Treating the Soft Centre

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Treating the Soft Centre

Pulp Therapy for the Deciduous Dentition
Summary of Lecture

- Goals and Examination
- Normal Pulp or Reversible Pulpitis
  - Vital pulp therapy
    - Medicaments and techniques
    - Non-pharmacological methods and techniques
  - Other pulp therapy
    - Pulpectomy
Summary of Lecture

• Irreversible Pulpitis or Necrotic Pulp
  – Non-Vital Pulp Therapy
    • Pulpectomy
      – Medicaments and techniques
    • Non-vital Pulpotomcy

• Pulp (Science) Fiction
  – Medicaments for the future

• Conclusions and Questions
Treating the Soft Centre

The Goals of Pulp Therapy and the Examination of the Tissues
Goals of Pulp Therapy

- Tooth restored and retained until normal exfoliation
- Arch length and vertical dimension maintained
- Clinically asymptomatic
- Histologically free of inflammation
Goals of Pulp Therapy

- Radiographically free of pathology
- Systemically - no adverse effects
- Materials & techniques non-threatening to subjacent permanent teeth
Pulp Therapy

Proper diagnosis = Success in pulp therapy

Proper diagnosis is the result of appropriate

• History taking
• Examination
• Special tests
Pulp Therapy - History

Medical history
- Aetiology
- Contra-indications

Consult with parent
- Cost
- Follow-up

Pain
- Spontaneous
- Precipitated
- Chronic
- None
Pulp Therapy - Examination

Hard tissue

- Caries
  - type
  - amount
  - colour
  - arrested?
  - gross breakdown?
  - restorable?
Pulp Therapy - Examination

Soft tissue

• Extra-oral
  – swelling
  – lymphadenopathy

• Intra-oral
  – inflammation
  – fistula
  – cellulitis
Pulp Therapy - Special Tests

Radiographs
- Most important diagnostic aid

Other tests
- Palpation
- Percussion
- Mobility testing
- Vitality testing
Pulp Therapy - Radiographs

Bitewing

- Surfaces involved
- Depth of lesion with respect to pulp
- Restorability
Pulp Therapy - Radiographs

Periapical

- Furcal or apical pathology
- Intra-pulpal calcified tissue
- Pathologic root resorption
  - external
  - internal
Pulp Therapy - Radiographs

Occlusal
Treating the Soft Centre

Pulp Therapy for Deciduous Teeth with a Normal Pulp or Reversible Pulpitis
Vital Pulp Therapy

- Protective base
- Indirect pulp treatment
- Direct pulp capping
- Pulpotomy

(American Academy of Pediatric Dentistry, 2009)
Pulp Therapy for Vital Teeth

Indications

• Deep caries
• No radiographic abnormality
• No spontaneous pain
• No mobility or fistula
• No sensitivity to percussion
• Restorable crown
• Normal tooth colour
• Medical - avoid extraction
Pulp Therapy for Vital Teeth

Contra-indications

- Periapical or furcal radiolucency
- Soft tissue swelling or fistula
- Over 2/3 of root resorbed

Systemic conditions
- rheumatic heart disease
- congenital heart disease
- shunts (AV shunts)
- immuno-compromised
A protective base is a material placed on the pulpal surface of the cavity preparation, covering exposed dentine tubules, to act as a protective barrier between the restorative material or cement and the tooth’s pulp.
Indirect Pulp Treatment

The caries near the pulp is left in place to avoid pulp tissue exposure. A protective dressing, such as Ca(OH)$_2$, ZOE or GIC, is placed over the remaining affected dentine to stimulate healing and repair.

The tooth is then restored with a material that seals the tooth from microleakage.
Indirect Pulp Treatment

Prognosis in deciduous teeth

- good

Success measured by

- maintenance of the tooth’s vitality
- absence of post-treatment symptoms or signs
- absence of pathological radiographic changes
- absence of harm to the succedaneous tooth
Direct Pulp Capping

Placement of a material, usually Ca(OH)$_2$, in contact with the exposed pulp tissue following a small mechanical or traumatic pulp exposure.

The tooth is restored with a material that seals the tooth from microleakage.
Direct Pulp Capping

Success measured by

- maintenance of the tooth’s vitality
- evidence of pulp healing and reparative dentine formation
- absence of post-treatment symptoms or signs
- absence of pathological radiographic changes
- absence of harm to succedaneous tooth
Direct Pulp Capping

- Rarely done in deciduous teeth
- Not recommended for carious exposures
- Valid technique for tooth with normal pulp following a small mechanical or traumatic exposure when conditions exist for a favourable response
“The coronal pulp is amputated, and the remaining vital radicular pulp tissue surface should be treated with a medicament or with electrocautery to preserve the radicular pulp’s health.”

(American Academy of Pediatric Dentistry, 2009)
Vital Pulpotomy - Ideal Outcome

“…..the ideal pulpotomy treatment should leave the radicular pulp vital and healthy and completely enclosed within an odontoblast-lined dentin chamber.”

“…..the tissue would be isolated from noxious restorative materials in the chamber, thereby diminishing the chances of internal resorption.”

(Ranly, 1994)
Vital Pulpotomy - Ideal Outcome

“…..the odontoclasts of an uninflamed pulp could enter into the exfoliative process at the appropriate time and sustain it in a physiologic manner.”

“ Implied in this scenario is the induction of the reparative dentin formation by the pulpotomy agent.”

(Ranly, 1994)
Success depends on
• Correct diagnosis
• Isolated field
Vital Pulpotomy

Success depends on
• Flossing the clamp!
Vital Pulpotomy

Success depends on

- Cavity access sufficient to see clearly all parts of the pulp chamber
- Medicament (or non-pharmacological method)
Vital Pulpotomy

Medicaments
- Formocresol
- Glutaraldehyde
- Calcium hydroxide
- Ferric sulphate
- Mineral trioxide aggregate (MTA)

Non-Pharmacological
- Electrocautery
- Laser
Formocresol

“Because formocresol is less sensitive to technique and diagnostic shortcomings than the (other modalities) - and has a success record equal to any - it remains he gold standard for teaching purposes.”

(Ranly, 1999)
"The search for an alternative to formocresol ..... has yet to reveal an agent or technique that has long-term clinical success rates matching those of formocresol."

(Fuks, 2000)
Formocresol

The pulp tissue … “remains in a metastable condition until the tooth is exfoliated.”

(Ranly, 2000)

Investigators claim … “fixation occurs in the coronal third of the radicular pulp, chronic inflammation in the middle third, and vital tissue in the apical third.”

(Fuks, 2000)
Formocresol

- Systemic distribution of formaldehyde demonstrated following 16 pulpotomies in a dog.

(Pashley, 1980)
Formocresol

Concerns that formaldehyde may pose health hazard

- Toxicity
- Immunogenic potential
- Mutagenic & causes regenerative proliferation of cells
- Carcinogenic potential
Formocresol

Minimization of amount used

- Dilution (1 in 5)
Formocresol

Minimization of amount used

- Renewed emphasis on haemostasis before application
- Pellet squeezed of excess before placement
- Damp pellet no longer sealed under temporary restoration
- Omission from the ZOE base
Recent systematic review of the literature concluded:

- Sufficient evidence that formaldehyde causes nasopharyngeal cancer in humans
- Limited evidence that it causes nasal cancer
- Strong but not sufficient evidence that it causes leukaemia

(International Agency for Research on Cancer, 2004)
Most paediatric dentists in UK have abandoned it (Duggal et al, 2005)

The University of Sydney stopped using it in teaching clinics in advance of the recent evidence

From 2006, the University of Melbourne has taught the theory of its use but students will cease to have access to it in pre-clinical and clinical sessions
Glutaraldehyde

Advocated because compared to formaldehyde

- True cross-linking fixative
- Self-limiting penetration
- Reduced toxicity
- Reduced antigenicity
- Reduced inflammation underlying the fixed tissue
- Avoids use of tricresol which is itself toxic
Glutaraldehyde

Less than ideal material because

- Systemic distribution of glutaraldehyde demonstrated (Myers et al, 1986)
- Longer-term success rates don’t match formocresol’s (Fuks, 2000)
- Results in higher rates of internal root resorption (Fuks, 1991)
Considered a safe medicament, locally and systemically, relative to the aldehydes.
Calcium Hydroxide

Relatively low success rate of inorganic Ca(OH)$_2$

- Failure mainly due to internal resorption
  - formation of intervening clot
- Some evidence to suggest success improved by
  - prior use of haemostatic agent
  - use of hard setting Ca(OH)$_2$
- Further research required
Ferric Sulfate / Sulphate

- Originally tested in primates as an adjunct to Ca(OH)$_2$
- Later tested in humans as a stand alone therapy
- Mechanisms of action
  - to prevent clot formation - and its attendant inflammatory cascade - and to precipitate a protein barrier at the amputation site
Ferric Sulfate / Sulphate

Advantages
- Considered a safe medicament
- 15 sec application

Limited Research
- Small samples
- Short-term follow-up
- Some studies used non-cariously exposed teeth
**Ferric Sulfate / Sulphate**

**ViscoStat™ (Ultradent)**
- 20% ferric sulphate equivalent solution
  - viscous aqueous vehicle

**Astringedent™ (Ultradent)**
- 15.5% ferric sulphate equivalent solution
  - aqueous vehicle
Best published study to date:

- Prospective
- 58 cariously exposed teeth
- 15.5% $\text{Fe}_2(\text{SO}_4)_3$ applied for 15 sec
- Controls (dilute formocresol) not matched for type of tooth, patient age or patient gender

(Fuks et al, 1997)
• Assessed clinically and radiographically
• Followed-up for between 6 and 35 months (mean 20.5)
• No significant difference between the 2 groups
• More clinical studies with longer follow-up times required before recommended as a substitute for formocresol

(Fuks et al, 1997)
Ferric Sulfate / Sulphate

- Evidence based assessment compared formocresol with ferric sulfate / sulphate
- Clinical data for ferric sulfate / sulphate significantly better
- Radiographic data also significantly better for ferric sulfate / sulphate

(Loh et al, 2004; Fuks and Eidelman, 2005)
Mineral Trioxide Aggregate (MTA)
Mineral Trioxide Aggregate (MTA)

- Biocompatible
- Powder that sets in presence of water
- pH = 12.5 when set
- Setting time = 4 hours
- Compressive strength comparable with IRM

(Eidelman, 2001; Holan et al, 2005)
Mineral Trioxide Aggregate (MTA)

- Seals better than amalgam or ZOE
- No cytotoxic effect
- Similar antimicrobial effect to ZOE
- Stimulates cytokine release from bone cells, indicating actively promotes hard tissue formation
- Expensive

(Eidelman, 2001; Holan et al, 2005)
Mineral Trioxide Aggregate (MTA)

Potential Uses

- Vital pulpotomy
- Capping pulps with reversible pulpitis
- Apexification
- Repair of root perforation

(Eidelman, 2001)
Mineral Trioxide Aggregate (MTA)

Prospective study
- 62 teeth in 33 children
- Follow up 4 - 74 months (mean = 38.2)
- MTA paste (powder:saline = 3:1) placed over pulp stumps once haemostasis was achieved

(Eidelman, 2001; Holan et al, 2005)
Mineral Trioxide Aggregate (MTA)

- Experimental group
  - MTA / IRM / stainless steel crown (SSC)
- Controls
  - Formocresol (5 min) / ZOE / IRM / SSC
- MTA clinically and radiographically successful
- MTA showed higher success (not significant)

(Holan et al, 2005)
Mineral Trioxide Aggregate (MTA)

- Internal resorption post-operatively self-limiting
  - pulp tissue replaced by calcified tissue

- Frequency in pulp canal obliteration not significantly different

(Holan et al, 2005)
Vital Pulpotomy - Techniques

Stages common to all medicaments

- Local anaesthesia
- Rubber dam
- Remove dental caries
- Remove roof of pulp chamber
Vital Pulpotomy - Techniques

Stages common to all medicaments

- Remove pulp from pulp chamber (excavate or bur)
- Achieve haemostasis with sterile cotton pellet
- Remove pellet
Vital Pulpotomy - Techniques

Formocresol

- Apply cotton pellet damp with formocresol (5 mins)
- Remove pellet
- Place ZOE over pulp stumps
- Restore tooth
Vital Pulpotomy - Techniques

Ferric Sulfate / Sulphate

- Apply ViscoStat™ or Astringedent™ for 15 sec
- Remove surplus with moist sterile cotton pellet
- Place ZOE over pulp stumps
- Restore tooth
Vital Pulpotomy - Techniques

Mineral Trioxide Aggregate (MTA)

- Mix MTA paste (powder:saline = 3:1)
- Place MTA paste over pulp stumps
- Place ZOE over MTA
- Restore the tooth
Vital Pulpotomy - Techniques

Restoration

- Build up core
- Restore with stainless steel crown
Electrocautery

• Burns and coagulates the radicular tissue
• Fast
• No pharmacotherapeutic agent required
• Variable success rates reported
  (Mack & Dean, 1993; Fulkerson et al, 1998)
• No published long-term clinical trials
Laser

- Burns and coagulates the radicular tissue
- Favourable response on small sample of non-carious teeth over 90 days (Elliot et al, 1999)
- No published long-term clinical trials on either carious or non-carious teeth
Other Pulp Therapy

- Pulpectomy

(Payne, Kenny, Johnston and Judd, 1993)
Vital Pulpectomy

- Advocated in 1990s
- Major proponent was Dr David Kenny at Hospital for Sick Children, Toronto, Canada
- Avoids use of aldehydes
Vital Pulpectomy

- Healthy radicular pulp removed
- Canal obturated with ZOE (non-reinforced)
- More technically complex than vital pulpotomy
- Behaviour management more difficult
Vital Pulpectomy

- Researchers claimed equivalent success to formocresol pulpotomy after 2 year follow-up

In fact ....

- Criteria for success less stringent
- 23% had pathological root resorption associated with bone rarefaction
- Low patient recall rate (48%)

(Payne et al, 1993)
Treating the Soft Centre

Pulp Therapy for
Deciduous Teeth with
Irreversible Pulpitis or Necrotic Pulp
(“Non-vital Teeth”)
Pulp Therapy for Non-vital Teeth

- Pulpectomy

(American Academy of Pediatric Dentistry, 2009)
Pulpectomy

Treatment Planning Considerations

- Number of non-vital teeth
- Behaviour management technique required
- Molar relationships
- Space loss due to caries
- Oral hygiene
- Dental IQ of patient and parent
- Follow-up
Pulpectomy

Indications

- Deciduous tooth with irreversible pulpitis or necrotic pulp tissue
- Traumatized deciduous tooth requiring a post and core prior to restoration
Pulpectomy

Contra-indications

• Unco-operative child
• Systemic conditions, for example
  – rheumatic heart disease
  – congenital heart disease
  – shunts (AV shunt)
  – immuno-compromised patient
Pulpectomy

Contra-indications

- Non-restorable tooth
- Perforation of the floor of the pulp chamber
- Dentigerous cyst surrounding successor
- Internal root resorption
Pulpectomy

Contra-indications

• More than 1/3 of the root pathologically resorbed
Pulpectomy

Ideal Root Canal Materials for Deciduous Teeth

- Disinfectant
- Readily handled
- Resorbable
- Radiopaque
- Systemically acceptable

(Ranly, 1991)
Root Canal Materials for Deciduous Teeth

- Iodoform paste - Kri
- Iodoform/resorbable ZOE mixture - Maisto’s
- Resorbable ZOE (not resin reinforced)
- Iodoform/Ca(OH)$_2$ mixture - Vitapex
- Iodoform/ZOE/Ca(OH)$_2$ mixture - Endoflas
Kri

- Efficacious

(Holan, 1993; Ranly, 2000; Fuks, 2000)
Kri

- Clinically forgiving
- Extradental material quickly resorbed and replaced by healthy connective tissue

(Holan, 1993; Ranly, 2000; Fuks, 2000)
Kri

- Long-term clinical trial showed better results than with ZOE

(Holan, 1993; Ranly, 2000; Fuks, 2000)
Maisto’s Paste

- Same components as Kri with addition of zinc oxide, thymol and lanolin
- Zinc oxide added to slow resorption
- Good results from case reports published
- No clinical trials performed

(Mass & Zilberman, 1989; Fuks, 2000)
Pure Inorganic ZOE

- Efficacious
- Extradental material significantly reduces success
- Not particularly antibacterial once set
- Slowly resorbable
  - pure inorganic ZOE often retained in bone after exfoliation

(Holan, 1993; Ranly, 2000; Fuks, 2000)
Resin Reinforced ZOE

- Kalsogen Plus, Kalzinol, IRM are resin reinforced
- NOT resorbable
- Contra-indicated
Vitapex
Vitapex

- Iodoform 40.4%  Ca(OH)₂ 30.3%
- Silicone 22.4%  Other 6.9%
- Efficacious
- Resorbable
- Not particularly antibacterial
- Studies with longer-term follow-up required

(Nurko & Garcia-Godoy, 1999)
Vitapex

- Prospective randomized study
- 58 teeth with necrotic pulps
- Vitapex (n=24) versus ZOE (n=29)
- 100% success (ZOE 78.5%)

(Mortazavi and Mesbahi, 2004)
Vitapex

But ……

• 2 stage treatment
• Formocresol sealed into tooth between stages
• Not restored with stainless steel crown
• Short follow-up (10-16 months)
• Conclusions unreliable

(Mortazavi and Mesbahi, 2004)
Endoflas

Endoflas F S

- **Powder**
  - Iodoform 40.6%
  - Ca(OH)$_2$ 1.07%
  - Other? 0.2%
  - Zinc oxide 56.5%
  - Barium sulphate 1.63%

- **Liquid**
  - Eugenol
  - Paramonochlorophenol
Endoflas

Endoflas F S

• One large-scale retrospective study in deciduous teeth
• Of 382 teeth, only 174 teeth had complete data to include in study group
• Assessed clinically and radiographically
• Follow-up: 6 - 77 months (mean = 21)

(Moskoviz et al, 2002)
Endoflas

Endoflas F S

- Success rate = 82 %

- Over- and under-filling had no effect on success

- Appears to be appropriate root canal filling material for primary molars

(Moskovitz at al, 2005)
Pulpectomy - Technique

- Local anaesthesia
- Rubber dam
- Access cavity
- Establish working length 2 - 3mm short of the radiographic apex
- File canals and irrigate
Pulpectomy - Technique

- Dry with sterile paper points
- Fill canals with spiral paste filler
  - iodoform paste: Kri paste
- Place ZOE over pulp canals
- Build up core
- Restore with stainless steel crown
Pulp Therapy for Non-vital Teeth

• Non-vital pulpotomy

(Faculty of Dental Surgery, Royal College of Surgeons, 2000)
Non-Vital Pulpotomy

The Past

• A technique that has been advocated mainly in the UK for the management of non-vital teeth

The Present

• “…. Only limited data are available relating to this technique and this indicates a low success rate (approximately 50%).”

(UK National Clinical Guidelines in Paediatric Dentistry, Faculty of Dental Surgery, Royal College of Surgeons, 2000)
Pulpectomy

The Past

• This is a long established technique

The Present

• “…. retrospective clinical studies have demonstrated a relatively high success rate.”

(UK National Clinical Guidelines in Paediatric Dentistry, Faculty of Dental Surgery, Royal College of Surgeons, 2006)
Treating the Soft Centre

- Pulp (Science) Fiction
  (Travolta, 1995)
Vital Pulp Therapy

Future Medicaments

• Bone Morphogenic Proteins
• Dentine Bonding Agents
Bone Morphogenic Protein (BMP)

- A non-collagenous protein
- A gene product which appears to have multiple and changing functions throughout embryonic development
- Confusing nomenclature
- The BMP family has now been renamed the DVR (decapentaplegic-Vg-related) family

(Ranly, 2000)
Bone Morphogenic Protein (BMP)

Alternative nomenclature

- DVR-2, BMP-2, BMP-2a
- DVR-3, BMP-3, Osteogenin
- DVR-4, BMP-4, BMP-2b
- DRV-6, BMP-6, vgr-1
- DVR-7, BMP-7, Osteogenic Protein-1 (OP-1)
- Etc

(Ranly, 1994)
Bone Morphogenic Protein (BMP)

Transforming Growth Factor-β Superfamily

- **TGF-β Subfamily**
  - For example, TGF-β1, TGF-β2, etc

- **Activin Subfamily**
  - For example, inhibin/activin-βA, etc

- **BMP Family**
  - For example, BMP-2, BMP-7/(OP-1), Osteogenic Protein-1, etc

- **Divergent Genes**
  - For example, Growth/differentiation Factor-9 (GDF-9), etc
Bone Morphogenetic Protein (BMP)

- Recombinant human (rH) BMP-2, BMP-4, and BMP-7 have all been shown to have dentine inductive potential in host teeth in animal studies.
- The response to human BMP-7 was dose dependent.
- Human BMP-7 can stimulate reparative dentine through existing dentine.
- All these experiments utilized clinically healthy teeth.

(Nakashima, 1994; Rutherford, 1993)
Bone Morphogenic Protein (BMP)

Potential Uses of BMP

- Indirect pulp treatment
- Direct pulp capping agent
- Vital pulpotomy medicament
Bone Morphogenic Protein (BMP)

Research is investigating

- A suitable animal model for pulpitis *in vivo*
- The effects of an application of exogenous recombinant BMP-7 to inflamed pulp tissue
- Results to date have failed to induce tissue formation in inflamed pulps

(Rutherford & Gu, 2000)
Hypothesis:

Latest DBA’s may be suitable for pulp capping

- Form impermeable hybrid layer
- Placed over pulp without displacement of pulp tissue
- Hydrophilic therefore no need to dehydrate pulp
- Light cured
- Act as barrier between pulp and composite resin
- Need acid conditioning of dentine for bonding
Dentine Bonding Agent (DBA)

- Pulp unlikely to be affected by acid conditioning provided micro-leakage prevented  
  (Snuggs et al, 1993)
- Short-term clinical studies on DBA’s as direct pulp cap agent on primary teeth have shown no adverse clinical or radiographic findings  
  (Araujo et al, 1996)
- Histological findings vary from excellent to severe  
  (Ranly, 2000)
Dentine Bonding Agent (DBA)

Further research required

• Determination *in vitro* of most biologically acceptable dental materials and ancillary agents

• Clinical trials of the acceptable candidates to test hypothesis
Treating the Soft Centre

Conclusions and Questions
Conclusions

- The success of pulp therapy in the deciduous dentition is determined by:
  - the success of the diagnosis
    - history
    - examination (clinical and radiographic)
  - Isolated field
  - Access
  - Medicament (or non-pharmalogical technique)
Conclusions

• Indirect pulp treatment:
  – is successful and its success is dependent on the effective sealing the tooth from microleakage.
  – allows the pulp to heal and repair the remaining affected dentine
  – potentially avoids the need for a pulpotomy
  – is a conservative approach
Conclusions

• Direct pulp capping is **only** a valid technique
  – for a tooth with normal pulp
  – following a small mechanical or traumatic exposure
  – when conditions exist for a favourable response.

  • For example, a pin-prick size mechanical exposure which occurs when the tooth is already isolated with rubber dam
Conclusions

• Formocresol, Ferric Sulfate / Sulphate and MTA are proven effective medicaments for vital pulpotomies in the deciduous dentition

• Formocresol has a carcinogenic ingredient and its continued use is questionable

• Whenever it is used, the amount of formocresol should be minimized to avoid unnecessary systemic distribution
Conclusions

• MTA appears to be the best medicament for a vital pulpotomy but its cost is prohibitive
• Ferric Sulfate / Sulphate is inexpensive, safe and effective
• Ferric Sulfate / Sulphate is becoming the most widely used medicament for vital pulpotomy
Conclusions

• Pulpectomy is the best pulp therapy for deciduous teeth with irreversible pulpitis or necrotic pulp tissue

• Kri currently appears to be the best root canal material in deciduous teeth
Conclusions

- New medicaments and techniques are being investigated ....

WATCH THIS SPACE!
Thank you!