycline solution for 5 minutes
- Replant and splint for two weeks
- Recall every 3-4 weeks
- If pathosis noted, extirpate pulp and do regenerative procedure
Managing Mature Tooth
Extraoral DRY Time > 1 Hour

- Objective is to delay inevitable root resorption

- Remove all PDL fragments (manually, NaOH, Citric acid)
- Soak in fluoride (Shulman, et al. JDR, 1973)
- Complete endo now or later
- Replant & splint
- Anticipate replacement resorption
- Consider decoronation

CLINICAL SIGNS OF ASPIRATION

1) No symptoms
2) Initial choking and coughing
3) Irritating cough
4) Wheezing
5) Unilateral obstructive emphysema
6) Atelectasis
7) Pulmonary suppuration


- Normal overjet 1 – 3 mm
- Overjet 3 – 6 mm = 2 X injuries
- Overjet 6 – 9 mm = 3 X injuries


- Retrospective study comparing pulp vitality after ortho extrusion of traumatized vs. non-traumatized incisors
- Traumatized teeth significantly more likely to become necrotic than non-traumatized
- Necrosis occurred most frequently in early stages of extrusion.

“traumatized teeth that show signs of root resorption before orthodontic tx are at high risk of increased root resorption as a result of orthodontic forces”

ROOT FRACTURES INVOLVING: DENTIN, CEMENTUM, and PULP

Healing Responses to Root Fracture

- Hard Tissue Formation
- Connective Tissue
- Bone & Connective Tissue
- Granulation Tissue (non-healing)


- 78% healed with hard tissue formation or interposition of soft tissue between the fragments
- Highest frequency of tooth loss occurred in teeth with horizontal fractures in the cervix of the root

Principles of Root Fracture Treatment in Permanent Teeth

- 1) Treat ASAP
- 2) Reduce displaced fragments
- 3) Light splint for
  - Middle & apical third 1 month
  - Coronal third 2 – 4 months
- 4) Monitor pulp vitality
- 5) Antibiotics NOT helpful


- Mouthguards reported to reduce dental injuries up to 90% in contact sports
- Laminated thermoplastic mouthguards are dimensionally most stable
- No ethically feasible in vivo models to complete prospective studies
- No evidence to support claims that mouthguards prevent neck or cerebral brain injuries

Dealing with “Lost-Cause” Injured Teeth

An Introduction to Regenerative Endodontics
Disadvantages: CaOH Apexification

- Multiple visits over 8 – 16 months
- Must achieve hard barrier at apex
- High incidence of subsequent root fracture (Cvek M. 1992)

Mineral Trioxide Aggregate (MTA)

- High pH (similar to CaOH)
- Exceptional sealing properties
- Hardens within hours enabling canal obturation
- No root wall thickening
  
  Simon S. et al. 2007

Revascularization

Periapical tissue grows into pulp space of necrotic immature permanent teeth.

- Promotes maturogenesis.
- Naturally or can be induced.


Thibodeau et al. 2007.

Regenerative Endodontics

- Biologically based procedures to replace damaged structures, including dentin and root structures and cells of the pulp-dentin complex, with live tissues that restore normal physiologic function.

Nygaard-Østby B. 1961

Murray, et. al. 2007.

History of Regenerative Dentistry

- 1950s-60s: Nygaard-Østby – role of blood clot in endo tx
- 1950s: Ca(OH)2 used in a case report of vital pulp amputation
- 1980-90s: Guided tissue or bone regeneration (GTR, GBR)
- 1990s: Distraction osteogenesis
- 1990s: Emdogain for periodontal tissue regeneration
- 1990s: Recombinant human bone morphogenic protein (rhBMP)
- 2000: Platelet rich plasma (PRP) for bone augmentation
- 2000: Fibroblast growth factor 2 (FGF2) for PDL regeneration
**Stem Cells**

- Embryonic/fetal
- Postnatal/adult

**Signaling Molecules**

- Self renewal
- Proliferation
- Differentiation

**Scaffolds**

- Potency – potential to divide and express cells of different phenotypes
  - Pluripotent – embryonic: can differentiate into endoderm, mesoderm or ectoderm
  - Multipotent – postnatal: can form other tissues; umbilical cord blood, bone marrow, postnatal dental stem cells

**Her own stem cells used to build tot a windpipe**

Associated Press• Wednesday May 1, 2013 6:25 AM

CHICAGO — A 2-year-old girl born without a windpipe now has a new one grown from her own stem cells, the youngest patient in the world to benefit from the experimental treatment.

**Dental Stem Cells**

- Dental pulp stem cells (DPSC)
  - differentiates into odontoblast-like cells
  - involved in reparative dentin formation
  - ~1% of pulp cells – decrease in number with age
- Stem cells from exfoliated deciduous teeth (SHED)
- Periodontal ligament stem cells (PDLSC)
  - Stem cells of the apical papilla (SCAP)
  - different than stem cells in mature tissues
  - superior for hard tissue regeneration – possibly in development of root dentin
  - Evoked bleeding triggers significant accumulation of undifferentiated stem cells into the canal space.

**SCAP**

- Essential for continued root development
- Undergo dentinogenic differentiation when stimulated
- Differentiate into functional dentinogenic cells in vivo, when implanted in animal models (Sonoyama, et al. 2006)
- Adipogenic and neurogenic differentiation capabilities when treated with appropriate stimulation medium.
- Potential to enable continued root development, pulpal healing and regeneration.

**Growth Factors**

- Proteins that bind to receptors on cells and induce cell proliferation and/or differentiation
- Some cell specific - others versatile
- Many control stem cell activity, e.g.
  - rate of proliferation
  - differentiation into another tissue type
  - synthesis/secretion of mineralized matrix.
- BMPs, PDGF, VEGF vascular endothelial growth factor (angiogenic factor), FGF-2
- Demineralization of dental tissue can stimulate growth factor release.
- Inflammation + and -

**References**

- Huang, et al. 2008
- Lovelace, et al. 2011
- Sonoyama, et al. 2006
- Smith, et al. 1995
- Mullan, et al. 2008
Scaffolds

- Tissues are 3-dimensional and need scaffold to promote cell growth and differentiation.
- Bind and localize cells
- Contain growth factors
- Biodegrade over time
- Blood clot
- Platelet-rich plasma - PRP

Biology of the root apex

- Dental papilla evolves into dental pulp
- Inner and outer enamel epithelia fuse to form HERS
- As HERS migrates apically, the dental papilla is located apically to the developing pulp and is called the apical papilla.

Hargreaves K. et al. 2008

Disinfection

- No tissue regeneration if infection.
- Better success with doxycycline soak.
- Bacterial biofilm on canal walls, anatomical recesses, periapical area and dentinal tubules.
- Higher level of disinfection needed for immature, infected teeth than mature teeth.
- Root canal system infection is polymicrobial.
- Combo antibiotics sterilize canal - minimize resistant bacteria
- Metronidazole, ciprofloxacin and minocycline effective.

Hoshino, E. et al. 1996.
Kling M. et al. 1986

Apical papilla – collateral circulation – maintains vitality when tooth is necrotic

- Soft, separable from tooth.
- Histologically, distinct from pulp, less vascular and cellular.
- Removing papilla halts root formation…yet it continues if pulp is extirpated and papilla remains.

Triple Antibiotic Paste

**Antibiotics (1:1:1)**
- Metronidazole 500mg cap
- Ciprofloxacin 200mg cap
- Minocycline 100mg cap

**Carrier (1:1)**
- Macrogol ointment
- Propylene glycol

**Antibiotics: Carrier (1:5)**

Hoshino et al. 1996

High concentrations of antibiotics are toxic to SCAP

- Ruparel N. et al. Direct effect of intracanal medicaments on survival of stem cells of the apical papilla. JOE 2012;58:1372-75
- 2% chlorhexidine is toxic to stem cells

Trevino E. et al. Effect of irrigants on the survival of human stem cells of the apical papilla in a platelet-rich plasma scaffold in human root tips. JOE 2011;37:1109-15
**Indications for Revascularization**

- No evidence-based guidelines for case selection
- Necrotic immature teeth caused by trauma (caries?)
- Apical opening > 1mm to allow ingress of regenerative tissue

Huang G. Journal of Dentistry 2008;36:379-386

**Tooth Discoloration**

- 14 teeth discolored
- 7 discolored using both minocycline and grey MTA
- 7 teeth discolored with no minocycline and white MTA
- 11 teeth successfully bleached

**Definition of success**

- Healing of sinus tract
- Absence of signs and symptoms
- Continued root development – “maturogenesis”

**Platelet-rich Plasma (PRP)**

- Contains growth factors
- Stimulates collagen production
- Recruits other cells to site of injury
- Produces anti-inflammatory agents
- Initiates vascular growth
- Induces cell differentiation
- Controls local inflammatory response
- Improves soft and hard tissue wound healing

Torabinejad M and Turman M. 2011
PRP

**PRO**
- Ease of application
- Shorter time to induce vital tissues within root canal system.

**CON**
- Drawing blood on young patient
- Special equipment & meds to prepare PRP
- Increased cost

Future Regenerative Endo

- PRP
- Apical negative pressure irrigation
- Autologous post-natal stem cells injected into teeth in a matrix
- Pulp implant – pulp tissue grown in vitro in sheets and implanted surgically
- Scaffold implant – pulp cells seeded to 3-D scaffold made of polymers and implanted surgically
- Gene therapy – mineralizing genes introduced into vital pulp cells of necrotic and symptomatic teeth

More Questions than Answers!

- “Revascularization” “Revitalization” “Regeneration”??
- Is it pulp…PDL…bone…cementum??
- Antibiotics?? CaOH??
- Biocompatible irrigants/disinfectants: NaOCl …chlorhexidine …noni juice …Aquatine EC??
- Stem cells??
- Immunologic profile?
- Definition of “Success”?

Complications - Challenges

- Adequate Disinfection
- Scaffold formation
- Staining
- Stimulating bleeding
- Placing MTA
- Bacteria-tight seal
- Behavior!!