

Vital Pulpotomy and its Perspectives



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Abstract

The article is devoted to the history of research and the development of materials being the protectors of the pulp used for vital amputation and direct pulp capping when it is accidentally exposed and also to the use of MTA in dentistry, including pediatric, as well as the prospect of the use of MTA in vital amputation of permanent teeth with the formed apex as a stage of preparation for prosthetics.

Keywords: Pulp; Apex; Vital amputation; Pulpotomy; Pulp protector; MTA; Primary teeth; Permanent teeth; Direct capping; In-direct capping

Introduction

Different materials for vital amputation and the reaction of the pulp are the subject of many studies [1-4]. Sometimes vital pulp therapy does not guarantee long-term success compared to endodontic treatment and the implications of various modifications of formocresol for pulpotomy of deciduous teeth are also not clear yet used since the 19th century [5,6]. More than 30 years ago there already had been a huge choice of varnishes and cements for the preservation of pulp vitality [7]. Currently, vital pulp therapy is undergoing a remarkable progress thanks to the invention of new biomaterials in combination with the perfection of adhesive technology [8]. reviewed clinical studies on the pulp survival for 12 months after the intervention (1960-2016) with subsequent meta-analysis concluding any type of pulpotomy in deciduous teeth using the most efficient MTA and formocresol [9]. Overview of clinical studies by [10]. Showed the complexity of the interpretation of these studies and the creation of an ideal clinical conditions for the evaluation of the materials used [11]. There were practically no studies on pulpotomy teeth with carious lesions.

The Types of Pulpotomy

Complete

According to is the most appropriate for the permanent teeth with formed top [12].

Partial

Is described by Olsson et al. [13] 1 and 5minute lasting with formocresol [14,15].

The History of the Development

Archaeological research showed that people of the Neolithic have been already familiar with the method of drilling and dental treatment. The remains of people with smooth holes of clearly artificial origin in teeth have been found on the territory of modern Pakistan. These graves are about 9 thousand years. It is assumed that the ancient physicians used substance similar to asphalt as the filling material. The papyri have brought to us a deep knowledge of the Egyptians about the healing properties of plants, which doctors of the time used in the manufacturing of filling materials and anti-inflammatory compounds for gingivitis, erosion and pulpitis treatment.

The story of the protectors of the pulp

First medicinal pulp capping was performed in 1756 by Philip Pfaff by applying gold leaf.

- I. **1921:** Calcium hydroxide was introduced by Hermann and for decades remained the "gold standard" to which, as a model other material have been compared.
- II. **1969-70 gg:** propose a mixture of antibiotics with corticosteroids for vital pulpotomy [16]. Describes the application "s Toverud 'paste" for pulpotomy [17]. Hannah DR, Rowe AH. researched material N2 as an agent for pulpotomy.
- III. **1975:** Describes the use of a mixture of corticosteroids and antibiotics when performing a vital amputation of the lateral teeth [18].

- IV. 1978:** Explored the application of a combination of calcium hydroxide and antibiotic-glucocorticoid mixtures in the conservative treatment of pulp in carious posterior teeth [19].
- V. 1986:** Examined antibiotic-glucocorticoid compound for pulpotomy [20].
- VI. 1987:** J Melcer et al. [21-23] suggested carbon dioxide laser in the 1985-87 for pulp defects repairing.
- VII. 1989:** Recommended calcium hydroxide, formocresol, glutaraldehyde, ferric sulfate, zinc-eugenol cement, polycarboxylate cement for VA [24]. In the early 90s Torabinejad proposed MTA for the pulp treatment and many studies confirmed its advantages over calcium hydroxide.
- VIII. 1993:** MTA is presented by dentistry market.
- IX. 1994:** Offered tricalcium phosphate in combination with a small amount of calcium hydroxide for pulpotomy [25].
- X. 1995:** Calcium phosphate cement is biocompatible and mechanically stable due to its ability to transform into a hydroxyapatite which is the most thermodynamically stable agent with good biocompatibility and pH 7.0. Yoshimine Y et al. [26] demonstrated that tetracalcium phosphate, unlike calcium hydroxide, stimulating the formation of the dentinal bridge without the risk of pulp necrosis and inflammation.
- XI. 1996:** Proposed a hydroxyapatite and beta-tricalcium phosphate for pulpotomy, guaranteeing the formation of dentin barrier [27].
- XII. 1997:** Consider ferric sulfate and modification of formocresol to be acceptable for pulpotomy of deciduous teeth reaffirming at the same time some cases of internal resorption during their application [28]. Note the same efficiency of formocresol and zinc-eugenol cement in pulpotomy *In vivo*, and that the ferric sulphate had no higher efficacy compared to these agents [29].
- XIII. 2000:** Ferric sulfate is recommended for pulpotomy of deciduous teeth [30]. Proposed the paste on the basis of the iodoform for pulpotomy of primary and permanent teeth in children [31].
- XIV. 2001:** Recommend MTA for pulpotomy in deciduous teeth [32].
- XV. 2002:** *In vivo* studies by [33]. Who investigated the direct capping of the inflamed pulp with calcium hydroxide showed the subsequent formation of the dentinal bridge.
- XVI. 2003:** Recommended ferric sulfate because of its low toxicity in comparison with formocresol for pulpotomy in primary molars [34]. Histological examination by [35]. Showed the superiority of MTA over other agents for pulpotomy in maintaining the health and integrity of the pulp.
- XVII. 2004:** Research by [36]. Showed the superiority of MTA over formocresol in pulpotomy of deciduous teeth.
- XVIII. 2005:** In his review study notes that among all the possible agents for pulpotomy of deciduous teeth formocresol is the most predictable and effective [37].
- XIX. 2006:** Suggest MTA for pulpotomy of primary teeth [38].
- XX. 2008:** Determined that the efficiency of electrocoagulation and formocresol is the same when performing pulpotomy of primary teeth in children 5-10 years. Offer the enamel matrix derivative as an alternative to formocresol for pulpotomy of deciduous teeth [39,40].
- XXI. 2009:** Recommended Portland cement as a cheaper alternative to MTA in pulpotomy of primary teeth. Propose the hydroxyapatite as the pulpotomy agent [41,42].
- XXII. 2011:** Recommended ferric sulfate pulpotomy for carious deciduous teeth [43].
- XXIII. 2012:** Assess zinc eugenol as an acceptable agent for pulpotomy [44,45]. Noted that the MTA, with all its effectiveness on the formation of dentinal bridges can thereby complicate future endodontic treatment [46]. Consider the bioceramic as an optimal agent for pulpotomy [47]. Made an attempt to mix formocresol and MTA. Propose the technique of minipulpotomy [48,49].
- XXIV. 2013:** Offer collagen and Pulpotec for pulpotomy. In addition to the use of MTA and CEM, the authors continue to assess zinc eugenol satisfactorily as pulpotomy agent in children [50,51]. Studied formocresol as a standard offering sodium hypochlorite as an agent for pulpotomy along with the MTA [52,53].
- XXV. 2014:** Offer preparations of fibrin as alternative to MTA for pulpotomy in permanent teeth with incomplete apexogenesis [54].
- XXVI. 2015:** Propose the use of stem cells for efficient healing of the pulp and the formation of tertiary dentin during pulpotomy [55]. *In vivo* have confirmed the biocompatibility and effectiveness of the bioceramic iRoot BP Plus (Innovative Bioceramics Inc, Vancouver, Canada) for pulpotomy [56]. Portland cement is still used in pulpotomy of primary teeth with the addition of iodoform and zirconium oxide with the appropriate reaction of the pulp within 24 months after the intervention [57].
- XXVII. 2017:** Offered a herbal preparation with Turmeric powder for pulpotomy of deciduous teeth [58]. Proposed propolis in the form of biodegradable films based on chitosan [59].

Physical Methods Pulpotomy

Showed the same efficiency of the laser and Biodental MTA for pulpotomy in primary teeth [60]. Noted the great efficiency of the laser pulpotomy compared to ferric sulfate and electrocoagulation in clinical studies of children 4-10 years according to clinical and radiological parameters [61]. Consider the laser and electrocoagulation acceptable alternative to pharmacotherapeutic pulpotomy agents [62]. Determined in vivo high efficiency of the KaVo Gentle Ray Diode Laser compared to formocresol and ferric sulfate consider electrocoagulation being efficient enough in the clinic of pediatric dentistry [63].

MTA in Pediatric Dentistry

Believe that the MTA, in particular white, soon will completely replace the "gold standard" formocresol in pulpotomy of deciduous teeth, outperforming its clinical and radiographic efficiency according to research by as well as to in vivo studies believe that the MTA provides normal apexogenesis during partial pulpotomy [64 -70]. In clinical trials for postoperative pain in primary teeth of the 6-10 years children after pulpotomy of carious molars determined that MTA and CEM were equally effective [71]. Efficacy of MTA and CEM pulpotomy in primary teeth is affirmed by [72]. The effectiveness of pulpotomy with MTA for primary teeth is demonstrated by MTA prevents premature removal of deciduous teeth [73-75]. Note the almost identical efficiency of Biodentin, white MTA and Tempopro for the treatment of carious deciduous teeth [76]. Confirmed the superiority of MTA as a pulpotomy agent for primary teeth over formocresol, Portland cement and enamel matrix derivative and confirmed that the MTA and Biodentin are reliable materials for the pulpotomy of primary teeth [77-79]. Showed the same efficiency of MTA, calcium hydroxide and enriched fibrin for pulpotomy of molars with the formed apex with irreversible pulpitis [80,81].

Noted greater efficiency and the potential for the formation of reparative dentin of Biodentin compared to calcium hydroxide (Pulpdent) when conducting pulpotomy in the 5-10 years children identified greater efficiency of MTA in comparison with formocresol during clinical studies of the primary teeth in the 5-8 years children [82-84]. Emphasize equally high efficiency of various types of MTA – RetroMTA, OrthoMTA and ProRoot MTA for pulpotomy in deciduous teeth [85]. consider it appropriate to use MTA and Portland cement for pulpotomy in deciduous teeth, affirming their reparative and bioinductive properties by the presence of dentin matrix protein DMP –in their review of the studies revealed a higher and long-term effectiveness of MTA in primary teeth pulpotomy in contrast to the ferric sulfate [86,87]. Recommend the treatment with 5% sodium hypochlorite to ensure maximum effectiveness of calcium in primary teeth pulpotomy [88].

Pulpotomy in Permanent Teeth

consider Biodentin and MTA to be effective for the treatment of traumatized permanent incisors [89]. believe that pulpotomy

with MTA is a reliable alternative to endodontic treatment of permanent teeth in children [90]. Confirmed similar efficacy of CEM and MTA in pulpotomy of permanent first molars with incomplete apexogenesis [91]. noted the effectiveness of MTA in pulpotomy of permanent molars with carious lesions [92]. Recommend MTA pulpotomy for permanent teeth with incomplete apexogenesis [13].

The Advantages of Modern Materials

note the absence of toxic and mutagenic effect in CEM compared to formocresol and ferric sulfate [93]. observed normal apexogenesis in pulpotomy of the 12 years girl second lower molar. confirm the minimum of toxic effect on the fibroblasts of the periodontium of white and grey MTA [94,95]. MTA is superior to calcium hydroxide on efficiency Northwest Practice-based Research Collaborative in Evidence-based According to in vivo studies by MTA and CEM are superior to calcium hydroxide for a favorable response and further healing of the pulp [96,97]. MTA has a lower cytotoxicity compared to calcium hydroxide Histological examination by demonstrated the efficacy of tricalcium phosphate, MTA and Portland cement in contrast to formocresol and ferric sulphate [98,99].

Disadvantages of Modern Materials

In their review of electronic database studies have evaluated the MTA potential for the formation of a protective barrier of hard tissues compared to calcium hydroxide as questionable [100]. In addition, the analysis of electronic databases of studies from 1950 to 2013 by never found out the preferred tactics in the treatment of teeth with deep carious lesions, endodontic treatment or pulpotomy [101]. Found out a weak inhibitory effect on cariogenic bacteria from MTA in primary teeth pulpotomy [102].

MTA Mechanism of Action

MTA is calcium oxide in the form of tri- and di- silicate with tricalcium aluminate prior to setting. The first product of the reaction between MTA and water is calcium hydroxide, which provides its biocompatibility [103]. Thus, MTA has all the properties of calcium hydroxide, and also provides a better connection to the dentin. In addition, the MTA reacts with fluids containing phosphates resulting in a precipitate in the form of hydroxyapatite [104]. Several authors have attributed high solubility in water high duration setting material gray MTA containing iron, can stain the tooth tissue to the shortcomings of MTA [105-107]. MTA is a universal material in the clinic of pediatric dentistry, ensuring the preservation of pulp vitality and the root pulp in particular and, therefore, a complete root formation of immature permanent teeth. MTA appears to be an apical barrier during the periodontitis treatment of immature teeth providing normal apex development [108]. Considers the possibility of completing the treatment of the tooth in one visit to be an advantage of MTA over calcium hydroxide, but some MTA types may cause clinical crown discoloration (Table 1).

Table 1:

Overview	Witherspoon DE [109]	MTA	MTA unlike calcium hydroxide has better integrity and a greater ability to stimulate the formation of perfect reparative dentin.
Physical	Eid AA, Komabayashi T, Watanabe E, Shiraishi T, Watanabe I. Interaction 2012 [110]	MTA and the GIC	GIC can be directly superimposed directly on the freshly mixed MTA without impairing the characteristics of these materials.
Physics (research tensile strength)	Savadi Oskoe S, Bahari M, Kimyai S, Motahhari P, Eghbal MJ, Asgary S (2014)	White MTA and CEM with different composite and adhesive systems	White MTA and CEM do not differ from each other in less strong adhesion to the composite in contrast to the composite glassionomeric cement
In vitro (Neutrophils)	Cavalcanti BN, Rode Sde M, França CM, Marques MM [111]	MTA	MTA unlike calcium hydroxide causes increased production of interleukin 1-β.
In vitro (pulp cells)	Paranjpe A, Smoot T, Zhang H, Johnson JD [112]	Gray MTA	Pulp cells are converted into odontoblasts with increased secretion of vascular endothelial growth factor in contact with gray MTA.
Clinical and histological	Banava S, Fazlyab M, Heshmat H, Mojtahedzadeh F, Motahhary P (2015)	Dycal, ProRoot MTA, ProRoot MTA, Multi-Cal	Pulpotomy in one visit with MTA as direct pulp protector is just as effective as a similar procedure in two visits using calcium hydroxide.
Clinical	Malekafzali B, Shekarchi F, Asgary S (2011)	MTA and CEM	Both materials are effective in primary molars pulpotomy
Clinical	Simon S, et al. (2012)	MTA	pulpotomy with MTA is successful in patients from 7 to 54 years in premolars and molars with no symptoms of irreversible pulpitis.
Clinical	Hilton TJ, Ferracane JL, Mancl L [113]		
	MTA	MTA is superior to calcium hydroxide as a direct pulp protector	
Clinical	Asgary S, Eghbal MJ (2013)	MTA and CEM	Both materials ensure success in the treatment of molars with irreversible pulpitis.
Clinical	Azimi S et al. [114]	iRoot BP or MTA	no necrosis of the pulp, dentin bridge is formed in 100%
Clinical	Barnkgkei IH, Halboub E, Alboni RS [115]	ProRoot MTA	pulpotomy with MTA - reliable alternative to endodontic treatment.
Clinical	Fallahinejad Ghajari M, Asgharian Jeddi T, Iri S, Asgary S [116]	MTA ProRoot and CEM	Both materials are equally effective as direct pulp protectors in the primary teeth treatment.

Recommendations for the MTA Use

Studies showed that the compound of composite GIC and white MTA was stable regardless the presence of the etching material [116-117]. The authors recommended isolating liner of composite GIC with its further etching along with dentin for pulp capping and restoration of bifurcation using MTA. The review of studies indicates the possibility of the future use of MTA not only medicinally, but also in the preparation of the permanent teeth for prosthetics [118-119]. Even Pierre Foshar in his works, recognized the significant loss of hard tissues during endodontic treatment, leading to additional complicated and sometimes risky prosthetic procedures.

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