Vital Pulp Therapy in Primary Teeth: An Update

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Dental caries, the most common chronic childhood disease, creates unique problems in the primary dentition. Untreated caries causes children to lose time from school and parents to lose time from work, and children with toothaches are at a greater risk of having lower grades. The goal of pulp therapy in primary teeth is to maintain the primary tooth until it exfoliates in order to maintain the integrity of the dental arch. Primary teeth also guide the eruption of the permanent tooth. Pulp therapy for a primary tooth helps avoid an abscess, and maintains the tooth for function, aesthetics, speech, mastication, and overall health.

There are now many options to treat primary teeth with deep caries approximating the pulp. These include: indirect pulp treatment (IPT), direct pulp cap (DPC), and pulpotomy. IPT is a procedure in which deep caries close to the pulp is left in place and covered with a biocompatible material to avoid a pulp exposure in asymptomatic teeth or a pulp with reversible pulpitis. The DPC is indicated when there has been a pinpoint mechanical or traumatic exposure to a normal pulp and caries was not the cause of the pulp exposure. A pulpotomy is a procedure in which the coronal pulp is removed, and the radicular pulp is treated after caries removal has created a pulp exposure in a healthy pulp or a pulp with reversible pulpitis. The DPC is indicated when there has been a pinpoint mechanical or traumatic exposure to a normal pulp and caries was not the cause of the pulp exposure. A pulpotomy is a procedure in which the coronal pulp is removed, and the radicular pulp is treated after caries removal has created a pulp exposure in a healthy pulp or a pulp with reversible inflammation.

This article will discuss the history of primary teeth pulp management and recent advances in the materials and techniques used in primary teeth pulp management.

HISTORY OF PULP THERAPY
In 1874, Nitzel used a tricresol formalin tanning agent on exposed pulps. The technique was unpopular until Buckley's method for treating necrotic pulps with formocresol was published in 1904. His formulation for formocresol is as follows: 19% formaldehyde, 35% tricresol, 15% glycerin, and 31% water base. In the 1930s, Sweet used Buckley's formulation during 5 consecutive visits. In 1962, Doyle et al suggested a...
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2-visit pulpotomy technique but soon after, Spedding et al. and Redig suggested a one-visit, 5-minute technique. Loos and Han, in 1971, noted formocresol diluted 1:5 had similar results to full strength formocresol.

Eventually, concern developed over the mutagenicity, genotoxicity, carcinogenicity, cytotoxicity, and systemic distribution of formocresol. Formocresol was replaced with 15.5% ferric sulfate; success was as good as or better than formocresol at the end of one year.

Clinical Diagnosis

Proper pulp treatment is based on whether the pulp is vital or non-vital. There are 4 types of clinical diagnoses of pulp vitality:

1. Normal pulp—asymptomatic, responds normally to pulp tests
2. Reversible pulpitis—inflamed pulp with the ability to heal
3. Symptomatic/asymptomatic irreversible pulpitis—a pulp that is unable to heal

Pulps diagnosed with reversible pulpitis are treated with vital pulp therapy and teeth diagnosed with irreversible pulpitis or necrosis are treated with a pulpectomy or extraction. The following signs and symptoms are indicative of irreversible pulpitis or a necrotic pulp:

1. A sinus tract
2. Gingival swelling not associated with periodontal disease
3. A history of spontaneous pain
4. Increased tooth mobility not associated with exfoliation
5. Furcation radiolucency

There are 4 diagnostic aids to assess the status of a pulp. They are: (1) history of pain, (2) percussion, (3) mobility, and (4) radiographic interpretation.

History of Pain

Determining the vitality of a primary tooth is challenging. First, the presence or absence of pain as a means of assessing the vitality of a primary tooth pulp is not as reliable as with permanent teeth. It is common to see a pediatric dental patient with a dental abscess but with no history of pain. Second, children are not good at giving an accurate history of pain. The only way to determine the degree of pulpal inflammation is histologically. However, there is no correlation between the clinical symptoms
and pulpal inflammation in children. Seltzer et al demonstrated that a patient may present with the signs and symptoms of reversible pulpitis but a histological examination would indicate chronic pulpitis, in which case the tooth would be treated with an extraction or a pulpectomy.

Nevertheless, a history of dental pain is still useful for a proper diagnosis. Pain associated while eating or just after a meal may be due to food accumulation in the deep caries. Farooq et al noted that this pain associated with food impaction can last up to 20 minutes even in pulps with reversible pulpitis. If the food is removed and the pain disappears or if any dental pain is relieved with analgesics, the pulp is in a state of reversible pulpitis. Spontaneous or lingering pain during the day or pain that wakes the patient up from a sound sleep at night are indicative of extensive degeneration of the pulp. Electric pulp tests have been shown to be unreliable in primary teeth. Although these tests can indicate if a pulp is vital, they do not indicate the degree of inflammation. Also, a child’s fear associated with the test itself can make the test unreliable. Thermal tests can also be unreliable because of a child’s inability to understand the test.

**Percussion and Mobility**

Sensitivity to percussion is a clinical symptom of pulpal disease, but the degenerative stage of the pulp is often acute inflammation. Testing for tooth mobility may elicit a pain response. When this pain is associated with large caries, there is the possibility of inflammation of the periodontal ligament.

**Radiographs**

After the clinical exam, good quality radiographs are important. Interpretation of radiographs of primary teeth can be challenging due to the presence of the succedaneous tooth and follicle. It is easy to confuse the follicle with periapical pathology. Superimposition of the permanent tooth might obscure visibility of the furcation and roots of the primary tooth, causing misdiagnosis. This can be complicated because of the normal physiologic resorption process.

Periapical radioluencies appear at the apices of maxillary anterior primary teeth. In primary molars, pathological changes are seen at the bifurcation or trifurcation (Figure 1). Often, bite-wing radiographs are the best method to detect pathological changes in posterior primary teeth. Bifurcation or trifurcation radioluencies in primary molars are consistent with a necrotic pulp, and the tooth should be extracted or treated with a pulpectomy. Changes in the supporting bone and thickening of the periodontal ligament can also be detected from radiographs.

**New Materials for Primary Teeth Pulp Therapy**

There are now several bioactive and biocompatible materials for vital pulp therapy. They are the calcium silicate-based materials. One is mineral trioxide aggregate (MTA) and the other is Biodentine (Septodont).

In the 1990s, Torabinejad et al introduced MTA as a root-end filling and perforation material. MTA is similar to Portland cement. It is biocompatible, less soluble than calcium hydroxide, and creates a better seal due to its setting expansion, thus preventing bacterial contamination. Histological studies have also shown that MTA creates less inflammation and a better dentinal bridge when compared to pulp capping with calcium hydroxide. MTA has been shown to be as good as or better than ferric sulfate and formocresol. Its uses have expanded to pulpotomies, direct pulp cap, and the indirect pulp cap. Its negative aspects are cost and a tendency to turn the tooth gray (Figure 2).
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MTA is Portland cement with bismuth oxide added in a ratio of 4:1 as a radio-opacifier. It is composed of tricalcium and dicalcium silicate and tricalcium aluminate. It comes as a white or gray powder (the gray MTA has iron added). When added to water, tricalcium aluminate in the presence of small amounts of gypsum normally found in MTA creates ettringite, which is then converted to monosulphate. When water is added to tricalcium and dicalcium silicate, the result is calcium silicate hydrate gel and calcium hydroxide.\(^1\) The following is the chemical reaction of MTA:

$$\text{Tricalcium} \text{Si} + \text{Dicalcium} \text{Si} + \text{H}_2\text{O} = \text{CaSilicate Hydrate} + \text{CaOH}$$

Biodentine has gained attention in recent years. It is similar to MTA but should be considered a medical-grade form of MTA.\(^2\) Though originally developed as a “dentin replacement,” much like MTA, it can be used for endodontic repair (root perforations, apicification, resorptive lesions, and retrograde filling material in endodontic surgery), pulpotomies, and as a pulp capping material. The powder consists of tricalcium silicate (the main core material), dicalcium silicate (secondary core), calcium carbonate, iron oxide, and zirconium oxide as a radio-opacifier. The liquid component is an accelerator and contains calcium chloride and a hydrosoluble polymer as a water reducing agent. When mixed, the chemical reaction is the following:

$$2(3\text{CaO.SiO}_2) + 6\text{H}_2\text{O} = 3\text{CaO.2SiO}_2.3\text{H}_2\text{O} + 3\text{Ca(OH)}_2$$

Biocompatibility, bioprediction, and chemical stability are key characteristics of both MTA and Biodentine. The success of a pulpotomy depends on a proper diagnosis. Any treatment plan should be based on a thorough history of the pain and a dental exam. indicating reversible pulpitis can be treated with a pulpotomy. In addition, the tooth must be restorable, vital, and have at least two thirds of its root length. Kassa et al\(^3\) showed that there are greater pulpal changes, increased pain, and less treatment success with interproximal caries than with a corresponding occlusal caries of the same depth, and first primary molar pulpotomies have a lower success rate than pulpotomies on second primary molars.

**Pulpotomy Technique**

Profound local anesthesia is necessary for patient comfort followed by rubber dam isolation to prevent contamination. If caries removal causes a pulp exposure, one should assess the condition of the pulp before performing the pulpotomy. First, with a high speed No. 330 bur or a No. 4 round bur, one circumscribes the dentin overlying the pulp chamber, at the expense of the sidewalls of the tooth, along the internal line angles. This offers good control with minimal penetration into the pulp chamber when making this delicate cut. Never use a fissure bur with a flat bottom; it cuts too aggressively for this procedure and can easily drop into the pulp. A disk of dentin will now be resting on the odontoblastic membrane. A spoon excavator is used to remove the disk of dentin on the roof of the pulp chamber, thus exposing the coronal pulp tissue. Prior to removing the remaining island of dentin, the cavity is cleansed again with sterile saline solution or sodium hypochlorite to remove all dentin dust and debris. This is critical because the presence of dentin particles can cause failure. This is accomplished with little or no bleeding.

Once the roof is removed, inspect the odontoblastic membrane to see if the prognosis for a pulpotomy is favorable. A healthy, intact odontoblastic membrane appears as a shiny, glossy sheath with a purplish gray color. It is firm and resilient. When slight pressure is applied, it returns to its original shape. If the membrane is not firm and resilient, the degenerative process may have extended into the radicular pulp, and a pulpotomy is not indicated. One can also determine if there are foci of pus and if the pulp is hemorrhagic.\(^4\)

Next, complete removal of the coronal pulp and any tissue tags is achieved with a sterile sharp spoon excavator. Hemostasis is achieved with a moist sterile cotton pellet applied with direct pressure over the radicular pulp, and this should be achieved in

**PULPOTOMY**

The success of a pulpotomy depends on a proper diagnosis. Any treatment plan should be based on a thorough history of the pain and a dental examination. It should also take into account the patient’s social, medical, and dental status. Teeth that are nonrestorable or exhibit signs of spontaneous pain, a sinus tract, increased mobility, uncontrolled bleeding from the pulp during the pulpotomy procedure, or a bifurcation radiolucency are indicative of irreversible pulpitis or a pulp that is incapable of healing. These teeth are best treated with nonvital pulp therapy. Primary teeth with a caries exposure (Figure 3a) or teeth
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4 minutes (Figure 3b). Healthy pulp does not bleed. Uncontrollable pulpal hemorrhage is consistent with irreversible pulpitis—a pulp incapable of healing—and requires an alternative treatment such as pulpectomy or extraction. The calcium silicate-based material is mixed and applied to the radicular pulp and condensed well to make sure the material is in direct contact with the pulp tissue (Figure 3c). To assure a perfect seal, glass ionomer (GI) cement is then placed over the medicament and the tooth is then appropriately restored (Figures 3d and 3e).

DIRECT PULP CAP

IPC treatment is the incomplete removal of caries in order to avoid a pulp exposure (Figure 4a). This treatment changes the lesion from an active lesion to an arrested lesion. It has a higher success rate than the pulpotomy technique in long-term studies. The clinical and radiographic criteria are the same as the pulpotomy technique. That is, the pulp has to be asymptomatic and vital in order to be able to heal from the carious insult, and the tooth has to be restorable.

IPC Technique

After profound anesthesia and isolation with a rubber dam, the caries is removed such that if one were to go further, there would be a pulp exposure (Figure 4a). No precise method has been determined as to how much caries has to be removed or how close to the pulp one needs to be. What seems to be important is all caries must be removed from the walls of the preparation to achieve a perfect seal and prevent microleakage. Massara et al indicated that GI cement is the best material to place over the remaining carious dentin (Figure 4b). It creates a seal to prevent microleakage, and GI cement appears to inhibit cariogenic bacteria. Then the tooth is appropriately restored (Figure 4c).

DPC Technique

With the rubber dam in place, any bleeding at the exposure site is controlled by pressure with a sterile cotton pellet. The calcium silicate-based material is mixed and condensed into the exposure site to assure it is in direct contact with the pulp tissue. To assure a good seal, a GI cement is placed over the silicate-based material and a final restoration is placed. The status of the pulp needs to be monitored about every 6 months to assess for sensitivity, pain, swelling, and to check for radiographic signs of pathology such as external or internal root resorption or a furcation radiolucency.

SUMMARY

New insight into pulp biology has created new techniques and materials for treating primary teeth with large caries. The IPC is a successful technique that prevents the pulp from being exposed, which in turn decreases the time the child patient is in the chair. The DPC has not been recommended for primary teeth until now because of greater long-term success with these new materials. The bioactive calcium silicate-based materials have proven to be more successful for pulpotomies, with a success rate greater than formocresol. The advantages are lower cost dental care, avoiding chemicals such as formocresol, and a more conservative dental treatment. Further research in pulp biology and these materials will allow more primary teeth to be saved and thus improve the dental health of our pediatric patients.

References

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1. Option(s) to treat primary teeth with deep caries approximating the pulp include:
   b. Direct pulp cap.
   c. Pulpotomy.
   d. All of the above.

2. Primary teeth pulps diagnosed with reversible pulpitis are treated with vital pulp therapy. Primary teeth diagnosed with irreversible pulpsitis or necrosis are treated with pulpectomy or extraction.
   a. The first statement is true, the second is false.
   b. The first statement is false, the second is true.
   c. Both statements are true.
   d. Both statements are false.

3. There is no correlation between the clinical symptoms and pulp inflammation in children.
   a. True.
   b. False.

4. Electric pulp tests can indicate if a pulp is vital in primary teeth. Electric pulp tests can also indicate the degree of inflammation.
   a. The first statement is true, the second is false.

5. Mineral trioxide aggregate (MTA) creates less inflammation and a better dentinal bridge when compared to pulp capping with calcium hydroxide.
   a. True.
   b. False.

6. Biodentine (Septodont) can be used in the following clinical applications:
   a. Endodontic repair.
   b. Pulpotomies.
   c. Pulp capping.
   d. All of the above.

7. Primary teeth with a caries exposure or teeth indicating reversible pulpitis can be treated with pulpotomy. First primary molar pulpotomies have a higher success rate than pulpotomies on second primary molars.
   a. The first statement is true, the second is false.
   b. The first statement is false, the second is true.
   c. Both statements are true.
   d. Both statements are false.
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8. In long-term studies, the indirect pulp cap (IPC) has a lower success rate than the pulpotomy. The clinical and radiographic criteria are the same for both techniques.
   a. The first statement is true, the second is false.
   b. The first statement is false, the second is true.
   c. Both statements are true.
   d. Both statements are false.

9. In the IPC technique, which of the following materials is the best choice to place over remaining carious dentin?
   a. MTA.
   b. Biodentine.
   c. Glass ionomer cement.
   d. Calcium hydroxide.

10. Recent research indicates that direct pulp caps with MTA have a clinical success rate of:
    a. 75% to 80%.
    b. 80% to 85%.
    c. 85% to 90%.
    d. 95% to 100%.
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