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Pulp Therapy for Primary and Immature Permanent Teeth

Purpose

The aim of this Clinical Guideline is to provide advice to public oral health providers on the diagnosis of pulp health versus pathosis and to set forth the indications, objectives, and therapeutic interventions for pulp therapy in primary and immature permanent teeth. Evidence-based clinical guidelines are intended to provide guidance, and are not a standard of care, requirement, or regulation. However, the application of clinical guidelines in publicly-provided oral health services allows for consistency to occur across large patient cohorts with a variety of oral health clinicians.
Note: This guideline does not form the basis of a *comprehensive* patient diagnosis. For further information, refer to DHSV guideline CG-A014-06 Caries Management

Guideline

Background

Vital permanent teeth with deep caries with actual or potential pulp involvement can be treated successfully with vital pulp therapy (VPT) (1). The primary objective of pulp therapy is to maintain the integrity and health of the teeth and their supporting tissues. It is a treatment objective to maintain the vitality of the pulp of a tooth affected by caries or traumatic injury. Especially in young permanent teeth with immature roots, the pulp is integral to continue apexogenesis (root formation in immature apex) and root maturation. Long-term retention of a permanent tooth requires a root with a favourable crown/root ratio and dentinal walls that are thick enough to with- stand normal function. Therefore, pulp preservation is a primary goal for treatment of the young permanent dentition. A tooth without a vital pulp, however, can remain clinically functional. The following guideline is based on the updated AAPD guideline on Pulp Therapy for Primary and Immature Permanent Teeth (20).

The use of rubber dam in managing teeth with deep carious lesions or pulpal exposures is **mandatory**. Soundness of the restoration is an important consideration that will impact on the prognosis of the tooth.

When the pulp inflammation is irreversible, **non-vital pulp therapies** are indicated.

Diagnostic findings which influence choice of therapy

The indications, objectives, and type of pulpal therapy is based on the clinical diagnosis of the pulpal health,

- vital and normal pulp (symptom-free and normally responsive to thermal pulp sensibility testing),
- reversible pulpitis (pulp is capable of healing),
- symptomatic or asymptomatic irreversible pulpitis (vital severely inflamed pulp is incapable of healing),
- necrotic infected pulp.

The clinical diagnosis is derived from:

- A comprehensive medical history.
- A review of past and present dental history and treatment, including current symptoms and chief complaint.
- A subjective evaluation of the area associated with the current symptoms/chief complaint by questioning the child and parent on the location, intensity, duration, stimulus, relief, and spontaneity.
- An objective extra-oral examination as well as examination of the intra-oral soft and hard tissues.
- Radiograph(s) to assess the involved tooth, furcation, peri-radicular region, and the surrounding bone. The presence in radiographs of loss of lamina dura, small periapical radiolucency and/or periapical sclerosis, are not necessarily indicative of an irreversible condition but can be useful to assist in identifying the offending tooth in a painful case.
- Clinical tests such as palpation, percussion, and mobility. In permanent teeth, thermal (CO_2) pulp tests are required and electric pulp tests in certain circumstances may be helpful. (2,3)

Teeth exhibiting signs and/or symptoms such as a history of spontaneous unprovoked toothache, a sinus tract, soft tissue inflammation not resulting from gingivitis or periodontitis, excessive mobility not associated with trauma or exfoliation, furcation/apical radiolucency, or radiographic evidence of internal/external resorption have a clinical diagnosis of **irreversible pulpitis or necrosis** are not candidates for vital pulp treatment (4).

Teeth exhibiting provoked pain of short duration relieved with over-the-counter analgesics, by brushing, or upon the removal of the stimulus and without signs or symptoms of irreversible pulpitis, have a clinical diagnosis of **reversible** pulpitis and are candidates for vital pulp therapy (4).

Only teeth diagnosed with a **normal pulp** requiring pulp therapy or with **reversible pulpitis** should be treated with vital pulp procedures.

Vital pulp therapies

These include: indirect pulp capping, direct pulp capping, partial pulpotomy and pulpotomy. They may be carried out in asymptomatic teeth with extensive caries or after complicated crown fractures and healthy or minimally inflamed pulp. Younger teeth have a better prognosis. The outcome of these therapies is maintenance of pulpal health in 80-100% of cases depending on the treatment type and material used (5-7)

Pulp therapy requires periodic clinical and radiographic assessment of the treated tooth and the supporting structures. Post-operative clinical assessment generally should be performed every six months and could occur as part of a patient's periodic comprehensive oral examinations. Patients treated for an acute dental infection initially may require more frequent clinical re-evaluation.

PRIMARY TEETH

Vital pulp therapy for normal pulp or reversible pulpitis

a) **Indirect pulp treatment**

Indirect pulp treatment 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 bio-compatible material.

Complete caries removal is not needed for success, provided the restoration is well sealed (8,9).

Radiopaque liner such as a dentine-bonding agent, resin modified glass ionomer, zinc oxide/eugenol or glass ionomer cement is placed over the remaining carious dentine to stimulate healing and repair. The use of glass ionomer cements or reinforced zinc oxide/eugenol restorative materials have the additional advantage of inhibitory activity against cariogenic bacteria. The tooth then is restored with a material that seals the tooth from micro-leakage.

Indirect pulp capping has been shown to have a higher success rate than pulpotomy in long term studies (10-12). It also allows for a normal exfoliation time. **Therefore, indirect pulp treatment in primary teeth is preferable to a pulpotomy when the pulp is normal or has a diagnosis of reversible pulpitis**.

• **Indications:** In a primary tooth with no pulpitis or with reversible pulpitis when the deepest carious dentine is not removed to avoid a pulp exposure. The pulp is judged by clinical and radiographic criteria to be vital and able to healfrom the carious insult.

• **Objectives:** The restorative material should seal completely the involved dentine from the oral environment. The tooth's vitality should be preserved. No post-treatment signs or symptoms such as sensitivity, pain, or swelling should be evident. There should be no radiographic evidence of pathological changes such as external or internal root resorption.

b) **Direct pulp capping**

When a pinpoint mechanical exposure of the pulp is encountered during cavity preparation or following a traumatic injury, a biocompatible radiopaque base such as **MTA** or **calcium hydroxide** may be placed in contact with the exposed pulp tissue. The tooth is restored with a material that seals the tooth from micro-leakage.

• **Indications:** This procedure is only indicated in a primary tooth with a normal pulp following a small mechanical or traumatic exposure when conditions for a favourable response are optimal. (even in these cases the success rate is not particularly high)

In general, direct pulp capping of a carious pulp exposure in a primary tooth is not recommended (4), rather a pulpotomy procedure should be undertaken.

• **Objectives:** The tooth's vitality should be maintained. No post-treatment signs or symptoms such as sensitivity, pain, or swelling should be evident. Pulp healing and reparative dentine formation should result. There should be no radiographic signs of

pathological external or progressive internal root resorption or furcation/apical radiolucency.

c) **Pulpotomy.**

A pulpotomy is performed in a primary tooth with extensive caries but without evidence of radicular pathosis when caries removal results in a carious or mechanical pulp exposure. The coronal pulp is amputated, and the remaining vital radicular pulp tissue surface is treated with a long-term clinically successful medicament such as ferric sulfate. Several studies have utilized sodium hypochlorite with comparable results to ferric sulfate. Calcium hydroxide has been used, but with lower long-term success. MTA is a more recent material used for pulpotomies with a high rate of success. Clinical trials show that MTA performs equal to or better than ferric sulfate and may be the preferred pulpotomy agent in the future (13, 14). After the coronal pulp chamber is filled with a suitable base, the tooth is restored with a restoration that seals the tooth from micro-leakage. The most effective long-term restoration has been shown to be a **stainless-steel crown**.

• **Indications:** The pulpotomy procedure is indicated when caries removal results in pulp exposure in a primary tooth with a normal pulp or reversible pulpitis or after a traumatic pulp exposure. The coronal tissue is amputated, and the remaining radicular tissue is judged to be vital without suppuration, purulence, necrosis, or excessive haemorrhage that cannot be controlled by a damp cotton pellet after several minutes, and there are no radiographic signs of infection or pathological resorption.

• **Objectives:** The radicular pulp should remain asymptomatic without adverse clinical signs or symptoms such as sensitivity, pain, or swelling. There should be no postoperative radiographic evidence of pathological external root resorption. Internal root resorption may be self-limiting and stable. The clinician should monitor the internal resorption, removing the affected tooth if perforation causes loss of supportive bone and/or clinical signs of infection and inflammation. There should be no harm to the succedaneous tooth.

Pulp treatment for primary teeth diagnosed with irreversible pulpitis or necrotic pulp

Pulpectomy

Pulpectomy is a root canal procedure for pulp tissue that is irreversibly infected or necrotic due to caries or trauma. The root canals are debrided and shaped with hand files or rotary nickel-titanium (NiTi) instruments. Since instrumentation and irrigation with an inert solution alone cannot adequately reduce the microbial population in a root canal system, disinfection with irrigants such as 1% sodium hypochlorite is an important step in assuring optimal bacterial decontamination of the canals. Because it is a potent tissue irritant, sodium hypochlorite must not be extruded beyond the apex. After the canals are dried, a resorbable material such as: Iodoform (Kri™) Paste; a combination of calcium hydroxide with iodoform (Vitapex™); a slurry paste of non-reinforced ZOE; pure calcium hydroxide (Pulpdent®); or a mixture of EndoPaste®/ZOE. Kri™ Paste and Vitapex™ have shown good success rates, whereas pure calcium hydroxide and ZOE pastes have shown contradictory results (15). These should be placed in the canals with

a paste-filler. Place reinforced ZOE over the pulp canal orifices, and the pulp chamber is then filled with a glass ionomer cement and then restored with a stainless-steel crown.

- **Indications:** A pulpectomy is indicated in a primary tooth with irreversible pulpitis or necrosis or a tooth treatment planned for pulpotomy in which the radicular pulp exhibits clinical signs of irreversible pulpitis (eg, excessive haemorrhage that is not controlled with a damp cotton pellet applied for several minutes) or pulp necrosis (eg, suppuration, purulence). The roots should exhibit minimal or no resorption.

- **Objectives:** Following treatment, the radiographic infectious process should resolve in six months, as evidenced by bone deposition in the pre-treatment radiolucent areas, and pre-treatment clinical signs and symptoms should resolve within a few weeks. There should be radiographic evidence of successful filling without gross overextension or under filling. The treatment should permit resorption of the primary tooth root and filling material to permit normal eruption of the succedaneous tooth. There should be no pathologic root resorption or furcation/apical radiolucency.

PERMANENT TEETH

Vital pulp therapy for teeth diagnosed with a normal pulp or reversible pulpitis

When an immature tooth is affected by caries or trauma, the pulp requires proper management according to the degree of inflammation and its vitality. Maintenance of pulp vitality will allow continued root development along the entire root length. Apexogenesis is a histological term used to describe the continued physiologic development and formation of the root apex.

Formation of the apex in vital, young, permanent teeth can be accomplished by implementing appropriate vital pulp therapy described in this section (i.e., indirect pulp treatment, direct pulp capping, partial pulpotomy for carious exposures and traumatic exposures).

a) Indirect pulp treatment

Indirect pulp treatment is a procedure performed in a tooth with a diagnosis of reversible pulpitis and deep caries that might otherwise need endodontic therapy if the caries were completely removed. In recent years, rather than complete the caries removal in two appointments, the focus has been to excavate as close as possible to the pulp, place a protective liner, and restore the tooth without a subsequent re-entry to remove any remaining affected dentine. The risk of this approach is either an unintentional pulp exposure or irreversible pulpitis (16).

Complete caries removal is not necessarily needed for disease control, provided the restoration is sealed well (8,9).

- **Indications:** Indirect pulp treatment is indicated in a permanent tooth diagnosed with a normal pulp with no symptoms of pulpitis or with a diagnosis of reversible pulpitis. The pulp is judged by clinical and radiographic criteria to be vital and able to heal from the carious insult.

- **Objectives:** The intermediate and/or final restoration should seal completely the involved dentine from the oral environment. The vitality of the tooth should be

preserved. No post-treatment signs or symptoms such as sensitivity, pain, or swelling should be evident. There should be no radio- graphic evidence of internal or external root resorption or other pathological changes. Teeth with immature roots should show continued root development and apexogenesis.

b) Direct pulp capping

When a small exposure of the pulp is encountered during cavity preparation and after haemorrhage control is obtained, the exposed pulp is capped with a material such as calcium hydroxide (chemical cure setting), MTA or Biodentine prior to placing a restoration that seals the tooth from micro-leakage.

- **Indications:** Direct pulp capping is indicated for a permanent tooth that has a very small carious or mechanical exposure in a tooth with a normal pulp. Pulp capping is regarded as appropriate for immediate minor exposures, whereas partial pulpotomy is more appropriate for small wounds that have been exposed to microbial challenges for a period of time, particularly in young teeth. As the former is often an unlikely scenario, i.e immediate presentation by the patient, the partial pulpotomy procedure is usually the indicated option.

- **Objectives:** The tooth's vitality should be maintained. No post-treatment clinical signs or symptoms of sensitivity, pain, or swelling should be evident. Pulp healing and reparative dentine formation should occur. There should be no radiographic evidence of internal or external root resorption, periradicular radiolucency, abnormal calcification, or other pathological changes. Teeth with immature roots should show continued root development and apexogenesis.

c) Partial pulpotomy for carious exposures

The partial pulpotomy for carious exposures is a procedure in which the inflamed pulp tissue beneath an exposure is removed to a depth of 2-3 millimetres or deeper to reach healthy pulp tissue. It is difficult to assess how far the inflammation has progressed into the pulp. Pulpal bleeding must be controlled by gentle irrigation with 1% sodium hypochlorite within 5-10 minutes, before the site is covered with calcium hydroxide (setting or non-setting), MTA, Biodentine or Odontocem. While calcium hydroxide has been demonstrated to have long-term success, MTA results in more predictable dentine bridging and pulp health (19). MTA (at least 1.5 mm thick) should cover the exposure and surrounding dentine followed by a layer of glass ionomer or cement. A restoration that seals the tooth from micro leakage is placed.

- **Indications:** A partial pulpotomy is indicated in a young permanent tooth for a carious pulp exposure in which the pulp bleeding is controlled within several minutes. The tooth must be vital, with a diagnosis of normal pulp or reversible pulpitis.

- **Objectives:** The remaining pulp should continue to be vital after partial pulpotomy. There should be no adverse clinical signs or symptoms such as sensitivity, pain, or swelling. There should be no radiographic signs of internal or external resorption, abnormal canal calcification, or periradicular radiolucency postoperatively. Teeth having immature roots should continue normal root development and apexogenesis.

d) Partial pulpotomy for traumatic exposures (aka Cvek pulpotomy)

The partial pulpotomy for traumatic exposures is a procedure in which the inflamed pulp tissue beneath an exposure is removed to a depth of 2-3 millimetres or more to reach the deeper healthy tissue. Pulpal bleeding is controlled using 1% sodium hypochlorite and the site then is covered with calcium hydroxide or a non-discolouring calcium silicate based material. White, rather than grey, MTA is recommended in anterior teeth to decrease the chance of discoloration. The calcium hydroxide or calcium silicate based material within the pulpotomy wound, and the surrounding dentine should be covered with a layer of cement or glass ionomer. A resin composite restoration that seals the tooth from micro-leakage is placed. Delay of treatment by 9 days or less may have minimal effect on the outcome of Cvek pulpotomies. A good restoration that prevents bacterial penetration into the tooth is essential for success (7).

- **Indications:** Pulpotomy is indicated for a vital, traumatically-exposed, young permanent tooth, especially crucial for one with an incompletely formed apex. Pulpal bleeding after removal of inflamed pulpal tissue must be controlled as above. Neither time between the accident and treatment nor size of exposure is critical if the inflamed superficial pulp tissue is amputated to healthy pulp.

- **Objectives:** The remaining pulp should continue to be vital after partial pulpotomy. There should be no adverse clinical signs or symptoms of sensitivity, pain, or swelling. There should be no radiographic signs of internal or external resorption, abnormal canal calcification, or periradicular radiolucency postoperatively. Teeth with immature roots should show continued normal root development and apexogenesis.

Non-vital pulp treatment for permanent teeth diagnosed with irreversible pulpitis or necrotic pulp in teeth with immature roots and open apex

Endodontic treatment of immature permanent teeth with necrotic pulp, with or without apical pathosis poses several clinical challenges. When pulp undergoes necrosis before root growth is complete, dentine formation ceases and root growth is arrested. In most cases, the canal remains wide, the apex open, the roots may be shorter and the walls of the canals are thinner.

The necrotic tooth with immature root has traditionally been treated by apexification, in which apical closure is achieved through the formation of mineralised tissue in the apical region of a non-vital tooth with an incompletely formed root. Although the use of calcium hydroxide apexification techniques or the placement of mineral trioxide aggregate as an apical stop has the potential to minimize the apical extrusion of the material, they do little in adding strength to the dentine wall. There is a risk of dentine wall fracture during compaction of the root filling material.

Apexification;

In the absence of a vital pulp, the tooth structure is susceptible to infection and dentine deposition is arrested. Apexification is a method of inducing root-end closure of an incompletely formed non-vital permanent tooth by removing the coronal and non-vital radicular tissue just short of the root end.

The entire roof of the pulp chamber is removed to gain access to the canal and eliminate all coronal pulp tissue. Root canal irrigation should be at a slow pace to prevent forcing

the sodium hypochlorite past the open apex from excessive pressure. It is important to minimally clean the thin dentine walls which are thin. The canal is lightly dried by using the irrigation syringe to withdraw excess irrigant and calcium hydroxide is placed in the canal using paste-filler or with specially designed syringes, for at least four weeks.

When the tooth is asymptomatic, the previously placed calcium hydroxide is removed and the root-end closure is accomplished with an apical barrier such as MTA. A dense apical plug of 4-6mm should be confirmed clinically and radiographically. Residual MTA is removed with paper points or cotton-tipped applicators. The canals then filled with gutta-percha and sealer against the MTA plug. Gutta percha can be used to fill the remaining canal space followed by a GIC base within the natural crown, followed by a resin composite restoration.

- **Indications:** This procedure is indicated for non-vital permanent teeth with incompletely formed roots.

- **Objectives:** This procedure should induce root-end closure (apexification) at the apices of immature roots or result in an apical barrier as confirmed by clinical and radiographic evaluation. Adverse post-treatment clinical signs or symptoms of pain or swelling should not be evident. There should be no radiographic evidence of external root resorption, root fracture, or breakdown of peri radicular supporting tissues during or following therapy. The tooth should continue to erupt, and the alveolus should continue to grow in conjunction with the adjacent teeth.

Revascularisation;

Revascularisation is regenerative endodontic treatment, a more contemporary approach of treatment for immature permanent teeth with pulpal necrosis. Pulp revascularisation allows the stimulation of apical development and the root maturation, thus reinforcing the dentinal wall and strengthening the root against fracture.

When any vital pulp remains, complete pulp regeneration and revascularisation can be achieved but the treatment outcome of revascularisation procedure remains somewhat unpredictable. Ongoing studies are aiming to identify procedures and material that allow pulp regeneration. At the present time stem cell based tissue engineering approaches provide the most promising solution. Pulp regeneration and revascularisation will be potentially new exciting treatment modalities in the near future.

Definitions

Nil

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