Current Concept in Vital pulp Therapy
Etiology

Treatment and Technique

- vital pulp therapy
  - apexogenesis
- non vital pulp therapy
  - apexcification:
    - traditional VS MTA
  - revascularization/regeneration
Immature permanent teeth

1. No apical stop -> hard to create optimal root canal filling
2. Thin dentin wall -> fracture easily 1/3
3. Childhood patient and parent’s attitude
Objectives of pulp treatment in immature teeth

1. maintain the vitality
2. continuation of the root growth
   (Apexogenesis)

Dentin wall thickness
Root strengthen
Objectives of pulp treatment in immature teeth

3. apical closure (Apexification)
Etiologies

• congenital abnormally
  ✓ dens evaginatus
• caries
• trauma
• open apex by
  ✓ root resorption or apicoectomy
Treatment

- Vital pulp therapy
  - apexogenesis

- Non vital therapy
  - apexification
  - revascularization / pulp regeneration
Apexogenesis

Physiological root end development and formation

AAE. 1981
All vital pulp therapy procedures that were done to maintain pulp vitality of the immature permanent teeth and allow the fully developed of the root with apical closer
Objectives of Apexogenesis

- To keep pulp vital for increasing canal wall thickness
- To keep Hertwig’s epithelium cells vital for continuing root growth
- To create the apical constriction
- To create dentin bridge at capped site

Webber1984
Apexification is the term that is used to describe the procedure of endodontic treatment in permanent teeth with an incompletely developed apex.
**VITAL PULP THERAPY**

- **Includes:**
  - PROTECTIVE SEALING
  - Indirect Pulp Therapy
  - Direct Pulp Cap: CH, MTA, 3MIX
  - Pulpotomy
    - partial pulpotomy (Cvek pulpo)
    - Cervical pulpotomy
    - MTA pulpotomy
Dens evaginatus
Protective sealing
Preventive resin restoration (PRR)
Preventive resin restoration (PRR)
Preventive resin restoration ( PRR )
Preventive resin restoration ( PRR )
Also called indirect pulp cap

**DEFINITION**
- Placement of protective dressing (CH) over thin remaining dentin which, if removed, might expose the pulp:

**PURPOSE**
- To protect the pulp from further injury and to permit healing and repair
**INDICATION**: deep caries nearly exposed pulp

- Minimal sign of pulpal inflammation
  - No clinical signs of pulpal degeneration
  - Asymptomatic or symptoms of reversible pulpits
  - Sharp pain to thermal, osmotic stimuli
  - No spontaneous pain
  - Responds WNL to thermal and electric pulp tests
- No radiographic sign of periapical inflammation
  - No widening PDL
  - No periapical radiolucency
INDIRECT PULP THERAPY

SUCCESS RATE

- 99% success for avoiding pulp exposure
- 92% success: 3 ½ - 4 ½ year follow up
- Failed indirect pulp therapy:
  - irreversible pulpitis
  - pain persist
INDIRECT PULP THERAPY

TECHNIQUE

- Anesthetic
- Apply rubber dam to provide aseptic area
- Remove all caries from outer area to inner area with low speed round bur
  - Large round bur less likely to cause accidental exposure than spoon excavator
- Leave only soft dentine above the suspicious exposure area
- Disinfect the cavity with NaOCl 5% soaked cotton pellet
INDIRECT PULP THERAPY

TECHNIQUE (cont’d)

- place capping material: Ca(OH)₂
- semi-permanent or permanent filling to achieve bacteria tight seal

**CORONAL SEAL**

is the most important step
INDIRECT PULP THERAPY

TECHNIQUE (cont’d)

- After 3 months, remove remaining caries, evaluate: arrested? Exposure?
- If no pulp exposure – final restoration
- If pulp exposure – direct pulp capping

RECALL: once a year

FAILURE

- leads to irreversible pulpitis
- pulpotomy or pulpectomy be applied further
Case: girl 11 yr 9 mth
Hx: Pain several times mostly after chewing
sometimes at night
not a serious pain no need for pain killer
Finding: large carious lesion with food packed
slightly pain on percussion
thickening of PDL on mesial root
Dx: reversible pulpitis
TX: Indirect pulp capping
Before

After 6 month
Secondary dentin formation

Refilling after 15 months
Recall

19 months

26 m

38 m
The coronal seal is the key to the success thus provide bacterial tight seal.
DIRECT PULP CAP

- DFINATIONS:
  - Placement of a protective dressing directly over pulp at site of exposure

- PURPOSE
  - To permit healing & repair and to maintain the pulp’s vitality and function
Indications

- For immature permanent tooth (came into oral cavity less than 3 yrs)
- Recent (< 24 hr) traumatic exposures and exposure size < 1 mm.
- Accidental mechanical exposure <1 mm.
- Best used on the immature permanent teeth with exposed pulp
- For mature permanent tooth only when simple restoration is performed
Careful Case Selection

- Mechanical better than carious exposure
- Small exposure better
- Location of exposure – axial wall worse
- Young pulp better prognosis
- Minimal pulpal inflammation
- No clinical signs of pulpal degeneration
- Little or no bleeding at exposure site
- No radiographic signs of periapical inflammation
Direct pulp capping
Direct pulp capping technique

- local anesthesia
- Apply rubber dam
- remove caries complete
  ( from outer to inner area )
- disinfect the exposure area
- controlled bleeding
- place the capping material directly onto an exposure site
- permanent simple filling
Pulpal healing after pulp capping

- Kozloska 1980 72%
- Ravn 1982 88%
- Fuks et al. 1982 81%
DIRECT PULP CAP

- **SUCCESS RATE**: Controversial
  - Depends on definition of success
  - High success rate if judged by absence of clinical signs and symptoms
  - Low success rate based on presence of chronic inflammation on histologic exam
  - High success rate in short term
  - Long term – persisting pulpal inflammation. May lead to calcification, internal or external resorption which complicates future NSRCT
- Therefore: IDEAL treatment for all carious exposure in mature permanent teeth is NSRCT
Direct pulp capping should not be done when:

- exposure time longer than 24 hours
- infections immigrated into the pulp
- having history of spontaneous pain
- having periapical pathology
- calcifications of the pulp chamber or root canals means long term irritation
- excessive hemorrhage
- having purulent or serous exudates
Requirements for success

- No inflamed pulp left
- bacteria tight seal
- pulp capping material
Critical for the success of any pulp capping treatment, regardless of material used for the pulp cap

Matsuo et al. 1996.

Classic studies: The role of germ free

Kakehashi et al. 1965 and 1966

Clinically we assume that:

There is no inflammatory pulp left.
A complicating factor in treating immature teeth is the difficulty predicting the degree of pulpal damage.

Currently, the best method appears to be the ability to control pulpal hemorrhage.
Hemorrhage control

Methods to achieve pulpal hemostasis

- Rinse with saline (physiological hemostasis)
- Mechanical pressure with a sterile soaked cotton pellet
- Soaked in saline, hydrogen peroxide, 2% chlorhexidine, 2.5-5% sodium hypochlorite to sterilize to the exposure site
CH was introduced in dentistry by Hermann (1920)

Calcium hydroxide is still the material of choice for all pulp conservative treatment.

High pH 12.5, pure Ca (OH)2 causes liquefaction necrosis of superficial pulp, thus removes 1.5 mm of inflamed pulp tissue

Neutralization of high pH in deeper layers of pulp, with only a mild irritation to the pulp, results in coagulation necrosis at the junction of necrotic and vital tissues

Stimulate inflammatory response, heal with hard tissue barrier (if absence of bacteria)
Calcium hydroxide

Formation of a dentinal bridge at 42 days after pulp exposure, under Ca (OH)2 pulp capping
Calcium hydroxide

MECHANISM OF ACTION:
- Ca(OH)$_2$ causes necrosis of superficial pulp and inflammation of contiguous tissue
- Dentin bridge formation occurs at junction of necrotic and inflamed vital tissue
- Dentin bridge consists of superficial bone-like layer and deeper dentin-like layer
- Blood clot inhibits bridge formation
MECHANISM OF ACTION (cont’d):
- Radiographic studies of radiolabelled Ca(OH)$_2$ have shown that Ca in dentin bridge comes from blood—not from Ca(OH)$_2$
- Bridge – irregular porous tubular dentin
  - Becomes thicker & less permeable with time
  - Exact mechanism of action unknown BUT certain concentrations of Ca(OH)$_2$ known to be mitogenic for pulp fibroblasts (odontoblast replacement cells)
Disadvantage of Ca(OH)$_2$

- Ca(OH)$_2$ itself cannot provide adequate seal to prevent the pulp from the external environment.
- Dissolve over time, leaving voids and other potential pathway for bacterial infection
- Dentinal bridges beneath pulp caps contain tunnel defects
FIGURE 2- Pulp exposure capped with calcium hydroxide (arrow). Observe that 30 days after the pulp therapy, a partial hard tissue barrier was formed adjacent to the capping agent. HE, ×32

Sixty days after applying calcium hydroxide on the pulp tissue, a complete hard tissue barrier (HB) is formed. Note the tunnel defect (horizontal arrow) and cellular inclusions (vertical arrows) within the hard tissue barrier, which is underlined by a new layer of odontoblast-like cells. HE, ×125
Bacteria tight seal
Disadvantage of Ca(OH)$_2$

- Ca(OH)$_2$ itself cannot provide adequate seal to prevent the pulp from the external environment.
- Dissolve over time, leaving voids and other potential pathway for bacterial infection.
- Dentinal bridges beneath pulp caps contain tunnel defects.
Other pulp capping materials

- Adhesive resin
- MTA
- 3Mix-MP or triantibiotics
Adhesive resin

The results of some short term experiments suggest that direct capping of a vital pulp with the modern resin – based composite systems maybe as effective as capping with Ca(OH)$_2$

(Schuurs et al 2000)
Vital pulp therapy using acidic agents and adhesive resins seems to be contraindicated.

(Costa et al 2000)
Mechanical exposure
No bleeding

19 m. follow up

31 m. 12/42-48
Disadvantage of adhesive resin

- No hard tissue barrier
- Persisted inflammation response
- Technique sensitive: fragments of material and observed in the pulp adjacent to exposure site

MTA AS THE PULP CAPPING MATERIAL

Traditional gray MTA
Pitt Ford T R, JADA 1996

white MTA was launched in 2002
MTA is composed of tricalcium silicate, tricalcium aluminate, tricalcium oxide and silicate oxide. Hydration of the powder results in a colloidal gel composed of calcium oxide crystals in an amorphous structure: 33 percent calcium, 49 percent phosphate, 6 percent silica, 3 percent chloride and 2 percent carbon. This gel solidifies into a hard structure in less than three hours. It has a compressive strength equal to zinc oxideeugenol with polymer reinforcement.

Witherspoon et al 2006
MTA properties

- Alkaline pH11: Antimicrobial agent
- Biocompatibility
- Stimulate tissue healing and dentinal bridge
- provide tight seal
In human teeth:
at six months,
- MTA = 0.43 mm thick dentin bridge
- Calcium hydroxide = 0.15 mm with no odontoblastic layer

Pulp capped with a dental material that present high pH (MTA). Sixty days after the pulp therapy, a defined hard tissue barrier was formed, which was underlined by a new layer of odontoblast-like cells (arrow). Masson’s Trichrome, ×86
• root canal gun (Messing)
• amalgam carrier
MTA mixed
Redefining pulpitis

- Normal pulp
- Pulpitis
- Pulp necrosis

Messer, AAE 2010
Trauma
Diagnosis

- history taking (dental and medical)
- clinical examination: extra and intra oral
- radiographic examination
History

Medical
- Consciousness, headache, amnesia, vomit
- Drug allergy, Medicine
- Vaccine

Dental
- When, where, how did the accident occur?
- Previous trauma
- History of pain and previous treatment
- function
Clinical examination
Soft tissue injuries need to be attended as soon as possible.
But avulsed tooth takes priority over tissue injury.
Rule out any contamination in the injury.
Assess if muscle is cut or damaged-special suturing of muscles are essential for a good healing.
Clinical examination

- Intraoral examination
  - oral mucosa
  - tooth structure, pulp, color, displacement
  - mobility test
  - pulpation of alveolar bone
  - percussion
  - occlusion
  - vitality test: EPT, thermal test, LDF
  - visible light: crown infraction
mobility test
Pulpal Test

- Cold test is most effective
- Place cold on incisal 1/3 if possible
- False negatives are common soon after injury
- Needs to be repeated at all recall appointments
Level of pulpal sensibility according to stage of root formation

Sirotest II

Fulling and Andreasen 1976
37 teeth subluxated
   20 none responsive to EPT immediately
   17 responsive to EPT immediately
At follow up
   6 of 20 non responsive to EPT now responsive
   2 of 17 responsive to EPT now non responsive

(Skiller 1960)
Radiographic examination

Give information about

- size of the pulp that usually smaller than the real size
- Stage of root development
- a base line information
• Intraoral radiograph

• Extraoral radiograph (optional)
always vary the angulation of X-ray tube to look for root fracture and displacement

Radiographic examination
Radiographic examination
Objectives of Treatment in Dental Trauma

Maintain pulpal function
- Prevent the pulpal canal space from becoming infected

Especially in immature tooth
- To continue the root formation
- Thus strengthen the tooth
- By increase the thickness of dentinal walls
- Avoid “difficult” endodontics
Classification

Fracture : crown / root

Luxation : PDL injuries

Avulsion
Crown Root Fracture

- Crown infraction
- Uncomplicated crown fracture
- Complicated crown fracture
- Uncomplicated crown-root fracture
- Complicated crown-root fracture
Crown Root Fracture
Crown Infraction

Clinical Presentation - Craze line
Complicated Crown Fracture

2 – 13% of all dental injuries

Exposed Vital Pulp
OPEN APEX CASES

Open Apex

Vital Pulp

Apexogenesis

Necrotic Pulp

Apexification
Complicated Crown Fracture

Vital pulp therapy

- Direct Pulp Capping
- Partial Pulpotomy
- Cervical Pulpotomy

Pulpectomy or Apexification

Make this the last choice after try everything and it is not work !!!!
Complications!!

- chronic inflammation or necrosis
- internal/external resorption
- dentin mineralization
  ( pulp obliteration )
Factors affected treatment plan of the traumatized teeth

- Root development
- Pulp involvement
- PDL involvement
- Displacement
- Time of injury
Pulp survival after fracture in mature teeth related with periodontal injuries

Andreasen et al. 1989
Pulp survival after fracture in immature teeth

Andreasen et al. 1992
vital pulp therapy (apexogenesis)
- Protective sealing
- Pulp capping
- Partial pulpotomy
- Cervical pulpotomy

non vital pulp therapy
- apexcification:
- traditional VS MTA
- revascularization/regeneration
Protective sealing

No pulp exposure: coronal seal
Protective sealing

No pulp exposure: coronal seal
Protective sealing with Dentin bonding of tooth fragment
Protective sealing
<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of teeth</th>
<th>Pulp Necrosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>No treatment</td>
<td>24</td>
<td>13 (54%)</td>
</tr>
<tr>
<td>Dentin coverage</td>
<td>620</td>
<td>30 (8%)</td>
</tr>
</tbody>
</table>

RAVN 1981
Protective sealing

No pulp exposure
Protective sealing
Class II malocclusion
Crown fracture
Percussion +
Mobility 2 degree

08-46

5/48  19 m

10/48 26m fracture again

Prone to accidental injuries
pulp necrosis after uncomplicated crown fracture

Crown fracture
No other symptoms

9 mths AAA

Recall 21 mths
Partial pulpotomy

Pioneer

• Cvek
• Andreasen
Partial pulpotomy is a form of vital pulp therapy that consists of the surgical amputation of 2 – 3 mm of damaged, inflamed, coronal pulp tissue, followed by placing a biocompatible agent to promote healing and maintain vitality of the remaining pulp tissue.

OBJECTIVE

• to maintain vitality and function of pulp
• to allow continuous root formation in immature teeth

Partial pulpotomy
PARTIAL PULPOTOMY

INDICATION

• mature or immature tooth
• exposed vital and healthy pulp
• open/close apex tooth
• no injury of PDL, no displacement
• exposure time >24hrs
• or carious exposure
PARTIAL PULPOTOMY TECHNIQUE

exposure time and size
PARTIAL PULPOTOMY TECHNIQUE
PARTIAL PULPOTOMY TECHNIQUE

- Sterile technique and anesthesia
- Cut 2-3 mm. Of the exposed pulp with high speed diamond bur
- Bleeding control physiological hemorrhagic control with soaked saline cotton pellet press 1 min. long
- Ca(OH)2, GI, Coronal seal
PARTIAL PULPOTOMY TECHNIQUE
PARTIAL PULPOTOMY TECHNIQUE

Ca(OH)$_2$ covered with GI

Before

Coronal seal
PARTIAL PULPOTOMY

34 months
PARTIAL PULPOTOMY

recall period at 7 days, 30 days, 3, 6, 12 months, yearly until 3-5 years

• oral examination
• pulp test
• radiograph
PARTIAL PULPOTOMY

Prognosis

Pulpal healing 94-96%

Cvek 1978, 1992
Fuks et al 1987
Disadvantages of calcium hydroxide:

- obliteration of the pulp chamber
- high solubility in oral fluids
- lack of adhesion to the dentin

MTA may be useful as a substitute for calcium hydroxide in pulpotomy procedures. Further research, however, is needed to clarify this conclusion. 23 cases, 93% heal and healing, recall 1.9 yrs

Witherspoon et al, JADA 2006
The use of MTA in vital pulp therapy indicate that it is the optimum material and better than the traditionally used material Ca(OH)2.

It has a greater long-term sealing ability and stimulates a high quality and a great amount of reparative dentin.

Witherspoon, JOE 2008
Local anesthesia and rubber dam are applied

Remove caries nearly complete

As the pulp is approached, the cavity is flushed with NaOCl

The remaining affected tissue is removed by using a coarse, high-speed diamond bur.

In the case of a pulpotomy, the pulp is removed to a level where adequate hemostasis can be achieved.

Hemostasis is achieved by irrigating with 6% sodium hypochlorite for up to 10 minutes. (Hafez et al., Quintessence Int 2002;)

MTA partial pulpotomy technique
MTA partial pulpotomy technique

- Place MTA over the exposed pulpal tissue 2 mm. thickness.
- Place a small amount of flowable compomer (or an equivalent light-cured resin or glass ionomer liner) cover the MTA.
- Cavity can then be etched, bonded, and restored.

Witherspoon, JOE 2008
Prophylactic Tx with MTA

Ortho extracted teeth

Partial pulpotomy

Koh et al. JOE 2001, p 540-2
Prophylactic Tx with MTA

MTA 5 mm
Dentin bridge (6m recall)

Koh et al. JOE 2001, p 540-2
Disadvantages of MTA

- High Cost
- Long setting time => need reentry to check whether MTA is set or not, before permanent filling. (some recommend to skip this step)
- Need long term studies
CERVICAL PULPOTOMY

Short crown left
PULPOTOMY

- **DEFINITION**
  - The surgical amputation of the coronal portion of an exposed pulp

- **PURPOSE**
  - To protect and preserve the remaining radicular pulp’s vitality and function
  - to allow continuous root formation in immature teeth
(CERVICAL) PULPOTOMY

INDICATION

• Open apex tooth only
• Carious Exposure or traumatic pulp expose
• larger exposed site / crown lost
• long time exposure
• pulp vitality was questionable
• slightly displacement
• As an emergency procedure prior to NSRCT
PULPOTOMY

PROGNOSIS

- Good for apexogenesis in immature teeth with carious exposures
- Excellent for traumatic exposures regardless of root maturity, size or exposure or time elapsed since injury
PULPOTOMY

TECHNIQUE:

- Pulp removed to cervical line in anterior teeth, to canal orifices in posterior teeth
- Clinical judgment influences amount of tissue removed
- High speed diamond with water spray
CERVICAL PULPOTOMY
CERVICAL PULPOTOMY

Case 1

10 days after injury
Pre-op

Post-op

3 months

6 months

12 months
Cervical pulpotomy

Hyperplastic pulp
Cervical pulpotomy

12 months
In ulcerative and hyperplastic pulpitis, the chronic response may be limited to the pulp chamber and that the apical pulp tissue may remain normal except for some vasodilation and minimal chronic inflammation.

Spouge 1973
Grossman 1974
Walton et al 1985
Weine 1989
Cervical pulpotomy

Coronal seal: hermatic tight seal
Cervical pulpotomy

recall period at 7 days, 30 days, 3, 6, 12 months, and yearly until 3-5 years
Cervical pulpotomy

Prognosis

72 – 79 % pulpal healing in crown fractured teeth

Hallet & Porteous 1963
Gelbier & Winter 1988
Controversy

Whether the pulp should be reentered after the completion of root development in the pulpotomized tooth?
Weather the pulp should be reentered after the completion of root development in the pulpotomized tooth?

It is routinely contra-indication unless dictated by the restorative consideration.
Rationale  Progressive calcification of the pulp is an infrequent sequelae of pulpotomy, if a gentle technique is used in removing pulp tissue, no contamination, no Ca(OH)$_2$ was packed into the underlying pulp tissue and good case selection.
Partial Pulpotomy follow with apexification

12 months failed

24 months healed