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Review Article

Two Regenerative Materials for Pulpotomies in Primary Teeth: Review of the Literature

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Abstract

Background: Several medicaments have been used in pulpotomy procedures of primary teeth with the objective to maintain pulp vitality and promote healing of the pulp remnants and maintain the tooth until its natural exfoliation time. The use of potentially toxic materials such as formocresol should be replaced with biocompatible materials that offer pulp healing and regeneration in pulpotomies of primary teeth. In recent times, the use of regenerative materials has been promoted, such as mineral trioxide aggregate (MTA) and tricalcium silicate (Biodentine) because of their regenerative and antibacterial capacity and high biocompatibility. The purpose of this study was to reviewed the current literature were included the use of MTA and Biodentine in pulpotomies of primary teeth.

Keywords: *Pulpotomy; Primary Teeth; MTA; Biodentine*

Abbreviations

MTA: Mineral Trioxide Aggregate; CH: Calcium Hydroxide; RCT: Randomized Clinical Trial

Introduction

Pulp treatments in primary teeth include but are not limited to vital pulpotomy, necrotic pulpotomy and pulpectomy. A pulpotomy is performed on a tooth with deep carious lesion, pulp exposure during the operatory process or after a traumatic pulp exposure. Several medicaments have been used in pulpotomy procedures of primary teeth with the objective to maintain pulp vitality and promote healing of the pulp remnants and maintain the tooth until its natural exfoliation time [1]. For vital pulpotomies, several materials are available for application in this technique; the ideal material should be bactericidal, promote healing of the radicular pulp, provide a relatively stable environment from the dentin-pulp complex, stimulate regeneration of the dentin-pulp complex and not alter the physiologic root resorption process [2]. Even with its limited bactericidal effects and potential toxicity, formocresol is still the standard reference of care worldwide; because of its negative effects, an alternative is searched that may have the clinical and radiographic success of formocresol without is adverse effects [3].

MTA (Mineral Trioxide Aggregate) and Biodentine (Tricalcium Silicate Cement) are used as substitutes for formocresol also permitting by their characteristics, repair of root perforations and of the pulp chamber floor, apexogenesis, root end filling in surgical endodontics and repair of internal and external root resorption [4,5]. A pulpotomy is contraindicated in the presence of signs and symptoms like spontaneous pain, pain to percussion, abnormal mobility, fistula, internal resorption, pulpal calcifications, pathologic external resorption, radiolucency at the periapex and furcation levels or excessive bleeding [6]. Likewise, the tooth should be restorable and a least 2/3 of the radicular length remain to assure a reasonable functional lifetime [1]. The British Society of Paediatric Dentistry recommends several medicaments including MTA for pulpotomies in primary teeth [7]. The American Academy of Pediatric Dentistry recommends various medicaments [8]. Pulpotomies can be classified according their therapeutic goals: devitalization (formocresol), preservation (ferric sulphate) or regeneration (calcium hydroxide, MTA, tricalcium silicate) [1].

MTA Physical Properties

MTA was developed at Loma Linda University, USA in 1993 for root-end obturation, and is used in procedures such as direct pulp capping, pulpotomy, apexification and repair of root and furcal perforations [9]. Marketed as ProRoot™ (DENTSPLY Tulsa Dental, Tulsa, OK, USA), Angelus™ (Industria de Produtos Odontologicos Ltda, Londrina, Brazil), Neo MTA Plus™ (Avalon Biomed Inc. Bradenton, FL, USA) and NeoMTA™ (Nu Smile, Houston, TX, USA), MTA comprises fine hydrophilic particles containing tricalcium silicate, tricalcium aluminate, tricalcium oxide and silicate [10,11]. Tetracalcium aluminoferrite from iron ports impurities and imparts a grey oxide color [11]. Bismuth oxide, is added for radioopacity [9] without affecting the biocompatibility of MTA [12]. Powder hydration forms a colloidal calcium silicate gel which sets in about 15 minutes or under 3 hours [9]. The pH of MTA after mixing is 10.2, rising to 12.5 after 3 hours and remaining constant over 22 hours [9]. The pH values of 11 - 12 were maintained *in vitro* in the aqueous environment of MTA after 78 days [13], conferring antimicrobial effects against some facultative bacteria [14]. The mean compressive strength of MTA at 21 days is 67.3 (± 6.6) MPa, comparable to that of IRM™ but less than amalgam, therefore it is not used in stress-bearing areas or as a permanent restoration [9]. NeoMTA™ (NuSmile, Huston, USA), on the other hand, is a pure MTA. It is marketed as a cost-effective MTA for pediatric pulp therapy. The powder is provided in a re-sealable vial which facilitates the use of only the needed amount of MTA in each treatment thereby enhancing cost effectiveness. The liquid used for mixing is a gel which makes it easier to mix and apply. In addition, it has a non-staining formulation and a fast setting time [10,15-25].

MTA Biocompatibility

Biocompatibility is defined as the ability of a material to perform with an appropriate response in a specific application [15]. The excellent biocompatibility of MTA is supported by studies of cytotoxicity, subcutaneous and intraosseous implantation, and direct contact with periradicular or pulpal tissues *in vivo* [16]. Cell line studies by Mitchell., *et al*. 1999 and Huang., *et al*. [17,18], suggest MTA induces cytokine expression *in vitro*, in particular interleukins 4, 6, 8 and 10, stimulating formative cell attachment and bone turnover [17,18]. *In vitro*, superior cementoblast adhesion to MTA compared with amalgam and IRM™, and expression of genes for cementogenesis to label MTA as cement-conductive [19]. The levels of osteocalcin, a protein marker suggestive of biomineralization, increased in the presence of MTA [19]. Yaltirik., *et al*. [20] found that after subcutaneous implantation in rats, MTA showed dystrophic calcification and moderate inflammation which resolved by day 90. Saidon., *et al*. [21] implanted MTA into guinea pig mandibles showed minimal inflammation and bone apposition. Torabinejad., *et al*. [22] showed in 6 of 6 root canal apices filled with amalgam in a monkey model showed moderate to severe peri-radicular tissue inflammation and cementum formation at the cut dentinal root ends, 5 of 6 apices filled with MTA showed no peri-radicular inflammation and a complete cementum layer over the root end and root-end filling [22].

Biodentine™ Physical Properties

Biodentine is a two components material: the powder is mainly composed of tricalcium silicates, also contains Di-Calcium silicate as a second core material and Calcium Carbonate and Oxide as filler. The powder contains zirconium oxide as a radio-opacifier. The liquid con-

tains Calcium Chloride as a setting accelerator and a water reducing agent [26]. The presence of a setting accelerator allows the material setting in 12 minutes and the presence of a water reducing agent avoids the formation of cracks within the material. Such cracks are usually observed after setting of cements containing high percentage of water [26]. The material is prepared by adding 5 drops of liquid to the powder present in the capsule. These components are then triturated with an amalgamator for 30s at 4000 rpm leading to the formation of a paste of creamy consistency. The preparation method and proportions between powder and liquid should be respected and applied according to the manufacturer's instructions as these proportions greatly influence the material's setting and mechanical properties. This is of particular significance mainly for applications under mechanical loads such as applications in Class II cavities [26].

Biodentine™ Biocompatibility

Like any other restorative material, Biodentine Biocompatibility was investigated to ensure its safety when applied onto the cells. Evaluation of its genotoxicity on bacteria strains by the Ames test and its effects on the formation of micronuclei by human lymphocytes demonstrated the absence of any mutagenic effect of the material. Similarly, when tested on target human pulp cells, no DNA breaks or damage was observed with the comet assay [26]. These results demonstrated no genotoxic effects of Biodentine *in vitro*. The biocompatibility of the material was also investigated through its direct application to human pulp cells simulating the direct pulp condition and indirectly through a dentin slice to simulate its indirect pulp capping *in vivo*. Under both conditions Biodentine was not found to affect target cell viability under *in vivo* application conditions [27]. When Biodentine was applied onto human pulp cells to investigate its effects on their specific functions by studying expression of odontoblast specific functions such as expression of Nestin (a human odontoblast specific marker) and Dentin Sialoprotein, Biodentine was not found to inhibit the expression of these proteins but rather induce their expression and the cells mineralization capacity [27-29]. Further investigations demonstrated the absence of toxicity of Biodentine to human MG63 human osteoblast cells with the MTT assay with properties comparable to that of MTA [30].

Clinical Reports

MTA

Zaror., *et al*. [23] has perform a study in 7 pulpotomies were performed with MTA and 6 with ferric sulphate (FS), the included patients had primary teeth with accidental exposure of the pulp during caries removal in the absence of clinical signs and symptoms and/or radiographic evidence of pulpal pathology. The treated teeth were restored with preformed stainless steel crowns and controlled clinically and radiographically every 6 months. The average follow-up was 15.6 months for both groups, with clinical success of 100% for both treatments. Radiographic success was 85.71% for the MTA and 83.33% for SF. Similar results were found in a Randomized Clinical Trial (RCT) comparing MTA and FC in pulpotomies of 64 molars that were pulpotomized equally and randomly with MTA and Formocresol [24]. Caicedo., *et al*. [25] performed a study of MTA for direct pulp capping and pulpotomy in 21 carious primary molars reported success rates of 80% (8 of10) in directly pulp-capped molars, and 91% (10 of 11) in pulpotomized molars after 6 months [25]. Although histological evaluation of teeth extracted at 6 months showed pulp necrosis, inflammation, bridging and intrapulpal calcifications, the clinically-favorable pulpotomy response was attributed to bacteria removal, sealing, and low toxicity of MTA. Sakai., *et al*. [26] evaluated thirty primary molars in 30 children which were randomly allocated to the Portland Cement (15 teeth) and MTA (15 teeth) groups. Both groups of the available teeth were clinically and radiographically successful during all the follow-up appointments, no teeth showed signs of mobility, sinus tract, swelling, or inflammation of the surrounding gingival tissue, and none showed radiographs suggestive of internal root resorption and furcation radiolucency.

Biodentine

Clinical application of Biodentine in pulpotomy has been investigated in few clinical studies as a pulpotomy medicament. Akhtar., *et al*. [32] presented a study where 122 patients were treated with pulpotomy and Biodentine was placed in children 4 to 11 years of age. Out

of 122 patients, 115 were radiologically successful. Cuadros-Fernandez., *et al*. [33] performed a randomized clinical study in children of 4-9 years of age. 84 pulpotomies were performed and attributed to MTA or Biodentine. All teeth were restored with stainless steel crowns. Clinical and radiographic evaluations were performed after 6 and 12 months. Data showed that one molar of the MTA group had an internal resorption while 1 molar of Biodentine treated group had internal resorption and another showed a radiographic radiolucency. Over all, both materials had a very high clinical success rate and the overall clinical success after 12 months is reported. Niranjanik., *et al*. [34] evaluated Biodentine and compared it to MTA in a short term clinical study. Biodentine was applied in pulpotomies of 20 teeth followed by restoration with stainless steel crowns. At 3 and 6 months, patients were recalled and Biodentine was shown as equally efficient as MTA with similar radiographic success [34]. Kusum., *et al*. [35] performed a study comparing Biodentine to MTA and propolis as pulpotomy medicaments. After 9 months, Biodentine and MTA showed comparable results with a high radiographic success rate and more favorable than Propolis. Finally, a confirmation of all these data reported no significant differences between MTA and Biodentine used as pulpotomy medicaments with clinical success higher than 95% for both materials [36].

Conclusion

The reviewed information suggests that both MTA and Biodentine offer excellent biocompatibility as well as clinical and radiographic success rates enabling is application in pulpotomies of primary teeth. The use of these regenerative materials should be encouraged. In result of the scarce clinical information, more randomized clinical trials are recommended.

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