Guideline on pulp therapy for primary and young permanent teeth

Originating Committee
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Revised

Purpose
The American Academy of Pediatric Dentistry (AAPD) intends these guidelines to describe the diagnosis of pulp pathosis and set forth the indications, objectives, and medications for pulp therapy for in primary and young permanent teeth.

Methods
These guidelines were revised based on a review of the literature and collaboration with experts. A MEDLINE search was conducted using the terms “pulptomy”, “pulpectomy”, “indirect pulp treatment”, “stepwise excavation”, “pulp therapy”, “pulp capping”, “pulp exposure”, “calcium hydroxide”, “formocresol”, “ferric sulfate”, and “glass ionomer”. Although these guidelines reflect the cited literature and consensus of experts, more research is needed in the areas of vital and nonvital pulp treatment in primary and young permanent teeth to aid clinicians in the proper technique and medications for use.

Background/literature review
The primary objective of pulp therapy is to maintain the integrity and health of the oral tissues, teeth and their supporting tissues. It is desirable to attempt to maintain the vitality of the pulp of a tooth affected or infected by caries, traumatic injury, or other causes. However, a tooth without a vital pulp can remain clinically functional without a vital pulp. It is possible to reduce pulp autolysis or eliminate the pulp entirely without significantly compromising the function of the tooth.¹

Appropriate pulp therapy is predicated upon the acquisition and analysis of appropriate diagnostic data. An examination and diagnosis lead to appropriate pulp therapy whenever a tooth pulp has been affected or infected by caries, operative exposure or physical (traumatic) injury. The indications, objectives, and type of pulpal therapy depend on whether the pulp is vital or nonvital based on the tooth’s clinical diagnosis of normal pulp, reversible pulpitis, irreversible pulpitis, or necrotic pulp.² Diagnosis and treatment planning for pulp therapy in children should include The clinical diagnosis is derived from an appropriate medical history, and dental history including characteristics of any pain, visual and radiographic evaluation, and, if obtainable, radiograph(s) showing the apical areas and any furcation, as well as
additional tests such as palpation, percussion, and mobility evaluation. In permanent teeth, electric pulp tests and thermal tests may be helpful. Teeth exhibiting signs and/or symptoms such as a history of spontaneous unprovoked toothache, a sinus tract, periodontal 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. These teeth are candidates for nonvital pulp treatment. Teeth exhibiting provoked pain of short duration, which is relieved upon the removal of the stimulus, with analgesics, or by brushing, without signs or symptoms of irreversible pulpitis have a clinical diagnosis of reversible pulpitis and are candidates for vital pulp therapy. Teeth with a normal pulp requiring pulp therapy are treated with vital pulp procedures.

Recommendations

All relevant diagnostic information, planned treatment and treatment follow up shall be documented in the patient’s record.

Any planned treatment. Treatment planning should include consideration of:

1. the patient’s medical history
2. consideration of the value of each involved tooth in relation to the child’s overall development;
3. consideration of alternatives to pulp therapy treatment.
4. restorability of the tooth.

When the infectious process cannot be arrested by the treatment methods included in this section, bony support cannot be regained, or inadequate tooth structure remains for an appropriate restoration, pulp therapy may not be indicated and or excessive pathologic root resorption exists, extraction may should be considered.

It is recommended that all pulp therapy should be performed with the use of a rubber dam isolation to minimize bacterial contamination of the treatment site. These guidelines are not intended to delineate chemicals recommend medicaments or procedures for pulp treatment, but the AAPD desires more research in pulp treatment to determine the best clinical choices. Apexification, reimplantation of avulsions and placement of prefabricated post and cores are not indicated for primary teeth.

Evaluation of pulp therapy requires periodic clinical and radiographic evaluation assessment of the treated tooth and the surrounding supporting structures and may require radiographic assessment of periradicular tissues and intraradicular pulp status.

Primary teeth

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

Protective base

A protective base is a material placed on the pulpal surface of a cavity preparation, covering exposed dentin tubules, to act as a protective barrier between the restorative material or cement and the pulp of the tooth. A radiopaque material placement of a protective base that possesses suitable physical properties and biocompatibility should be used, such as calcium hydroxide or glass ionomer cement is at the judgement of the dentist.14,15

Indications: In a tooth with a normal pulp, when dentin is exposed during the preparation of a tooth for a restoration, a protective radiopaque base may be placed between the permanent restoration and the dentin to minimize injury to the pulp, or promote pulp tissue healing, and minimize post-operative sensitivity.

Objectives: A protective base is utilized to preserve the vitality of the tooth, and promote pulp tissue healing and tertiary dentin formation, and minimize microleakage. Adverse post-treatment clinical signs or symptoms such as sensitivity, pain, or swelling should be alleviated not occur.

Indirect pulp treatment

Indirect pulp treatment is a procedure performed in a tooth with a deep carious lesion adjacent to the pulp. The caries near the pulp is left in place and covered, carious dentin removal sometimes is left incomplete, and the decay process is treated with a biocompatible material to avoid pulp tissue exposure. A radiopaque base such as calcium hydroxide, zinc oxide and eugenol16, or glass ionomer cement8,9 is placed over the remaining affected dentin to stimulate healing and repair. The tooth then is restored with a material that seals the involved dentin tooth from microleakage the oral environment.

Indications: In a tooth that has a carious lesion near the dental pulp, a protective dressing or cement may be placed over a layer of remaining carious dentin to prevent operative pulp exposure and stimulate healing and repair. Indirect pulp treatment is indicated in a primary tooth with no pulpitis17 or reversible pulpitis when the deepest carious dentin is not removed to avoid a pulp exposure8. The pulp is judged by clinical and radiographic criteria to be vital and able to heal from the carious insult.8,9

Objectives: The restorative material should seal completely the involved dentin from the oral environment. The vitality of the tooth should be preserved. No prolonged post-treatment signs or symptoms of sensitivity, pain, or swelling should be evident. The pulp should respond favorably and tertiary dentin should be formed, as evidenced by radiographic evaluation. There should be no radiographic evidence of pathologic external or internal root resorption or other pathologic changes. There should be no harm to the succedaneous tooth.

Direct pulp capping

When a small mechanical exposure of the pulp is encountered during cavity preparation or following a traumatic injury, an appropriate biocompatible radiopaque base such as
calcium hydroxide may be placed in contact with the exposed pulp tissue prior to placing a restoration. The tooth is restored with a material that seals the tooth from microleakage.

**Indications**: This procedure is valid for indicated in a primary tooth with a normal pulp following a small mechanical or traumatic exposures when conditions for a favorable response are optimal. Direct pulp capping of a carious pulp exposure in a primary tooth is not recommended.

**Objectives**: The vitality of the tooth should be maintained. No prolonged post-treatment signs or symptoms of sensitivity, pain, or swelling should be evident. Pulp healing and reparative tertiary dentin formation should result. There should be no radiographic signs of pathological external or internal root resorption or furcation/apical radiolucency changes. There should be no harm to the succedaneous tooth.

### Pulpotomy

The pulpotomy is a procedure performed in a tooth with a deep carious lesion adjacent to the pulp. The coronal pulp is amputated and involves amputation of the coronal portion of the affected or infected dental pulp. Treatment of the remaining vital radicular pulp tissue surface should be treated with a medicament such as formocresol or ferric sulfate, or electrocautery to preserve the health, vitality and function of all or part of the remaining radicular portion of the pulp. The coronal pulp chamber is filled with a suitable base and the tooth restored with a restoration that seals the tooth from microleakage.

**Indications**: The pulpotomy procedure is indicated when caries removal results in pulp exposure in a primary tooth with a normal pulp or reversible pulpitis after a traumatic pulp exposure. The infected coronal tissue can be amputated and the remaining radicular tissue is judged to be vital, or affected but still vital, by clinical and/or radiographic criteria.

**Objectives**: The vitality of the majority of the radicular pulp should remain healthy without being maintained. No prolonged adverse clinical signs or symptoms such as prolonged sensitivity, pain, or swelling should occur. There should be no post-operative radiographic evidence of pathologic external or internal root resorption or abnormal canal calcification as determined by radiographic evaluation. There should be no breakdown of periradicular supporting tissues, and there should be no harm to the succedaneous tooth.

### Nonvital pulp therapy 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 which then are debrided, enlarged, and disinfected, and the canals are filled with a resorbable material such as non-reinforced zinc oxide-eugenol. The tooth then is restored with a restoration that seals the tooth from microleakage.

**Indications**: A pulpectomy is indicated in a primary tooth with irreversible pulpitis or necrosis or a tooth treatment planned for pulpotomy carious pulp exposures.
in which the radicular pulp exhibits clinical signs of hyperemia, pulp necrosis, such as excessive hemorrhage, or in cases where there is evidence of radicular pulp necrosis with or without caries involvement. The roots should exhibit minimal or no resorption.

**Objectives:** Following treatment, the radiographic infectious process should resolve in 6 months as evidenced by bone deposition in the pretreatment radiolucent areas and resolution of adverse pretreatment clinical and radiographic signs and symptoms within 2 weeks. There should be radiographic evidence of successful filling without gross overextension or underfilling. The treatment should permit resorption of primary tooth root structures and filling materials at the appropriate time to permit normal eruption of the succedaneous tooth. There should be no radiographic evidence of further breakdown of supporting tissues. Treatment should alleviate and prevent further sensitivity, pain, or swelling. There should be no pathologic internal or external root resorption or furcation/apical radiolucency/other pathology.

**Young Permanent teeth**

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

**Protective base**

A protective base is a material placed on the floor pulpal surface of a cavity preparation, covering exposed dentin tubules, to act as a protective barrier between the restorative material or cement and the pulp of the tooth. A radiopaque material that possesses suitable physical properties and biocompatibility should be used. Placement of a protective base such as calcium hydroxide or glass ionomer cement is at the judgement of the dentist.14,15

**Indications:** In a tooth with a normal pulp, when dentin is exposed during the preparation of a tooth for a restoration, a protective radiopaque base may be placed between the permanent restoration and the dentin to minimize injury to the pulp, or promote pulp tissue healing, or minimize post-operative sensitivity.

**Objectives:** A protective base is utilized to preserve the vitality of the tooth, promote pulp tissue healing and tertiary dentin formation, and minimize microleakage. The restorative material should seal completely involved dentin from the oral environment. The vitality of the tooth should be preserved. No prolonged Adverse post-treatment signs or symptoms of sensitivity, pain, or swelling should not occur be evident. The pulp should respond favorably and tertiary dentin should be formed, as evidenced by radiographic evaluation. There should be no evidence of internal resorption or other pathologic changes.

**Indirect pulp treatment**

Indirect pulp treatment is a procedure performed in a tooth with a deep carious lesion adjacent to the pulp. The carious dentin near the pulp is left in place and covered, carious dentin removal sometimes is left incomplete, and the decay process is treated with a biocompatible material to avoid pulp tissue exposure. A radiopaque base such as calcium hydroxide, zinc oxide and eugenol, or glass ionomer cement is placed over the remaining affected dentin to stimulate healing and repair. The tooth then is restored with a material that seals the involved dentin/tooth from the oral environment/microleakage.
**Indications:** In a tooth that has a carious lesion near the dental pulp, a protective dressing or cement may be placed over a layer of remaining carious dentin to prevent operative pulp exposure and stimulate healing and repair. Indirect pulp treatment is indicated in a permanent tooth with a normal pulp or 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 and able to heal from the carious insult.

**Objectives:** The restorative material should seal completely the involved dentin from the oral environment. The vitality of the tooth should be preserved. No prolonged post-treatment signs or symptoms of sensitivity, pain, or swelling should be evident. The pulp should respond favorably and tertiary dentin should be formed, as evidenced by radiographic evaluation. There should be no radiographic evidence of internal or external root resorption or other pathologic changes. Teeth with immature roots should show continued root development and apexogenesis.

**Direct pulp capping**

When a small exposure of the pulp is encountered during cavity preparation or following traumatic injury, an appropriate biocompatible radiopaque base may be placed in contact with the exposed pulp tissue, after hemorrhage control is completed, capping the exposed pulp with a material such as calcium hydroxide or mineral trioxide aggregate (MTA) is indicated prior to placing a restoration that seals the tooth from microleakage.

**Indications:** Direct pulp capping is indicated for a permanent tooth that has a small carious lesion which, upon caries removal, sustains a minimal exposure of the pulp. Direct pulp capping also is valid for mechanical exposure or traumatic exposures in permanent teeth when conditions favor a positive response, such as in the case of a clean fracture recently sustained or mechanical exposure in a tooth with a normal pulp.

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

**Partial Pulpotomy for carious exposures**

The pulpotomy procedure involves amputation of the coronal portion of the affected or infected dental pulp. Treatment of the remaining vital radicular pulp tissue surface should preserve the vitality and function of all or part of the remaining radicular portion of the pulp. In cases of traumatic injury to permanent teeth, the use of a partial pulpotomy (removal of only a part of the coronal pulp tissue) sometimes is indicated to promote healing. Following treatment, the coronal area is filled with a suitable base and the tooth restored. The partial pulpotomy for carious exposures is a procedure in which the inflamed pulp tissue beneath an exposure is removed to a depth of 1 to 3 millimeters (mm) or, in some cases, deeper to reach healthy pulp tissue. Pulpal bleeding must be controlled, and then the site covered with calcium hydroxide or MTA. A restoration that seals the tooth from microleakage is placed.
Indications: A partial pulpotomy is indicated in a young permanent tooth for a small (<2 mm) carious pulp exposure in which the pulpal bleeding is controlled in 1 to 2 minutes. The tooth must be vital with a diagnosis of normal pulp or reversible pulpitis when the pulp is exposed and all infected or affected coronal pulp tissue can be amputated and the remaining radicular tissue judged to be vital by clinical and radiographic criteria. Pulpotomy treatment of permanent teeth is undertaken when time constraints or economic reasons prevent immediate conventional root canal therapy.

Objectives: The remaining pulp should continue to be vital after partial pulpotomy. There should be no adverse clinical signs or symptoms such as prolonged sensitivity, pain, or swelling. The majority of the radicular pulp should remain vital. There should be no radiographic sign of internal or external resorption, abnormal canal calcification, or breakdown of periradicular supporting tissue should be evident. Periapical radiolucency postoperatively. Teeth having immature roots should continue normal root development and apexogenesis.

Partial Pulpotomy for traumatic exposures (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 1 to 3 mm to reach the deeper healthy tissue. Pulpal bleeding is controlled and then the site covered with calcium hydroxide or MTA. A restoration that seals the tooth from microleakage is placed.

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

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 sign of internal or external resorption, abnormal canal calcification, or periapical radiolucency postoperatively. Teeth having immature roots should show continued normal root development and apexogenesis.

Root formation (apexogenesis) Apexogenesis (Root Formation)

Apexogenesis is a histological term that has been used to describe the result of vital pulp procedures that allow the continued physiologic development and formation of the root’s apex. Formation of the apex in vital young permanent teeth can be accomplished by implementing the appropriate vital pulp therapy already described in this section (ie, indirect pulp treatment, direct pulp capping, partial pulpotomy for carious exposures and traumatic exposures). This procedure encourages normal root and apex formation (apexogenesis) of pulpaly involved, vital permanent teeth with immature root development. It involves the surgical amputation of the affected pulp tissue. The remaining radicular tissue is treated with a suitable biocompatible agent that encourages normal root formation and apical closure. It generally is considered to be an interim procedure to promote root apex development so that conventional root canal therapy can be accomplished later.
**Indications**: This procedure is indicated for traumatized or pulpally involved, vital permanent teeth when the root is incompletely formed.

**Objectives**: There should be no post-treatment adverse clinical or radiographic signs or symptoms such as prolonged sensitivity, pain, or swelling. The tooth should remain vital and normal canal and root apex closure should be evident, sometimes accompanied by a normal increase in root length. There should be no radiographic evidence of breakdown of the periradicular supporting tissues.

**Nonvital pulp therapy treatment**

**Pulpectomy (conventional root canal therapy treatment)**

Pulpectomy in permanent teeth is conventional root canal (endodontic) therapy for exposed, infected, and/or necrotic teeth to eliminate pulpal and periradicular infection. In all cases, the entire roof of the pulp chamber is removed to gain proper access to the canals and eliminate all of the coronal pulp tissue. Following debridement and shaping of the root canal system, obturation of the entire root canals is accomplished with a biologically acceptable nonresorbable filling material. Obturation as close as possible to the cementodentinal junction should be accomplished with a restorative material gutta percha or other filling material acceptable as described in the AAE’s Guide to Clinical Endodontics. Of the entire root canal as close to the cementodentinal junction as possible.

**Indications**: Pulpectomy or conventional root canal therapy treatment is indicated for a restorable permanent tooth with exposed, infected, irreversible pulpitis or a necrotic pulps in which the root is formed fully. In root canal-treated teeth with large unresolved periradicular lesions, root canals that are not accessible from the conventional coronal approach, or calcification of the root canal space, endodontic therapy treatment of a more specialized nature may be indicated.

**Objectives**: There should be evidence of a successful filling without gross overextension or underfilling in the presence of a patent canal. There should be no adverse post-treatment adverse signs and symptoms such as prolonged sensitivity, pain, or swelling, and there should be evidence of resolution of pretreatment pathology and with no further breakdown of periradicular supporting tissues clinically or radiographically should this be evident.

**Apexification (Root end closure)**

Apexification is a method of inducing apical root end closure of the root or roots of an incompletely formed nonvital permanent tooth by removing the coronal and nonvital radicular tissue just short of the root end and placing a suitable biocompatible agent such as calcium hydroxide (several treatments with a fresh agent may be necessary) or MTA in the canal. Several treatments with a fresh agent may be necessary. Once apical closure is obtained or an apical barrier is established, root canal therapy treatment should be completed.

**Indications**: This procedure is indicated for nonvital permanent teeth with incompletely formed roots.

**Objectives**: This procedure should induce root end closure (apexification) at the apices of immature roots or an apical barrier, as evidenced by periodic radiographic evaluation.
Adverse post-treatment adverse clinical signs or symptoms such as prolonged sensitivity, pain, or swelling should not be evident. There should be no radiographic evidence of abnormal canal calcification or internal or external root resorption, lateral root pathosis, or breakdown of periradicular supporting tissues during or following therapy.

**Surgical root canal therapy**

**Periradicular curettage**

Periradicular curettage consists of the removal of soft tissue and/or foreign material around the root apex without removal of the root end.

**Indications**: Periradicular curettage is indicated when a persistent periradicular lesion has not decreased in size or shows evidence of enlarging 1 or 2 years after the completion of acceptable conventional root canal treatment. It may be utilized when a sinus tract or periradicular inflammation persists, when a biopsy or surgical exploration of the area is deemed necessary and/or when there is evidence of marked apical overextension of filling materials into the periradicular tissue.

**Objectives**: No prolonged post-treatment adverse clinical signs or symptoms such as sensitivity, pain or swelling should be evident. Alveolar bone at the apex of the treated root(s) should exhibit a normal appearance with reestablishment of a normal periodontal ligament space. Previously present sinus tract(s) should heal. There should be no damage to adjacent teeth or anatomical structures.

**Apicoectomy**

Apicoectomy is a surgical procedure in which a portion of the apex of the root of the tooth is removed to:

1. evaluate or improve the apical seal of the root canal filling;
2. facilitate the access for creation of a root end preparation for a retrofilling;
3. allow for curettage behind the root;
4. remove a portion of the root which cannot be obturated with a root canal filling material because of severe curvature of the root or calcification of the root canal space.

This procedure may include curettage of the apical tissue.

**Indications**: Apicoectomy is indicated when a persistent periradicular lesion has not decreased in size or shows evidence of enlarging 1 or 2 years after completion of acceptable conventional root canal treatment. It may be utilized when a sinus tract or periradicular inflammation persists, when a biopsy or surgical exploration of the area is deemed necessary and/or when there is evidence of marked apical overextension of filling materials into the periradicular tissue. It also may be utilized when an obstruction such as a post or a separated instrument prevents nonsurgical treatment.

**Objectives**: No prolonged post-treatment adverse clinical signs or symptoms such as sensitivity, pain or swelling should be evident. There should be evidence of normal reestablishment of the periodontal ligament space and alveolar bone at the apex of the
surgically altered root(s). Previously present sinus tract(s) should heal. There should be no damage to adjacent teeth or anatomical structures.

**Retrofilling**

Retrofilling is an additional procedure following apicoectomy by which a cavity is prepared in the root end or lateral aspect of the root and a biologically acceptable filling material is placed into the prepared cavity.

**Indications:** Retrofilling is indicated for correction of resorptive defects of the root or when the clinician is unable to negotiate a canal in a routine manner because of iatrogenic problems or anatomic complications of the canal system. This technique may be utilized when a root is perforated in previously treated teeth and where an inadequate apical seal may be present, as evidenced by a periradicular lesion which is enlarging or has not decreased in size over a 2-year period after acceptable completion of conventional root canal filling. It also is indicated for a tooth that exhibits periradicular symptoms or pathosis and has a post crown which cannot be removed for treatment of root perforations or when there are persistent or recurrent signs and/or symptoms of lateral or periapical pathosis which cannot be sealed by a nonsurgical approach.

**Objectives:** No prolonged post-treatment adverse clinical signs or symptoms such as sensitivity, pain or swelling should be evident. Alveolar bone repair at the site of the treated root(s) should exhibit a normal appearance with reestablishment of the periodontal ligament space. Retrofilling material should be within the confines of the root and should seal the root canal. Scatter of retrofilling material into the surrounding bone should be avoided. There should be no damage to the adjacent teeth or anatomical structures.

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