



## Pulpotomy and Recent Advancement in Pulpotomy Materials: A Review

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### Abstract

The aim of pulpotomy is to maintain the integrity and health of the teeth and their supporting tissues. This is the choice of treatment for cariously exposed vital primary molars, with formocresol considered as golden standard. However, controversies surrounding this medicament have generated inquisitiveness to exploration for various chemical and natural alternatives. This review article focus on the use of various materials that have been recently used as alternative pulpotomy agents to formocresol so as to guide the clinicians in choosing proper medicament.

**Keywords:** Material, Primary, Pulpotomy, Vital

### Introduction

Primary teeth are very important for child's smile, proper chewing, and for developing permanent dentition [1]. Premature loss of primary tooth can cause a number of problems including arch perimeter loss, supraeruption of opposing teeth and changes in the patient's occlusion [2]. Pulp vitality leads to development of a favourable crown-to-root ratio, apical closure and formation of secondary radicular dentin [3]. The long term survival of tooth is also greater when pulp vitality is maintained. Therefore, the duty of paediatric dentist is to diagnose early and give proper and early treatment to the child to prevent various complications [4]. Vital pulpotomy can be defined as the surgical amputation of infected and inflamed coronal pulp followed by placement of a suitable medicament over the radicular pulp to preserve the vitality and functions of the tooth [5]. The American Academy of Pediatric Dentistry defines a pulpotomy (2006-2007) as when the coronal pulp is amputated, and the remaining vital radicular pulp tissue surface is treated with a medicament such as formocresol or ferric sulfate or with electrocautery to preserve the radicular pulp's health [6].

### Discussion

Pulpotomy is also an alternative for a tooth with traumatic pulp exposure. Under ideal circumstances it may be preferable to do pulpectomy and root canal treatment for such teeth but primary teeth may have very unpredictable and tortuous root canal systems which makes it difficult or impossible to clean and shape and properly obturate the root canals. In addition, primary teeth have thin enamel and large pulp chambers and caries can progress very easily [7].

### Indications [8]

- Vital teeth
- Healthy periodontium
- Only coronal involvement
- Contraindicated extraction
- Absence of infection/abscess, fistula, spontaneous pain, pulp floor involvement and inter-radicular bone loss

### Contraindications [9]

- Abnormal sensitivity to heat and cold
- Chronic pulpalgia
- Tenderness to percussion or palpation because of pulpal disease
- Periradicular radiographic changes resulting from extension of pulpal disease into the periapical tissues
- Marked constriction of pulp chamber or root canals.

This treatment can be performed using different techniques including formocresol, calcium hydroxide, enriched collagen solution, ferric sulphate, mineral trioxide aggregate, growth factors or by non-pharmacological hemostatic techniques like electro surgery or Er: YAG laser. With some modification and advancements in pulpotomy techniques, the formocresol pulpotomy continues to be used in clinical practice. In an effort to find a more biologically acceptable and effective alternative to formocresol, other agents and techniques have been examined [9]

### Newer Materials of Pulpotomy

Various studies have been carried out in search of ideal pulpotomy material. Some of the materials which proved effective are lyophilized freeze dried platelet, enamel matrix

derivative, propolis, sodium hypochlorite, bioactive glass and ankaferd blood stopper<sup>[10]</sup>.

### Mineral Trioxide Aggregate (MTA)<sup>[11, 12]</sup>

MTA a new material currently being used in pulp therapy is a non resorbable material that has been used experimentally for a number of years and was used for human usage by the FDA. MTA was introduced by Torabinejad in 1993. It is an ash coloured powder made primarily of fine hydrophilic particles of tricalcium aluminate, tricalcium silicate, silicate oxide and tricalcium oxide. When material is hydrated it becomes a colloid gel, it sets in approximately 3-4 hrs, and bismuth oxide has been added for radioopacity.

Studies on MTA reveal that it not only exhibits good sealing ability, excellent long term prognosis and good biocompatibility but favors tissue regeneration as well. MTA has a pH of 10.2 immediately after mixing and increases to 12.5 after 3 hours of setting. MTA in contact with pulp tissue encourages dentin bridge formation. Dominguez *et al.* following histological evaluation reported that MTA caused minimal pulpal inflammation.

Several *in vitro* and *in vivo* studies shown that MTA prevents microleakage, is biocompatible and promotes regeneration of the original tissues when it is placed in contact with the dental pulp or periradicular tissues.

### Bone Morphogenetic Proteins (BMP)<sup>[6]</sup>

Bone Morphogenetic Proteins (BMP) is thought to induce reparative dentin with recombinant dentinogenic proteins similar to the native proteins of the body. Urist observed that demineralized bone matrix, stimulated new bone formation when implanted in ectopic sites such as muscle. Urist concluded that bone matrix contains a factor capable of autoinduction and he named this factor bone morphogenetic protein.

Although tightly associated with collagen of matrix, BMPs are classified as noncollagenous proteins.

Rutherford studied pulp response in monkey teeth and stated recombinant human BMP-2 and BMP-4 induce differentiation of adult pulp cells into odontoblasts.

### Laser Pulpotomy<sup>[13, 14]</sup>

Lasers have been suggested for a number of procedures in dentistry including pulpotomy. Some of the earlier studies used CO<sub>2</sub>, argon and Nd: YAG lasers to perform pulpotomies on dogs and swine. Subsequent to animal studies different studies were led on laser energy to overcome the histological deficits of electro surgery. Ideally, laser irradiation creates a superficial zone of coagulation necrosis that remains compatible with the underlying tissue.

Wilkerson *et al.* (1996), studied the effect of argon laser on primary tooth pulpotomy in swine. They reported that after 60 days, pulps appeared to retain their vitality and capability of normal pulp healing. They also concluded that the use of argon laser pulpotomy did not appear to be detrimental to pulp tissues.

### Lyophilized Freeze Dried Platelet<sup>[10, 15]</sup>

It acts as signalling proteins that get involved in regulation of cell proliferation, migration and extracellular matrix production. It contains transforming growth factor, platelet derived growth factor, bone morphogenetic proteins and insulin growth factor. These regulate key cellular processes

like differentiation, mitogenesis and chemotaxis. Kalaskar and Damle compared the efficacy of lyophilized freeze dried platelet derived preparation with calcium hydroxide as pulpotomy agents in primary molars and reported that the success rate of lyophilized freeze-dried platelet derived preparation was better than calcium hydroxide.

### Enamel Matrix Derivative (EMD)<sup>[10, 16]</sup>

It is obtained from embryonic enamel as amelogenin. *In vitro* experiments on EMD have shown that, it stimulates PDL cell proliferation and is widely used in periodontology. The ability of EMD to facilitate the regenerative process is well established, this process mimic normal ontogenesis and it is believed that reciprocal ectodermal signaling controls and patterns the same. Currently, emdogain gel (starutmann, Switzerland) has been successfully employed for pulpotomy procedures.

Ishizaki *et al.* noted abundant tertiary dentin formation after 8 weeks of EMD pulpotomy.

### Propolis<sup>[10, 17]</sup>

It is a wax - cum - resin substance that is produced by bees. It is shown to have antibacterial, antiviral, antifungal, immunostimulation hypotensive and cytostatic activity mainly due to the presence of flavonoids (2-phenyl-1, 4-benzopyrone), aromatic acids, and esters. As an anti-inflammatory agent, it inhibits prostaglandin synthesis.

Carmen *et al.* compared the effectiveness of 10% propolis tincture and formocresol pulpotomy in primary molars and showed that 10% propolis tincture was as effective as FC.

### Sodium Hypochlorite (NaOCl)<sup>[18]</sup>

Sodium hypochlorite (NaOCl) has been successfully used for decades in endodontic therapy as an irrigant. Since the 1950s, studies have verified that NaOCl is biocompatible, nonirritating to exposed pulpal tissue and an effective hemostatic agent. Hafez and others demonstrated that the application of NaOCl selectively dissolves the superficial necrotic pulp tissue while leaving the deeper healthy pulp tissue unharmed.

### Bioactive Glass<sup>[10, 19]</sup>

Bioactive glass has been studied more than 30 years as a bone substitute. It reacts with aqueous solution and form a carbonate apatite layer. Originally BAGs were considered as osteoconductive. Recent evidence suggests that they are osteoinductive. BAGs are biocompatible, antibacterial and stimulate osteoblasts. Some authors state odontoblast stimulation and subsequent reparative dentin formation; however studies are ongoing to prove exact mechanism of bridge formation.

Animal study by Salako *et al.* reported that BAG showed localized areas of inflammation in the pulp especially in the mid root portion and 4 week old samples showed comparative better results where the inflammation was resolved and odontoblastic layer was evident.

### Ankaferd Blood Stopper (ABS)<sup>[20, 21, 22]</sup>

It is a herbal extract obtained from 5 different plants: Thymus vulgaris, Glycyrrhiza glabra, Vitis vinifera, Alpinia officinarum, and Urtica dioica. Each of these plants has some effect on the endothelium, blood cells, angiogenesis, cellular proliferation, vascular dynamics and also as cell mediators.

The possible mechanism is explained by Goker *et al.* Following application of ABS, it forms an encapsulated protein network that provides focal points for vital erythrocyte aggregation.

ABS induced protein network formation with blood cells particularly erythrocytes covers the primary and secondary haemostatic system without disturbing individual coagulation factors. It is suggested that ABS may be used to control pulpal haemorrhage following the mechanical exposure of pulps. The levels of coagulation factors II, V, VIII, IX, X, XI, and XII were not affected by ABS, therefore ABS might be used in patients with deficient primary or/and secondary hemostasis, including patients with disseminated intravascular coagulation. Studies on pulpotomy with ABS have shown success rate ranging from 89% to 100%. However, long term studies are required in this regard

#### **Nano Hydroxy Apatite** <sup>[10, 23]</sup>

It has been introduced for augmentation procedures in osseous defects and is attracting increasing interest in medicine and dentistry. NHA is biocompatible and non-irritating to pulp tissue.

Shayegan *et al.* following histological evaluation reported that there was a significant difference between NHA and FC in terms of pulp response. The results of the study show that NHA appears to be more biocompatible and provokes only mild inflammatory reaction in pulp tissue in both pulpotomy and direct pulp capping treatments.

#### **Platelet Rich Plasma** <sup>[24, 25]</sup>

This was introduced by Marx in 1998 for reconstruction of mandibular defects, and it represents a relatively new biotechnology that is part of the growing interest in tissue engineering and cellular therapy.

Gibble and Ness in 1990 introduced fibrin glue, alternatively referred to as fibrin sealant or fibrin gel, a biomaterial developed in response to the necessity for improved haemostatic agents with adhesive properties.

#### **Platelet Rich Plasma gel (PRP gel)** <sup>[10]</sup>

It is an autologous modification of fibrin glue obtained from autologous blood used to deliver growth factors in high concentrations. It is an autologous concentration of human platelets in a small volume of plasma, mimics the coagulation cascade, leading to formation of fibrin clot, which consolidates and adheres to application site. Its biocompatible and biodegradable properties prevent tissue necrosis, extensive fibrosis and promote healing.

#### **Pulpotec** <sup>[26]</sup>

It is a newly available radiopaque, non resorbable paste that is used for pulpotomy treatment. It is available as powder liquid system. Powder consists of polyoxymethylene, iodoform and liquid consists of dexamethasone acetate, formaldehyde, phenol, guaiacol.

Its mode of action is by cicatrization of the pulpal stump at the chamber-canal interface, while maintaining the structure of underlying pulp.

#### **Calciumphosphate** <sup>[27, 28, 29]</sup>

This cement falls in the class of hydraulic cements, which self-harden to hydroxyapatite (HA), the bone mineral. Several formulations of CPC have been successfully

designed for various orthopedic and dental applications. CPCs possess the combination of biocompatibility, osteoconductivity and mouldability.

Moreover, they are non-toxic and non-immunogenic and do not have any mutagenic or carcinogenic potential. Animal studies reported the capacity of calcium phosphate to form dentin without areas of necrosis.

Chitra-CPC is a new CPC formulation with good rheological properties developed in India. Ratnakumari and Bijimole *et al.* used chitra-CPC and reported favourable results with mild pulpal inflammation and improved quality of dentin bridge formation.

#### **Nigella Sativa Oil (NS)** <sup>[30]</sup>

Nigella Sativa oil (NS) extracted from black seed or black cumin is traditionally used in herbal medicine. It is shown to possess bronchodilator, immune-potentiating activity, hypotensive, analgesic, antibacterial and anti-inflammatory. Omar OM *et al.* conducted a histopathological comparison of FC and NS pulpotomies in dogs. Specimens in NS groups showed mild to moderate vasodilatation, continuous odontoblastic layer and few samples showed scattered inflammatory cell infiltration.

#### **Turmeric Powder** <sup>[31, 32]</sup>

Curcuma longa is a perennial herb cultivated extensively in India, China, and other countries with a tropical climate. It has a wide range of pharmacological applications, owing to its antioxidant, anti-inflammatory, and antimicrobial properties. It is widely used in foods for its color and flavor. It is extensively used in Ayurvedic systems of medicine for the treatment of flatulence, menstrual difficulties, jaundice, hemorrhage, hematuria, and colic diseases. It has specific lipoxygenase and cyclooxygenase 2-inhibiting property which acts as a potent anti-inflammatory agent. The following are the reported uses of turmeric in dentistry; as a mouth rinse, a dentifrice, coloring agent in pit and fissure sealants and staining agent in dental-plaque detection system. Due to the medicinal and anti-inflammatory properties, turmeric powder was used as a pulpotomy medicament in primary teeth by Purohit *et al.* with good clinical and radiographic success.

#### **Thymus Vulgaris** <sup>[31, 33, 34]</sup>

Thymus vulgaris is a perennial plant, indigenous in the Mediterranean region and is cultivated in several countries. Due to its antimicrobial, antitussive, spasmolytic, and antioxidant activity, it has been used in medical field for thousands of years. Some studies revealed that thyme extract has anti-inflammatory and wound healing properties. Conventionally, thyme is the most commonly recommended herb in European countries for treating cough and upper respiratory congestion. The German expert panel has approved thyme for relieving bronchitis and whooping cough. Thymol, one of the ingredients of thyme, is most commonly used as antiseptic mouthwash which showed a reduction in plaque formation, gingivitis, and caries. Alolofi *et al.* (2016) performed clinical and radio graphical assessment on thymus vulgaris as a pulpotomy agent in primary molar teeth and showed good clinical success rate. This has been ascribed to the antibacterial, anti-inflammatory and hemostatic properties of thymus components such as thymol, carvacrol flavonoids, and apigenin.

**Antioxidant** [31, 35, 36]

Antioxidants have a capacity of deactivating free radicals in human cells. This can be exogenous or endogenous as a part of the diet or dietary supplements. The endogenous component is generated through a highly multifaceted antioxidant systems (enzymic or nonenzymic), which work synergistically and in combination with each other to prevent cells or organs against free radicals whereas, exogenous ones are produced from several sources and available as supplements. In dentistry, there are mouth rinses, toothpastes, or oral sprays containing antioxidant supplements. The majority of enhancements include propolis, green tea, pine bark, or grape seed extracts. Antioxidants have potential to alteration the progress of oral problems such as gingivitis and periodontitis by negotiating antioxidant volume of crevicular fluid and plasma. Studies revealed that antioxidants such as green tea have a role in restorative dentistry on caries prevention as it has been reported that epigallocatechin-3-gallate molecule had scavenging effect on caries prevention. The antioxidant mix works on the principle of wound healing and maintaining anatomic continuity of the damaged tissue. Kathal *et al* stated that antioxidant mix pulpotomy is more biocompatible and cost-effective than any other commercially available medicament. This may be due to the elimination of reactive oxygen species as it was an important strategy for improving healing of radicular pulp.

**Allium Sativum Oil** [31]

It is commonly recognized as garlic and it is one of the widely investigated medicinal plants. The antibacterial activity of Allium depends on allicin produced by enzymatic activity of alliinase. Thus, the therapeutic effects of garlic are due to allicin and other thiosulfonates. Garlic extract has been stated to prevent growth of numerous Gram-positive and Gram-negative bacteria. Allium sativum extract has been identified to take inhibitory action on several pathogenic bacteria, fungi and viruses. There is inhibitory activity of garlic extract on multidrug-resistant strains of *Streptococcus mutans* isolated from human carious teeth. One of the utmost prominent features in specimens of *A. sativum* oil was the presence of osteodentin.

**Copaifera Langsdorffii Oil Resin** [31, 37, 38]

This phytochemical chemically defined as a solution of diterpene acids in an essential oil that is mostly constituted by sesquiterpenes. It has a wide range of pharmacological applications due to its reported analgesic, anti-inflammatory, antiulcer, antinociceptive, gastric protection, antioxidant, antitumoral, antimicrobial, and wound-healing properties. *Copaifera langsdorffii* oil resin (CLOR) is largely used in alternative medicine as a dietary supplement to produce flavoring agents and food additives. This encouraged CLOR usage in dentistry as a pulpotomy medicament, anticariogenic agent, bioendodontic sealer, and to treat periodontal conditions. Lima *et al.* conducted a study using fibrin sponge as a vehicle for application of CLOR in the pulpotomized teeth. They concluded that the fibrin sponge without CLOR showed the worst healing and inflammatory response outcomes, and they graded the inflammatory response of the pulpal tissue to CLOR as less severe compared to fibrin sponge. The impervious resinous layer of CLOR provided topical wound healing properties to the amputated radicular pulp tissue.

**Acemannan** [31, 39]

The b-(1, 4) acetylated polymannose is an extract from Avera that is biocompatible with various oral mesenchymal cell types. This compound has been known to have immune stimulant, antiviral, antineoplastic, and gastrointestinal properties. The results of the pulpotomy treatment indicated that acemannan stimulated dentine bridge formation covering the exposure site and predominantly normal pulp tissue organization.

**Conclusion**

The acceptable outcome of pulpotomy in primary teeth depends on case selection, proper clinical and radiographic evaluation, and most importantly, on aseptic clinical procedure and material used for pulpotomy. Form cresol shows a good clinical success rate over the period of years but concerns raised due to its toxicity, mutagenicity, and carcinogenicity. Other materials such as MTA and can be used as an alternative to form cresol. Natural products claimed to play a vital role and appear to be a viable replacement to form cresol. Although these natural products are being projected for their advantages and having a wide scope; there is lack of higher level of evidence to support its usage in paediatric dentistry.

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