Vital Pulp Therapy with New Materials for Primary Teeth: New Directions and Treatment Perspectives

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Abstract

Vital pulp therapy aims to treat reversible pulpal injury and includes 2 therapeutic approaches: (1) indirect pulp treatment for deep dentinal cavities and (2) direct pulp capping or pulpotomy in cases of pulp exposure. Indirect pulp treatment is recommended as the most appropriate procedure for treating primary teeth with deep caries and reversible pulp inflammation, provided that this diagnosis is based on a good history, a proper clinical and radiographic examination, and that the tooth has been sealed with a leakage-free restoration. Formocresol has been a popular pulpotomy medicament in the primary dentition and is still the most universally taught pulp treatment for primary teeth. Concerns have been raised over the use of formocresol in humans, and several alternatives have been proposed. Controlled clinical studies have been critically reviewed, and mineral trioxide aggregate and ferric sulfate have been considered appropriate alternatives to formocresol for pulpotomies in primary teeth with exposed pulps. In most of the studies reviewed, the caries removal method has not been described. The use of a high-speed handpiece or laser might result in an exposure of a "normal" pulp that would otherwise not be exposed. *(J Endod 2008;34:S18-S24)*

Key Words

Ferric sulfate, formocresol, mineral trioxide aggregate, primary teeth, pulp therapy

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The aim of vital pulp therapy is to treat reversible pulpal injuries in both permanent and primary teeth, maintaining pulp vitality and function (1). In addition to these, in primary teeth it is important to preserve the tooth until its natural exfoliation time, thus preserving arch integrity (2). Vital pulp therapy includes 2 therapeutic approaches: indirect pulp treatment (IPT) in cases of deep dentinal cavities and direct pulp capping (DPC) or pulpotomy in cases of pulp exposure (1).

Advances in biomedical research open avenues for the design of new methods of dental treatment, aiming at regeneration of the dentin-pulp complex. New approaches have been based on the understanding of the molecular and cellular mechanisms regulating dentinogenesis during dental tissue repair and their potential for clinical exploitation (1).

The dental pulp possesses the ability to form a dentin-like matrix (tertiary dentin) as part of the repair in the dentin-pulp organ (3). Vital pulp therapy aims to treat reversible pulpal injury in cases in which dentin and pulp are affected by caries, restorative procedures, or trauma. Whenever the dentin-pulp complex is affected by injury, 3 different physiopathologic conditions might be observed at the dentin-pulp border:

1. In the case of mild injuries as in noncavitated enamel caries or slowly progressing dentinal caries, the odontoblasts might survive, and the odontoblastic layer is stimulated to form a tertiary dentin matrix beneath the injury (reactionary dentin). Reactionary dentin shows many similarities to the primary and secondary dentin and can effectively oppose exogenous destructive stimuli to protect the pulp (4).
2. With severe dentinal injuries without pulp exposure as in rapidly progressing carious lesions or in severe tissue damage caused by cavity preparation, odontoblasts are destroyed subjacent to the affected dentin (5, 6). In an appropriate metabolic state of the dentin-pulp complex, a new generation of odontoblast-like cells might differentiate and form tubular tertiary dentin (reparative dentinogenesis) (3, 7). It must be emphasized that under clinical conditions, the matrix formed at the pulp-dentin interface often comprises reactionary dentin, reparative dentin, or fibrodentin formation. It is impossible to distinguish these processes at the in vivo level, and the process might also be indistinguishable from a biochemical and molecular point of view.
3. In the case of pulp exposure, the amputated pulp can be repaired by itself or after application of capping materials (8–10). Pulp exposure caused by caries shows very limited potential for pulp recovery as a result of bacterial infection of the pulp for a substantial period of time, which compromises the defense reaction (11). As part of the wound healing process in the repairing pulp, the dentinogenic potential of pulp cells can be expressed. Proliferation, migration, and differentiation of progenitor cells can give rise to a new generation of reparative dentin-forming cells (odontoblast-like cells), reconstituting the lost continuum at the pulp-dentin border (12, 13).

Indirect Pulp Treatment

After this brief review of the cellular changes during tooth development and how they are mimicked during tissue repair, we are able to assess the biologic validity of the various vital pulp treatments. In this light, IPT, contrary to what was believed in the past, can also be an acceptable procedure for primary teeth with reversible pulp inflammation, provided that the diagnosis is based on a good history and proper clinical and

radiographic examination, and the tooth has been sealed with a leakage-free restoration (2).

In a recent systematic review on complete or ultraconservative removal of decayed tissue, Ricketts et al. (14) concluded that "in deep lesions, partial caries removal is preferable to complete caries removal to reduce the risk of carious exposure."

Several articles reported the success of this technique in primary teeth (15–19). On the basis of the biologic changes previously described and the growing evidence of the success of IPT in primary teeth, we can recommend IPT as the most appropriate treatment for symptom-free primary teeth with deep caries, provided that a proper, leakage-free restoration can be placed. This issue will be discussed in greater detail further in this symposium.

Direct Pulp Capping

DPC is carried out when a healthy pulp has been inadvertently exposed during an operative procedure. The tooth must be asymptomatic, and the exposure site must be pinpoint in diameter and free of oral contaminants. A calcium hydroxide medicament is placed over the exposure site to stimulate dentin formation and thus "heal" the wound and maintain the pulp's vitality (20).

DPC of a carious pulp exposure in a primary tooth is not recommended but can be used with success on immature permanent teeth. DPC is indicated for small mechanical or traumatic exposures when conditions for a favorable response are optimal. Even in these cases, the success rate is not particularly high in primary teeth. Treatment failure might result in internal resorption or acute dentoalveolar abscess (20).

Presently, DPC should still be looked on with some reservations in primary teeth. This treatment, however, could be recommended for exposed pulps in older children 1 or 2 years before normal exfoliation. In these children, a failure of treatment would not imply the need for a space maintainer after extraction, as it would in younger children.

In a recent article, Caicedo et al. (21) demonstrated good pulp response in primary teeth after DPC or pulpotomy with MTA and concluded that MTA might be a favorable material for pulp capping and pulpotomy in primary teeth.

Pulpotomy

Pulpotomy is still the most common treatment for cariously exposed pulps in symptom-free primary molars. The aim of this treatment is to preserve the radicular pulp, avoiding pain and swelling, and ultimately to retain the tooth, preserving arch integrity (2). Formocresol (FC) has been a popular pulpotomy medicament in the primary dentition for the past 70 years since its introduction by Sweet in 1932, and it is still considered the most universally taught and preferred pulp treatment for primary teeth (22–24). Concerns have been raised over the use of FC in humans, mainly as a result of its toxicity and potential carcinogenicity (25–32).

The International Agency for Research on Cancer classified formaldehyde as carcinogenic for humans in June 2004, leaving the profession to look for other alternatives to FC (31). On the basis of the information available, an expert working group has determined that there is now sufficient evidence that formaldehyde causes nasopharyngeal cancer in humans, a rare cancer in developed countries, limited evidence for cancer of the nasal cavity and paranasal sinuses, and "strong but not sufficient evidence" for leukemia.

There has been a significant amount of discussion in the dental literature about the appropriateness and safety of using aldehyde-based products in pediatric dentistry (29). FC is no longer used in some countries, mainly as a result of safety concerns.

Milnes (33) published an extensive and detailed review of the more recent research on the metabolism, pharmacokinetics, and carcinogenicity of formaldehyde and concluded that formaldehyde is not a potent human carcinogen under conditions of low exposure. He concluded that extrapolation of these research results to pediatric dentistry suggests an inconsequential risk of carcinogenesis associated with formaldehyde use in pediatric pulp therapy.

In a case-control study in which FC pulpotomies were performed in 5- to 10-year-old children, blood samples were taken before (control) and after treatment to observe the mutagenic potential of FC on lymphocytes cultures. No statistically significant differences could be observed in the cultured lymphocytes. FC was mutagenic for one patient, however, leading the authors to raise doubts about the desirability of using this technique in children (34).

No correlation between FC pulpotomies and cancer has ever been demonstrated. Nevertheless, several studies have reported that the clinical success of FC pulpotomies decreases with time, and the histologic response of the primary pulp is "capricious," ranging from chronic inflammation to necrosis (35).

Presently, there are several pulp dressing medicaments that have been proposed to maintain radicular pulp vitality that are equal to, if not better than, FC and can be used as alternatives to pulpotomies in primary teeth. The pulp dressing materials and techniques proposed include: electrosurgery (36, 37), laser (38, 39), glutaraldehyde (GT) (40–44), calcium hydroxide (CH) (45–47), freeze-dried bone (48), bone morphogenetic protein (49), osteogenic protein (50), ferric sulfate (FS) (51–56), mineral trioxide aggregate (MTA) (24, 57–59), and sodium hypochlorite (60).

Although a considerable number of clinical trials and laboratory animal studies have been published on this subject, the Cochrane review found that evidence is lacking to conclude which is the most appropriate technique for pulpotomies in primary teeth (61). The Cochrane review assessment is extremely rigorous, and with the exception of 3 articles, none of the articles evaluated could meet the criteria and were excluded.

Evidence-Based Analysis of Pulpotomy Literature

Loh et al. (62) published an evidence-based assessment of FC versus FS by using a different sieving system including all suitable clinical trials, not only randomized ones. They concluded that both materials were likely to produce similar clinical/radiographic success.

Following Cochrane's criticism regarding the paucity of appropriately designed, statistically assessed investigations and the lack of long-term outcomes, many studies have been reported, and several others have begun to contribute to the literature (32).

Fuks and Papagiannoulis (63) assessed the relevant articles that have appeared after the aforementioned reviews by using the clinically based criteria listed by Curzon and Toumba (64). In this review, the MEDLINE search used generated a total of 358 citations, and the sieving of these articles was conducted by examining the article title and assessing its relevance (62).

All articles were graded according to the aforementioned criteria and classified as A if the article met 90% or more of the criteria; B1 if an article scored from 75%–89%; B2 if it scored between 60%–74%; and C if it scored 59% or less, which meant that it had to be excluded. Even with different weights attributed to the evaluated articles, no conclusion could be reached as to the optimum treatment or technique for pulpally involved primary teeth. In a meta-analysis to compare the clinical and radiographic effects of MTA with FC, Peng et al. (65) reported that MTA was superior to FC. These authors claimed that MTA induces less undesirable responses and might be a suitable replacement for FC.