BIODENTINE- A REVIEW ARTICLE ON ITS CHEMICAL CHARACTERISTICS AND CLINICAL APPLICATIONS

A REVIEW

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ABSTRACT

Biodentine is a calcium-silicate based material that has drawn attention in recent years. It has been introduced by the Septodont Company in 2010 as the "the first all-in-one, bioactive and biocompatible material for damaged dentin replacement".It is a second generation hydraulic calcium silicate material that is composed mainly of tricalcium silicate and it also contains zirconium oxide radiopacifier and some additives and has been advocated to be used in various clinical applications, such as root perforations, apexification, resorptions, retrograde fillings, pulp capping procedures. The purpose of this article is to review the clinical applications and advantages of biodentine over MTA in the operative endodontic procedures.Although number of materials like Amalgam, GIC, Composite and MTA are available in market for repair of dentin loss in tooth structure, none of these possesses ideal properties. Thus its major advantages and unique features gives biodentine, a great potential to revolutionize the different aspects of both the primary and permanent tooth in endodontics.

Key words: Biodentine; Dentine Replacement; Composition; Setting reaction; Clinical Applications; MTA

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INTRODUCTION

Calcium silicate based materials have gained popularity in recent years due to their resemblance to mineral trioxide aggregate (MTA)[1]. However there exist some drawbacks of this material such as slow setting kinetics and complicated handling properties. The Minimal Intervention philosophy has seen a shift towards the biological non-operative management of teeth. Intervention when required has become more effective and predictable with the advent and development of technologies to support this approach. One such material is biodentine, known as "dentine in a capsule", a biocompatible and bioactive dentine substitute which overcomes the draw backs of Calcium hydroxide and Mineral trioxide[1].

The preservation and protection of the dental pulp with specific emphasis on regeneration is the new treatment strategy in the fields of paediatric dentistry, endodontics and dental traumatology. The use of hydraulic calcium silicate cement apparently stimulates pulpal cell recruitment and differentiation, up-regulates transformation factors (gene expression), and promotes dentinogenesis[2]. Compared to others calcium based cements, biodentine presents two advantages: i) a faster setting time of about 12 minutes and ii) higher mechanical properties. These physico-chemical properties associated with the biological behaviour suggest that it may be used as a permanent dentine substitute [3].

CHEMICAL CHARACTERISTICS

Composition: The powder component of the material Biodentine consists of tricalcium silicate, dicalciumsilicate, calciumcarbonate and oxide filler, iron oxide shade, and zirconium oxide. Tricalcium silicate and dicalciumsilicate are indicated as main and second core materials, respectively, whereas zirconium oxide serves as a radiopacifier. The liquid, on the other hand, contains calcium chloride as an accelerator and a hydrosoluble polymer that serves as a water reducing agent. It has also been stated that fast setting time, one unique characteristics of the product, is achieved by increasing particle size, adding calcium chloride to the liquid component, and decreasing the liquid content. The setting period of the material is as short as 9-12minutes. This shorter setting time is an improvement compared to other calcium silicate materials[4]. The material is characterized by the release of calcium when in solution[5]. Tricalcium silicate based materials are also defined as a source of hydroxyapatite when they are in contact with synthetic tissue fluid [6-8].

Setting reaction: The reaction of the powder with the liquid leads to the setting and hardening of the cement. The hydration of the tricalcium silicate leads to the formation of a hydrated calcium silicate gel (CSH gel) and calcium hydroxide. The cement located in inter-grain areas has a high level of calcite (CaCO3) content. The hydration of the tricalcium silicate is achieved by dissolution of tricalcium silicate and precipitation of calcium silicate hydrate. In general, it is designated by chemists as C-S-H (C=CaO, S=SiO2, H=H2O). The calcium hydroxide takes origin from the liquid phase. C-S-H gel layers formation is obtained after nucleation and growth on the tricalcium silicate surface. The unreacted tricalcium silicate grains are surrounded by layers of calcium silicate hydrated gel, which are relatively impermeable to water; thereby slowing down the effects of further reactions. The C-S-H gel formation is due to the permanent hydration of the tricalcium silicate, which gradually fills in the spaces between the tricalcium silicate grains. The complete hydration reaction is summarized by the following formula[9].

$$2(3CaO.SiO2) + 6H2O \rightarrow 3CaO.2SiO2.3H2O + 3Ca(OH)2$$

CLINICAL APPLICATIONS

1. Pulp capping and dentine replacement

Biodentine is calcium ion releasing with the initial rate of release higher than other similar material types, thus it is ideal for use as a pulp capping material[10]. The Biodentine surface exhibits the thickest surface calcium concentration compared toProRoot MTA, Dycal and Theracal. Dentine bridge formation is evident clinically when Biodentine is used for direct pulp capping. Clinical cases showing evidence of irreversible pulpitis that were treated with Biodentine exhibited reduction in the sizes of the apical areas when evaluated with cone beam computed tomography[11]. The pulpal reaction to Biodentine is similar to other similar material types like mineral trioxide aggregate with favourable cell proliferation and alkaline phosphatase activity of human dental pulp cells. The calcium releasing ability contributes also for the antimicrobial properties of Biodentine. This property is important since dental caries is a bacterial induced disease. Biodentine exhibits adequate antimicrobial properties and which were lower than calcium hydroxide pulp capping materials. However, the increase in the antimicrobial properties of calcium hydroxide was accompanied by higher cytotoxicity[12].

Furthermore its physical properties allow the material to be used in bulk thus avoiding unnecessary layering and interfaces that can allow micro-leakage and restoration failure. In fact Biodentine shows less micro-leakage than resin-based dentine replacement material. Placing a final restoration over Biodentine can be challenging as it is water-based. The final restoration should be delayed for at least 2 weeks and both total etch and self-etch adhesives can be used. Biodentine was shown to be able to restore teeth for up to six months and when overlayed with a composite resin it provided an effective dentine replacement material[13].

2. Pulpotomy procedures

More advanced pulp involvement particularly in primary teeth will necessitate pulpotomy procedures to be undertaken. Biodentine exhibited better cytocompatibility and bioactivity than MTA Angelus, Theracal and IRM in contact with stem cells isolated from human exfoliated primary teeth[14]. Clinically, high success rates were shown in pulptotomy procedures performed with Biodentine in primary molars showing more favourable results than formocresol, which is the standard treatment methodology. When compared to calcium hydroxide in vital pulpotomies in primary molars the group treated with Biodentine revealed favourable regenerative potential along with clinical success sharing both indications and mode of action with calcium hydroxide, but without its drawbacks of physical and clinical properties[15]. Pulpotomy with Biodentine resulted in a predictable clinical outcome similar to that of MTA. Biodentine was superior to less standard treatment methodologies like laser and propolis. Biodentine used for pulpotomy procedures does not cause tooth discolouration [16].

3. Treatment of the immature apex

Once the pulp tissue is lost, it is necessary to fill the root canal space. Immature teeth present a problem due to their anatomy as the roots are short and thin and routine canal obturation is difficult due to the root canal configuration[17]. The thin dentine walls are also at risk of fracture. Apexification procedures allow the formation of a calcific barrier at the root apex thus closing off the root-end from the periapical space. A calcific bridge is created by providing an environment where calcium ions from the dentine form a calcific bridge. Such conditions are created by materials releasing calcium hydroxide. Apexification with hydraulic calcium silicate cements as apical plugs permits apexification procedures to be performed in two visits. The two visits were necessary since MTA has a long setting time and needs to set prior to the placement of the final restoration[18]. More recently it was shown that apexification with an apical plug of Biodentine a single visit is enough since wetting the surface of the material did not affect the material properties. This treatment methodology can be considered as predictable, and may also be an alternative to the use of calcium hydroxide. The hydraulic nature of these material types and the formation of calcium hydroxide make these materials ideal for such procedures. Biodentine has been shown to release more calcium ions in solution than MTA. Its hydration is optimised by the addition of calcium carbonate as a nucleating agent spiking up the reaction rate in the early stages. The addition of calcium chloride accelerator and the water soluble polymer allow low water/powder ratios. The fracture resistance of immature teeth with an apical plug of Biodentine was similar to that of MTA and higher than the control[19]. Biodentine has also been used successfully in cases of regenerative endodontics. The fracture resistance in the cases was also reported to be similar to that of MTA. Biodentine showed the least discolouration potential when used in these clinical cases, thus it is the material of choice for regenerative endodontics, especially for cases where aesthetics is a concern[20].

4. Root end filling and perforation repair

Materials used for root-end filling need to exhibit specific properties since they have to perform and attain clinical success under very adverse conditions. The hydraulic nature of all tricalcium silicate cements is thus a desirable property. In fact these material types were invented for this purpose. The main issue with the hydraulic cements is that they react with the environment they are placed in[21]. At the root-end the materials are placed in contact with blood as soon as they are placed. They are also in contact with the root dentine and remnants of gutta-percha and sealer used to obturate the root canal. The physical properties of Biodentine are not adversely affected by contact with tissue fluids and blood[22]. The bond strength of Biodentine was better than that of MTA when used as a root-end filling material. Both materials were adversely affected by blood contamination. Less bacteria in apical root dentine were found when cases were treated with Biodentine and compared to MTA indicating that the antimicrobial properties of Biodentine are superior too those of MTA[23]. The biocompatibility of Biodentine was considered to be marginally better than that of MTA with better cell adhesion to the materials when it was used as a root-end filling material. Biodentine was also found to be adequate to repair root perforations producing a positive tissue response and mineral deposition at the perforation site. This response is related to the release of calcium hydroxide in solution. It also seals well the area since perforations are inadvertently highly infected thus an adequate seal is necessary[24]. Root perforation repair materials are also subject to dislodgement during tooth restoration. Biodentine shows high early push-out bond strength which did not deteriorate in contact with blood. Furthermore it was not affected by the irrigating solutions used indicating material stability[25].

CONCLUSION

The clinical uses of bioceramics have increased exponentially over the years because of their wide range of applicability in restorative dentistry and endodontics. The introduction of MTA was considered as a major break-through in the history of material science and since then the properties of this material have been improvised in order to achieve its maximum benefits. However, there have been a few limitations of this material which have always compelled the researchers worldwide to look for its alternatives. Difficult manipulation, slow setting time and high cost are the ones to name a few. In order to overcome these limitations, a new bioceramic material named Biodentine was introduced in the year of 2010 which has proved to be a second major break-through. Relatively easier manipulation, low cost and faster setting is the major advantages of this material when compared to MTA. Studies have also proved that its compressive and flexural strength are superior to that of MTA. High biocompatibility and excellent bioactivity further go in favour of this dental replacement material.The good handling properties of Biodentine associated with its favourable biological, mechanical and physical properties indicate that material can be used efficiently in clinical practice as a pulp capping agent and as an endodontic repair material. The easy handling and fast setting time are the major advantages in comparison to other similar materials available commercially.

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