NAHDA UNIVERSITY

MANAGEMENT OF DEEP CARIES IN CHILDREN

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I. DENTAL–PULP COMPLEX

- As long as dentine is covered peripherally by enamel on coronal surfaces and cementum on radicular surfaces, the dental pulp will generally remain healthy for life.

- **Dentin structure:** Dentin is a calcified connective tissue consisting of approximately 70% inorganic material and 10% water. Organic matrix accounts for 20% of dentin, of which about 91% is collagen. Most of the collagen is type I.

- Dentin is penetrated by millions of tubules; their density varies from 40,000 to 70,000 tubules per square millimetre.

- Tubules are from 1 mm in diameter at the DEJ to 3 mm at their pulpal surface.

- **Dentin permeability:** Area of dentin occupied by tubules is only 1% at the DEJ and increases to 45% at the pulp chamber.

- **Pulp innervation:** There are 2 types of sensory nerve fibres in the pulp are myelinated A fibres (A-delta 90% and A-beta fibres10%) and unmyelinated C fibres.

II. CLASSIFICATION OF PULPAL DISEASES

Based on the extent of pulpal damage, disease of the pulp can be classified as:

1. **Pulpitis**
   - Reversible pulpitis
   - Irreversible pulpitis
     - Hyperplastic pulpitis
     - Internal resorption

2. **Pulp degeneration-pulp calcification**

3. **Necrosis**

III. DIAGNOSIS OF PULP PATHOLOGY

1. **History of pain**
   - The absence of toothache does not preclude a histologic pulpitis. The active lives of children, together with their short attention spans, may mean that minor discomfort passes without comment in a whirlwind of activities.
   - A positive history of toothache suggests definite pulp pathology. However it is difficult to correlate the type of pain with the degree of pathosis.
   - **Provoked pain**—may be due to exposure of dentin from a leaking restoration or an open lesion and the pathosis is confined to coronal pulp.
   - **Unprovoked pain**—indicates widespread inflammation of the pulp, extending throughout the radicular filaments.
   - Pain may be radiated to other teeth, jaw, temple or sinuses. It then becomes difficult to identify the involved tooth.
• **Momentary pain:** Immediate stresses to hot or cold that disappear on the removal of the stimulus indicate that the pathosis is limited to the coronal pulp

• **Persistent pain:** pain from thermal stimuli would indicate wide spread inflammation of the pulp, extending into the radicular filaments

• **Spontaneous pain:** throbbing, constant pain that may keep the patient awake at night. This type of pain indicates pulpal (damage-irreversible pulpitis

2. Clinical examination

2.1. Intraoral examination

2.1.1. Tooth mobility
  • Mobility associated with a deciduous tooth may be physiologic or may be due to any persisting pathology
  • Abnormal tooth mobility may indicate severely damaged pulp or PL involvement
  • Radiographic evaluation of the roots of deciduous tooth, the position of the developing tooth and amount of root completion of permanent tooth will determine the cause

2.1.2. Percussion
  • Pain from pressure on a tooth indicates that periodontal ligament is inflamed. A useful clinical test is to apply finger pressure to the tooth and check the child’s response by watching the eyes

2.1.3. Size of exposure and amount of bleeding
  • Small pinpoint exposure surrounded by sound dentin indicated for vital pulp therapy
  • Large exposure with watery exudates or pus not indicated for vital pulp therapy

2.2. Extraoral examination

2.2.1. Swelling/cellulitis
  • Spread of exudate into various spaces along the fascial planes. In the mandibular arch, submandibular region is commonly involved and in the maxillary arch, the swelling may extend up to the infraorbital margin
  • The drainage occurs through the path of least resistance, which is through the skin
3. Pulp testing

<table>
<thead>
<tr>
<th>Assess Nerve Supply</th>
<th>Assess Blood Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Thermal tests</td>
<td>• LDF</td>
</tr>
<tr>
<td>• EPT</td>
<td>• Pulse oximetry</td>
</tr>
</tbody>
</table>

3.1. Thermal pulp testing

<table>
<thead>
<tr>
<th>Cold tests</th>
<th>Hot tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ice cones</td>
<td>• Heated gutta-percha</td>
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<tr>
<td>• Ethyl chloride (-41°C)</td>
<td>• Hot water</td>
</tr>
<tr>
<td>• Dichlorodifluoromethane (DDM) (-0°C)</td>
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<tr>
<td>• Dry ice (-72°C)</td>
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3.2. EPT
Requirements
- Tooth isolation
- Plastic strip interperoximally
- Don’t place the current on metallic restoration, ortho. Appliance or crowned tooth
- Electric pulp tests and thermal tests are of limited value because of
  - Varied responses as roots mature.
  - Unreliable responses from children because of fear, management problems, and inability to understand or communicate accurately

Consequently, most diagnoses are made on observation of clinical symptoms and radiographic evidence of pathosis

3.3. Laser Doppler Flowmeter LDF
- Source of laser: Helium Neon (633nm) or Diode Laser (780-810 nm)
- The technique utilizes a beam of infrared light produced by a laser that is directed into the tissue. As light enters the tissue, it is scattered and adsorbed by moving red blood cells and stationary tissue elements

3. Radiographic examination
Recent pre-operative radiographs are requisites to pulp therapy in primary and young permanent teeth
- Proximity of carious lesion from the pulp (not pulp exposure)
- Periapical or interradicular bone radiolucenies
- Widening of PMS
- Pulp calcification
- IRR and/or ERR
IV. MANAGEMENT TECHNIQUES

1. INDIRECT PULP TREATMENT
   - It is a procedure performed in a tooth with a deep carious lesion approximating the pulp but without signs or symptoms of pulp degeneration. The caries surrounding the pulp is left in place to avoid pulp exposure and is covered with a biocompatible material

1.1. Aim
   - To remove the infected dentin and leaving intact the affected dentin, so that the affected dentin will remineralize and act as a barrier above the healthy pulp

1.2. Indications
   - Indirect pulp treatment is indicated in a primary tooth with no pulpitis or with reversible pulpitis when the deepest carious dentin is not removed to avoid a pulp exposure. The pulp is judged by clinical and radiographic criteria to be vital

1.3. Contraindications
   - Any signs of pulpal or periapical pathology
   - Non restorable tooth acute pulpal inflammation
   - Prolonged night pain
   - Mobility of the tooth
   - Discoloration of the tooth
   - Definite pulp exposure
   - Interrupted or broken lamina dura
   - Radiolucency about the apices of the roots

1.4. Procedures
   - First visit
     - Tooth is isolated with rubber dam
     - All the caries on the cavity walls and at the DEJ are removed, due to its closeness to the surface. Caries left in this area will likely cause failure due to the lateral spread
     - Large round bur or spoon excavator is used to remove the carious dentin
     - The caries surrounding the pulp is left in place to avoid pulp exposure and is covered with biocompatible material

Dressing materials
  - A radiopaque liner such as a dentin bonding agent,
- resin modified glass ionomer,
- calcium hydroxide,
- zinc oxide/eugenol,
- or glass ionomer cement is placed over the remaining carious dentin to stimulate healing and repair.

If calcium hydroxide is used, a glass ionomer or reinforced zinc oxide/eugenol material should be placed over it to provide a seal against microleakage since calcium hydroxide has a high solubility, poor seal, and low compressive strength.

The use of glass ionomer cements or reinforced zinc oxide/eugenol restorative materials has the additional advantage of inhibitory activity against cariogenic bacteria.

Second visit

- The treated tooth can be re-entered (if two step procedure is done) after 6-8 weeks and remaining caries is removed. The pulp is safe from exposure, due to the formation of reparative dentin.
- The color would have changed from red rose to light gray or light brown and the texture changes from spongy and wet to hard.
- Criteria of success:
  - Intact restoration
  - No history of pain
  - Normal clinical findings
  - Normal radiographic findings

2. DIRECT PULP CAP

Placement of a biocompatible material over a pinpoint mechanical exposure of the pulp is encountered during cavity preparation or following a traumatic injury.

2.1. Indications

- Mechanical exposures that occurs following trauma or during cavity preparation which is <1 sq mm, surrounded by clean dentin in an asymptomatic vital deciduous tooth.
- Mechanical or carious exposures <1 sq mm, in an asymptomatic vital young permanent tooth.

2.2. Procedures

- Debridement: During caries removal if there is a pulpal exposure, necrotic and infected dentin chips will be pushed into the exposed pulp, and this can impede healing, causing further pulpal inflammation. Therefore while excavating caries from a deep cavity, it should be remembered that peripheral carious dentin from the walls should be removed first followed by removal from the floor of the cavity. Following a clinical exposure a nonirritating solution of normal saline or anesthetic solution should be used to cleanse the area and keep the pulp moist.

- Hemorrhage and clotting: A blood clot formed after cessation of the bleeding, impedes the pulpal healing. Therefore care must be taken not to
allow clot formation. The clot that is formed does not allow the capping material to contact the pulp tissue directly, or the clot material itself could breakdown, producing degradation products that act as substrate to the bacteria

- **Bacterial contamination:** Adequate seal following pulp capping is a must to prevent bacterial contamination

- Stainless steel crown restoration is the most preferred one

<table>
<thead>
<tr>
<th>2.3. Ideal requirements of capping material</th>
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<tbody>
<tr>
<td>• Stimulate reparative dentin formation</td>
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<tr>
<td>• Maintain pulpal vitality</td>
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<tr>
<td>• Bactericidal or bacteriostatic</td>
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<tr>
<td>• Adhere to dentin</td>
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<tr>
<td>• Adhere to restorative material</td>
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<tr>
<td>• Resist forces during restoration placement</td>
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<tr>
<td>• Must resist forces under restoration during lifetime of restoration</td>
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<tr>
<td>• Radio-opaque</td>
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<tr>
<td>• Provide bacterial seal</td>
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<td>• Release fluoride to prevent secondary caries</td>
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<table>
<thead>
<tr>
<th>2.4. Capping materials</th>
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<tbody>
<tr>
<td>• Calcium Hydroxide</td>
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<tr>
<td>• Zinc oxide eugenol: No calcific bridge formation occurs.</td>
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<tr>
<td>• 3. Mixture of corticosteroids and antibiotics (Ledermix)</td>
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<td>• TCP cement</td>
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<td>• MTA</td>
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<tr>
<td>• BMP</td>
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2.5. Calcium Hydroxide (CH)

2.5.1. Histological reaction

- Because of its alkalinity (pH of 12), it is so caustic that when it is placed in contact with vital pulp tissue deeply staining zone comprising basophilic elements of the calcium hydroxide dressing
- New area of coarse fibrous tissue likened to a primitive type of bone
- On the periphery of the new fibrous tissue, cells resembling odontoblasts appear to be lining up
- One month after the capping procedure, a calcified bridge is evident radiographically. This bridge continues to increase in thickness during the next 12 months

2.5.1. Disadvantages of CH

- Does not exclusively stimulate dentinogenesis
- Does exclusively stimulate reparative dentin
- Associated with primary tooth resorption
- May degrade during acid etching
- Degrades upon tooth flexure
- Marginal failure with amalgam condensation
- Does not adhere to dentin or resin restoration
- Dentin bridges beneath Ca(OH)2 are associated with tunnel defects
- Failure to provide a long-term seal against microleakage
when used as a pulp capping agent and this may lead to penetration of microorganisms into pulpal tissue and induce pulpal irritation and potential pulpal death

2.6. Mineral Trioxide Aggregate (MTA)

2.6.1. Composition

This bioactive silicate cement was originally composed of:

- tricalcium silicate,
- tricalcium aluminate,
- tricalcium oxide,
- silicate oxide, and
- Other mineral oxides

The cement exhibits many favorable characteristics, which make it a superior material when used as a direct pulp capping material in adult teeth or as an agent in partial or complete pulpotomy in primary teeth

2.6.2. Advantages

- Set in the presence of blood and moisture
- Superior marginal adaptation and is nonabsorbable
- When it cures in the presence of calcium ions and tissue fluids, it forms a reactionary layer at the dentin interface resembling hydroxyapatite in structure
- Sustained alkaline pH after curing, small particle size, and a slow release of calcium ions
- Stimulates cytokine release, induces pulpal cell proliferation, and promotes hard tissue formation

3. PULPOTOMY

Surgical removal of the entire coronal pulp, till the entrance of root canals leaving intact the vital tissue in the canals, followed by placement of a medicament or dressing over the remaining pulp stump

3.1. Aim

To remove the inflamed and infected pulp tissue and allowing the vital pulp in the root canals to heal, thus maintaining the vitality of the tooth

3.2. Indications

Carious or mechanical exposure of vital primary teeth and young permanent teeth, where inflammation is restricted to coronal pulp only

3.3. Procedures

- Administration of local anesthesia and rubber dam isolation
- All caries should be removed
- Entire roof of the pulp chamber is cut with highspeed bur and water spray
- The coronal pulp is removed with the round bur or spoon excavator
- Pulp chamber is washed thoroughly, to remove all debris
- Hemorrhage is controlled with cotton slightly moistened with saline, placed against the stumps of the pulp at the opening of the root canals. Bleeding should be controlled within 3-5 min
- Pulp status is assessed
- Cotton pellet moistened with 1/5th dilution formocresol is placed over the amputated pulp for 5 min
- When the cotton pellet is removed, the pulp stump must appear dark brown or even black, as a result of fixation
Creamy mix of ZOE is placed over the amputated pulp. The tooth is then restored with SSC.

3.4. Formocresol (FC)

3.4.1. FC chemical structure
- Formaldehyde—19%
- Cresol—35%
- Glycerin—15%
- Water

A dilute 20% (1:5 concentrations) of Buckley's FC.

3.4.2. Variation in FC pulpotomy
- Garcia-Godoy compared the pulpal response of various application times to FC in dogs. He found that an application time of 1 minute produced less inflammation than 3 and 5 minutes.
- FC was incorporated into the ZOE base, it produced a more intense inflammatory response (worse the tissue response).

3.4.3. Problems encountered with FC
- Local toxicity: to the pulp and the tooth becomes devitalized.
- Systemic toxicity: Studies have shown that full strength formocresol, is absorbed into the systemic circulation from the pulpotomy site. FC was found in the liver, lung, muscle, heart, spleen, kidney, and even in CSF.
- Cytogenic and mutagenic effect.
- Enamel defects in the permanent successor may occur.

3.4.5. Histological changes following FC pulpotomy
- Immediately following placement of the formocresol the pulp tissue became fibrous and acidophilic 7-14 days later, 3 distinct zones appears. They are:
  - Broad acidophilic zone of fixation
  - Broad pale staining zone of atrophy with few cells and fibers
  - Broad zone of inflammatory cells extending apically from the border of the pale staining zone
- Progressive apical movement of these zones occur and at the end of one year the entire pulp will be comprised of only the acidophilic zone.

3.5. Laser
- Creates a superficial zone of coagulative necrosis and this gets replaced by granulation tissue.
- CO₂ and Nd:YAG lasers to perform pulpotomies.

3.6. Glutaraldehyde (GA)
- GA is less likely to diffuse out of the apical foramen
- GA has effective disinfecting properties
- GA was also found to have better fixative properties
- with true crosslinking
- GA is 15-20 times less toxic than FC.
- Although GA seems to compare favorably with FC as a pulp-capping agent, it has not consistently demonstrated significant superior results in clinical trials.
3.7. Ferric Sulfate (FS)
FS agglutinates blood proteins and controls hemorrhage in the process without clot formation

4. APEXOGENESIS (CH PULPOTOMY)
Indicated in vital permanent due to caries or trauma teeth with large pulp exposures and incompletely formed apices

4.1. Aim
- To remove the infected coronal pulp and place calcium hydroxide over the healthy amputated radicular stumps
- A calcific barrier should form in response and the radicular pulp should retain its vitality so that root closure can occur
- To achieve normal growth of the root to assume its normal length and apical closure
- RCT treatment following closure of the root apex and permanent restoration

5. PULPECTOMY
Removal of the entire pulp and subsequent filling of the canals of the primary teeth with a suitable resorbable material

5.2. Indication
- Primary teeth with pulp inflammation extending beyond the coronal pulp (irreversible pulpitis)
- Roots and alveolar bone with minimum pathologic resorption
- Primary teeth with necrotic pulp and or periapical abscess

5.2. Contraindications
- Nonrestorable clinically
- Periradicular involvement extending to the permanent tooth bud, where the risk of damage to the permanent tooth is high
- IRR or ERR
- Extensive mobility
- Gross bone loss at the apex or at furcation

5.3. Procedures
- Done under local anesthesia and rubber dam isolation
- All caries should be removed
- Entire roof of the pulp chamber is cut with highspeed bur and water spray
- The coronal pulp is removed with the round bur or spoon excavator
- Pulp chamber is washed thoroughly, to remove all debris
- All accessible radicular pulp is removed with broach or headstrom files
- Radiograph with the endodontic instrument need not be taken for working length determination
- Canals are irrigated with saline and dried. Paper points are used for drying the canal walls
- Canals are then obturated with suitable resorbable filling material
- Zinc Oxide Eugenol mix is placed over the obturating material
- Tooth is sealed with amalgam restoration and finally restored with stainless steel crown restoration

5.4. Ideal requirements of material used
- Must be resorbable
- Should not interfere with eruption of permanent tooth
- Should be bactericidal
- Must be radio-opaque
- Must be nonirritant

- Zinc oxide eugenol
  - Is used without catalyst. Lack of catalyst is used to allow adequate working time
  - Iodoform paste
  - Is also being used. It consists of zinc oxide and iodoform mixed into a paste. Its advantages over zinc oxide eugenol are
    - Potent bactericidal
    - Nonirritant
    - Radio-opaque
    - Chemically active until entirely resorbed
    - Good healing properties
    - Rate of resorption is faster
  - Iodoform, calcium hydroxide, and zinc oxide—is commercially available as Endoflas;
  - Iodoform paste in combination with calcium hydroxide has also been used; it is commercially available as Vitapex and Metapex
  - Iodoform paste is and contains iodoform, camphor, para-chlorophenol commercially available as KRI

6. APEXIFICATION

Indicated in a nonvital pulp with incompletely formed or open apices (blunderbuss canal). The toxic products from the necrotic pulp causes death of the cells (Hertwig’s epithelial root sheath) responsible for root growth, which reduces the chance of further root development and apical closure

Apexification is a procedure where a suitable material is placed in the root canal which aids in the formation of a calcific barrier at the apical end of the root canal

6.1. Materials
- Calcium hydroxide
- Zinc oxide paste
- Antibiotic paste
- Tricalcium phosphate
- Collagen—calcium phosphate gel
- Mineral trioxide aggregate

6.2. Procedures
- The tooth is anesthetized and isolated.
- Access opening is similar to conventional root canal treatment
- Barbed broach is used to remove the pulp and necrotic debris
- Diagnostic X-ray helps in assessing the root length (working length is approximately 2 mm from the apex)
- Hedstrom file is used along with constant irrigation to cleanse the canal off the debris.
- Canal is dried and filled with calcium hydroxide or any other desired material.
- Chances of success are greatly improved when the canal is filled in the absence of inflammation.
- If acute signs are present, canal is debrided, irrigated and filled temporarily.

**Follow up**

- Evaluation of signs and symptoms are made regularly. IOPA is taken once in 2-3 months, to evaluate the amount of root closure.
- Root appearance can be compared with that of the antimere.
- Calcific repair may be complete in 6 months to 2-3 years.
- Once the repair is complete, calcium hydroxide should be removed, canal irrigated and a root canal filling material placed.

6.3. **Apical plug with MTA**

- Access opening is done under local anesthesia and rubber dam.
- The root canal is cleaned with intracanal irrigants.
- Calcium hydroxide paste can be placed in the canal to disinfect for about 1 week.
- Calcium hydroxide is removed by rinsing.
- Excess moisture is removed from the canal.
- Mixed MTA is placed in the cavity using MTA carrier.
- The apical plug should be at least 3-4 mm thick and this should be checked radiographically.
- A moist cotton pellet is placed in the canal and the tooth is temporarily restored.
- After 3 hours, the remaining canal is obturated with gutta percha and a permanent restoration is then placed.

8. **PULP REVASCULARIZATION/REGENERATION**

- This technique is recommended for a tooth with nonvital pulp tissues from the periapical area are able to regeneration into the pulp canal.
- The first step in this procedure is to disinfect the necrotic pulp. It is done by gentle debridement of the canal by flushing it with 5.25% sodium hypochlorite solution, followed by placement of a combination paste of antibiotic containing metronidazole, minocycline and ciprofloxacin.
- When the pulp is disinfected after about 15-20 days, the vital tissue at the periapical area is gently irritated with an endodontic instrument and bleeding is initiated.
- The blood is allowed to clot and a paste of MTA is placed over the clot and access cavity sealed permanently.
- Pulp revascularization is generally performed over two clinical sessions. In the first session, root canals are cleaned through copious irrigation with chemical substances, followed by dressing with intracanal medication for three weeks.
After this period, a blood clot is induced and sealed with Mineral Trioxide Aggregate (MTA) and composite resin.

V. FAILURES AFTER VITAL PULP THERAPY
Failure in the formation of a calcified bridge across the vital pulp has often been related to
- Age of the patient
- Degree of surgical trauma
- Sealing pressure
- Improper choice of capping material
- Low threshold of host resistance,
- Presence of microorganisms with
- Subsequent infection

Common failures
- Internal resorption
- External root resorption
- Alveolar abscess