Tipping the Cap: New Developments in Materials Used in Vital Pulp Therapy

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The Problem
The Great Pretenders
Anatomy

• Root development does not complete for 1-4 years after eruption
• Buccal/Lingual Width > Mesial/Distal Width
• Radiographs pass through the Buccal/Lingual Plane
• Apical closure cannot always be verified by radiographic examination
Diagnosis

1. Chief Complaint
2. Medical, Dental, Social History
3. Clinical Examination
4. Radiographic Examination
5. Diagnostic Aids
6. Consultation/Referral
Diagnosis

- Subjective Findings
- Objective Findings
- Diagnosis Reached On:
  - Combination of Findings
  - Not a Single Finding
- Treatment
  - Based on Presence or Absence of Pathology
Pulp Testing

- EPT was significantly less effective than CO2 and DDM
- p < 0.05
Pulp Testing

False Positives
• Multi-rooted Teeth
• Adjacent Teeth
• Soft Tissues
• Patient

False Negatives
• Root Development
• Trauma
• Calcified Roots
• Analgesics
• Patient
The Dilemma...

Reversible Pulpitis

Irreversible Pulpitis
Restorable Teeth with Immature Root Development

History
Diagnostic Testing
Radiographic Examination

Vital
- Reversible Pulpitis
  - Pulp Not Exposed
    - Restore Monitor for Symptoms
  - Pulp Exposed
    - Vital Pulp Therapy (Direct Pulp Cap)
- Irreversible Pulpitis
  - 1. Pulpotomy
  - 2. Repair
  - 3. Regeneration**

Necrotic
- Repair (Apical Barrier)
- Regeneration*

*Cases that require a post for coronal restorations are not good candidates for Regeneration.

**Cases that have multiple roots may be more difficult to perform Regeneration.
• “The presence or absence of a microbial flora is the major determinant of healing”

• Control Rats
  • Pulpal necrosis
  • No instance showed evidence of repair

• Germ-free Rats
  • No devitalized pulps
  • Dentin bridging evident at 14 day
Bacterial Progression

- **Affected Tissue**
  - Bacterial Byproducts
  - No Bacteria

- **Infected Tissue**
  - Bacteria Present
48 Lesions (No Exposures) As Size Progressed:

- Changes in the Odontoblast Layer
- Changes in Vascularity
- Changes in Cell Free Zone

12 Lesions > 3/4 Dentin

- Coagulative/Liquefactive Necrosis
- Inflammatory Cells Present
- Bacteria not seen in adjacent vital pulp

Infected Pulp

- Affected Pulp Below Necrosis
- Inflamed Radicular Pulp
Remaining Dentin Thickness

- > 1.1 mm
  - No pathologic changes
- < 0.5 mm
  - Pathologic pulpal changes
Biocompatibility of surface sealed dental materials against exposed pulps

- Zinc Oxide Eugenol
  - Variety of reactions at 7 days
    - chronic pulpal inflammation
    - deeper pulp was free of inflammation
  - No sign of hard tissue repair

- Amalgam
  - 5/8 inflammation free at 21 days
  - No hard tissue barrier
  - Concluded Amalgam is either:
    - Inert (Does not initiate inflammation)
    - Or Inhibits Matrix Formation
Biocompatibility of surface sealed dental materials against exposed pulps

- **Composite**
  - Unsealed: inflammation/necrosis
  - Sealed: healing, hard tissue barrier formation

- **Ca(OH)2**
  - Minimal inflammation at 7 days
  - No inflammation at 21 (4/5 teeth)
  - Hard tissue repair (4/5 teeth)

- **Conclusions:**
  - Bacteria associated with inflammation
  - No bacteria associated with healing
  - Calcium, hydroxyl ion, or pH are not necessary to initiate pulp healing but rather the prevention of bacterial leakage
Ca(OH)$_2$

- **Properties**
  - Forms a layer of necrosis over the superficial (1.5 mm) pulpal tissue
  - Coagulative Necrosis
  - In absence of bacteria pulp will heal

- **Advantages**
  - Fast Setting
  - Ease of Placement
  - Antibacterial (basic pH)

- **Disadvantages**
  - Slower formation of barrier
  - Tubular Defects (89% at 2 years)
  - Deterioration over time
  - Not Resistant to Condensation
  - Dissolution with A/E
Mineral Trioxide Aggregate (MTA)

• **Properties**
  - Similar to Portland Cement
  - Ca$^{2+}$ ions release to combine with PO$_4^{3-}$ ions to form hydroxyapatite
  - pH is supportive of dentin formation

• **Advantages**
  - Faster bridging than Ca(OH)$_2$
  - Bioactive
  - Biocompatible
  - Antibacterial (basic pH)

• **Disadvantages**
  - Long Setting Time
  - Difficult to Handle
  - Cost
  - Staining
MTA Placement
Bioceramics

• Properties
  – Contains main components of Portland Cement
    • Tricalcium Silicate
    • Dicalcium Silicate
  – Forms reparative dentin

• Advantages
  – Placement
  – Bioactive
  – Biocompatible

• Disadvantages
  – Changes in components may make it inferior to MTA
  – Lack of Research
  – Different Formulations
Indirect Pulp Therapy

- Incomplete Caries Removal
- Avoid Pulpal Exposure
- Seal Bacteria from Substrate
- Dentin Changes
  - Tertiary Dentin, Dentin Sclerosis, Remineralization
- Types
  - No Re-entry (1 Visit)
  - Re-entry (2 Visit, Stepwise Caries Excavation)
IPT Material

<table>
<thead>
<tr>
<th>Material</th>
<th>N (Teeth)</th>
<th>CFU Reduction</th>
<th>Re-entry</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRM Dycal</td>
<td>40</td>
<td>p&lt;0.001 p&lt;0.01</td>
<td>5 months</td>
<td>Fairbourn et al</td>
</tr>
<tr>
<td>Dycal</td>
<td>27</td>
<td>p&lt;0.05 p&lt;0.05</td>
<td>3 months</td>
<td>Duque et al</td>
</tr>
<tr>
<td>Vitrebond</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fuji Lining LC</td>
<td></td>
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</tr>
</tbody>
</table>

- Reduction in CFU/mg in all groups
- No difference between materials respectively
- Re-entry may be unnecessary provided coronal seal is intact
Oops? Or What?
Indirect Pulp Cap

• Despite conscious effort to avoid the pulp; pulp exposures still occur.
  • Magnusson et al – 15%
  • Leksell et al – 18%
  • Bjorndal, Thylstrup – 5%
  • Bjorndal et al – 0%
## Direct Pulp Cap

<table>
<thead>
<tr>
<th>Material</th>
<th>N</th>
<th>%</th>
<th>Length</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca(OH)₂</td>
<td>149</td>
<td>87.3%</td>
<td>&gt; 5 yrs</td>
<td>Haskell et al</td>
</tr>
<tr>
<td>MTA</td>
<td>49</td>
<td>96%</td>
<td>1-9 yr</td>
<td>Bogen et al</td>
</tr>
<tr>
<td>MTA</td>
<td>51</td>
<td>67.7% /56.2%</td>
<td>1 yr, 2 yr</td>
<td>Miles et al</td>
</tr>
<tr>
<td>MTA/Ca(OH)₂</td>
<td>229</td>
<td>80.5% MTA 59% Ca(OH)₂</td>
<td>2-5 yrs</td>
<td>Mente et al*</td>
</tr>
</tbody>
</table>

*Immediate restoration after capping increased success regardless of material (OR: 3.18, p=0.004)
TheraCal LC

- No Human or Animal Studies
- Releases Ca$^{2+}$ ions
- Physiologic pH after 7 days
- Depth of cure 1.7 mm
Biodentine

• Radiographic Bridge
  • Biodentine – 96.8%
  • MTA – 72.2%

• Histologic Bridge
  • Both Groups – 100%

• Bridge Thickness
  • Biodentine (P < .0001)
  • < 0.5 mm; radiographs not reliable
Biodentine

• “Regarding the histologic evaluation criteria, our investigation showed that there was no statistically significant difference between the responses of teeth to Biodentine compared with MTA as a pulpcapping agent (P > .05)”
Success

• Indirect Pulp Therapy
  • 93% in Primary Teeth, Marchi et al
  • 96% in Primary Teeth, Gruythuysen et al
  • 10 year survival in Permanent Teeth, Maltz et al

• Direct Pulp Cap
  • 96% in Permanent Teeth, Bogen et al
  • 80.5% in Permanent Teeth, Mente et al
  • 93% at 3 months, Song et al
  • 87.5% in Permanent Teeth, Haskell et al
Thank you!

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