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Biodentine: A review

Hannah Saju Padiken* and Swathi

Department of Conservative Dentistry and Endodontics, A.J Institute of Dental Sciences, Mangalore, Karnataka, India.

Corresponding author: *Dr. Hannah Saju Padiken, Department of Conservative Dentistry And Endodontics, A.J.Institute of Dental Sciences, NH-66, Kuntikana, Mangalore - 575004, India.

Abstract

Biodentine was developed as a new class of dental material which could conciliate high mechanical properties with excellent biocompatibility, as well as a bioactive behaviour. Biodentine fulfils the requirements found in the literature for a material suitable for biocompatibility, long-term impermeability, antibacterial properties, induction of hard tissue regeneration, stability, low solubility, non-absorbability and ease of handling. An ideal orthograde or retrograde filling material should seal the pathways of communication between the root canal system and its surrounding tissues. It should also be non toxic, non cariogenic, biocompatible, insoluble in tissue fluids, and dimensionally stable. Since existing materials did not have all these ideal characteristics, a new bioactive cement – Biodentine was introduced with all these ideal properties. It overcomes the drawbacks of Calcium hydroxide and Mineral trioxide aggregate. It is a promising material for repair of perforations of the pulpal floor, apexifications, open immature tooth, retrograde filling, pulp therapy. In this article the availability, composition, manipulation, mechanism of action, properties, clinical implications of biodentine has been reviewed.

Keywords: Biodentine, pulp capping material, dentine substitute, bioactive cement

Introduction

Mineral trioxide aggregate (MTA) and its wide range of applicability has taken dentistry by storm and recently the development of calcium silicate based cements with their resemblance to MTA has gained popularity recently. Out of the various calcium silicate based products which has been launched to the market recently, Biodentine has been the focus of attention and the topic for a variety of investigations that became commercially available in 2009 (Septodont, http://www. septodontusa.com/). Biodentine is a newly developed biologically active cement which has mechanical properties similar to dentine. Regarding biocompatibility, long-term impermeability, antibacterial properties, induction of hard tissue regeneration, stability, low solubility, non-absorbability and ease of handling, Biodentine fulfils the requirements for a material suitable for these purposes. This cement is an upcoming alternative to the conventional materials which were hitherto recommended.

Biodentine has a wide range of applications including pulp capping, endodontic repair such as root perforations, apexification, resorptive lesions, and retrograde filling material in endodontic surgery, and can be used as a dentine replacement material in restorative dentistry. Biodentine can be used both in the crown and in the root. In the crown region it is used as a base, provisional seal, for deep caries therapy, as a cervical filling, for direct and indirect pulp capping and in pulpotomies. In the region of the root, Biodentine can be used for the treatment of perforations of the root canal or pulp chamber floor, internal and external absorption processes, for apexification and as a retrograde root canal filling material. On one hand, Biodentine serves as a dentine replacement, and on the other hand it is used for maintaining the vitality of the dental pulp or stimulation of hard tissue regeneration, i.e. both tertiary dentine formation and also bone regeneration, e.g. after root end surgery. The material is actually formulated using the MTA-based cement technology and the improvement of some properties of these types of cements, such as physical qualities and handling. This review article makes a general analysis, provides a summary of studies on Biodentine, and critically evaluates the existing knowledge regarding the properties of the product. Articles were retrieved that were published since the launching of the material into the market and classified according to the topic that they focused on.

Composition

Powder component of biodentine consists of Tri-calcium silicate, Di-calcium silicate, Calcium carbonate & oxide, Iron oxide and Zirconium oxide. Liquid consists of Calcium chloride and Hydrosoluble polymer.[1]

Tricalcium silicate and dicalcium silicate 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 [2].

Manipulation

The powder is mixed with the liquid in a capsule in the triturator for 30 seconds. The initial setting is 9-12 minutes [3].

Properties of biodentine

Setting time

The setting time of Biodentine was investigated by Grech at al. using an indentation technique while the material was immersed in Hank’s solution. The setting time of Biodentine was determined as 45 minutes[4]. This short setting time was attributed to the addition of calcium chloride to the mixing liquid. Calcium chloride has also been shown to result in accelerated setting time for mineral trioxide aggregate[5]. The product sheet of Biodentine indicates the setting time as 9 to 12 minutes, which is shorter than the one observed in the study by Grech et al.. However, 9–12 minutes indicated in the product sheet is the initial setting time, whereas Grech et al. evaluated the final setting time[4].

Specific property of biodentine as dentine substitute

Elastic modulus, at 22.0 Gpa, is very similar to that of dentine at 18.5[6]. Compressive strength of about 220 MPa is equal to average for dentine of 290 MPa[6]. Microhardness of Biodentin at 60 HVN is same as that of natural dentin[6]. Acid resistance in acid erosion tests showed that the tricalcium silicate material presented with less surface disintegration. There was a deposition of apatite like calcium phosphate crystals on the surface. This results in improved the interface between the dentine substitute, Biodentine and the adjacent phosphate-rich hard tooth substance[6].

Bond strength

Biodentine has significantly higher push-out bond strength than MTA (p<o.5). The statistical ranking of push out bond strength values are DyractAP>amalgam≥IRM≥ Biodentine>MTA. The push out bond strengths of Dyract AP, amlgam, IRM and biodentine were not significantly different when immersed in sodium chloride, chlorhexidine and saline solution whereas MTA has lost its strength when exposed to chlorhexidine. Hence biodentine shows considerable performance as a perforation repair material even after being exposed to various endodontic irrigants [7].

Porosity and material dentine interface analysis

Tricalcium silicate based materials are indicated in cases such as perforation repair, vital pulp treatments, and retrograde filings where a hermetic sealing is mandatory. Therefore, the degree of porosity plays a very important role in the overall success of treatments performed using these materials, because it is critical factor that determines the amount of leakage. In case the procedure is a retrograde filing where there is a continuously moist environment, lesser porosity that occurs by Biodentine is advantageous[7]. However, in procedures such as liners, bases, or dentine replacement, the material is generally kept dry which might pose a problem in terms of porosity and result in the formation of gaps at the interface, leading to bacterial passage. This leads to the conclusion that caution must be exercised during the selection of Biodentine in certain clinical conditions where moisture is not necessarily present.

Radiopacity

Contrary to bismuth oxide which is the radiopacifier used other materials, Zirconium oxide is the radiopacifier used in Biodentine. It is preferred over bismuth oxide due to its biocompatible characteristics and favourable mechanical properties and resistance to corrosion [8]. The drawback to the usage of Zirconium oxide is that it is not adequately visible on a radiograph which poses difficulties in practical application of Biodentine [9].

Solubility

Grech et al.[4] demonstrated negative solubility values for a prototype cement, Bioaggregate, and Biodentine, in a study assessing the physical properties of the materials. They attributed this result to the deposition of substances such as hydroxyapatite on the material surface when in contact with synthetic tissue fluids. This property is rather favourable as they indicate that the material does not lose particulate matter to result in dimensional instability.

Microleakage

The good marginal integrity of Biodentine with the ability of calcium silicate materials to form hydroxyapatite crystals at the surface was explained by Koubi et al[10]. These crystals might have the potential to increase the sealing ability, especially when formed at the interface of the material with dentinal walls. Furthermore, the interaction between the phosphate ions of saliva and the calcium silicate based cements might lead to the formation of apatite deposits, thereby increasing the sealing potential of the material. Slight expansion was also noted for these materials which contributed to their better adaptation.

Wash-out resistance

Washout of a material is defined as the tendency of freshly prepared cement paste to disintegrate upon early contact with fluids such as blood or other fluids. Biodentine demonstrated a high washout resistance with every drop used in the methodology[4]. The authors attributed this result to the surfactant effect water soluble polymer added to the material to reduce the water/cement ratio[11].

Tissue regeneration and early mineralisation

Biodentine induces early mineralization by increasing the secretion of TGF-β1 from pulpal cells after its application[12]. It also acts by odontoblasts stimulation and cell differentiation, there by facilitating reactionary and tertiary dentin formation. Majorie et al suggested that biodentine is bioactive because it increased OD- 21 cell proliferation and it can be considered as a suitable material for clinical indications of dentine-pulp complex regeneration [3].

Antibacterial property

The high alkaline pH of Biodentine has inhibitory effect on the microorganisms. In addition, the alkaline change leads to the disinfection of surrounding hard and soft tissues[13].

Good material handling

Ease of manipulation, better consistency, safety handling with favourable setting kinetics – about 12minutes [14].

Biocompatibility

Biodentine preserves pulp vitality and promotes its healing process [15]. Laurent et al concluded that the Biodentine material is biocompatible. The material was not found to affect the specific functions of the target cells and thus could safely be used [16]. The study by About et al concluded that bio dentine is stimulating dentine regeneration by inducing odontoblast differentiation from pulp progenitor cells [17]. Laurent et al did further study to investigate the capacity of biodentine to affect TGF-β1 secretion from pulp cells and to induce reparative dentine synthesis. Biodentine was applied directly onto the dental pulp in a human tooth culture model, resulting in a significant increase of TGF-β1 secretion from pulp cells and thus inducing an early form of dental pulp mineralization shortly after its application [18]. It does not affect human pulp fibroblast functions, expression of collagen1, dentine sialoprotein & Nestin [19][20][21]. It is non-genotoxic.

Clinical implications of biodentine

Pulp capping

Biodentine can be used as pulp capping agent since it causes early mineralization by release of TGF – β from pulpal cells to encourage pulp healing and by odontoblast stimulation for dentine bridge formation to protect the pulp. Calcium hydroxide is formed during the setting of the cement. Due to its high pH, Calcium hydroxide results in irritation of the exposed area, which result in a zone of coagulation necrosis that has been suggested to cause division and migration of precursor cells to substrate surface; resulting in addition and cyto-differentiation into odontoblast like cells [22]. Alicja Mowicka et al reported that the majority of specimens showed complete dentinal bridge formation and absence of inflammatory pulpal response of human dental pulp capped with Biodentine. Layers of well arranged odontoblast and odontoblast –like cells were formed to tubular dentine under the osteodentin. Therefore he concluded that within the limitations of his study Biodentine had a good efficacy in the clinical setting and may be considered as an interesting alternative to MTA in pulp capping treatment during vital therapy [23].

Repair of root perforations and apexification

To overcome all the draw backs of calcium hydroxide and MTA such as poor bonding to dentin, material resorption, mechanical instability, poor setting kinetics and poor handling properties; biodentine is used due to its appreciable properties like ease of handling, faster setting kinetics, biocompatibility, early mineralisation [24]. Expression of odontoblastic markers and increased TGF-Beta1 secretion from pulpal cells enables early mineralization. Calcium hydroxide has been suggested to cause division and migration of precursor cells to substrate surface; resulting in addition and cyto-differentiation into odontoblast like cells. Thereby Biodentine induces apposition of reactionary dentine by odontoblast stimulation and reparative dentin by cell differentiation [25].

Root end filling

The purpose of root end filling material is to establish an impermeable seal of all the apical avenues of the root canal system and prevent the percolation of bacteria and their products between the root canal systems and periradicular tissues. Many materials have been used as root end filling agents but the main disadvantage is their failure to prevent leakage and the lack of biocompatibility. Requirements of ideal root end filling material is to adhere or bond to tooth tissue, be dimensionally stable, unaffected by moisture in either the set or unset state, be well tolerated by periradicular tissues with no inflammatory reactions, stimulate the regeneration of periodontium and be non toxic both systemically and locally [26][27][28]. Zinc present in the amalgam is considered Cytotoxic [29][30], Eugenol is the main cytotoxic component in the Zinc Oxide Eugenol cements [31][32], Glass Ionomer Cement is greatly affected by moisture and blood during the initial setting time, resulting in increased solubility and decreased bond strength [33][34], MTA had a good sealing ability, marginal adaptation but it has a drawback of long setting time of about 45minutes to 2hours [35]. Biodentine stimulates dentine regeneration by inducing reparative dentine synthesis. Biodentine has better consistency, better handling, safety and faster setting time which prevents a need for two step obturation [35].

As dentine substitute

Due to its dentine like mechanical properties Biodentine can be used as an dentine substitute [36]. The results of a study by Josette Camalleri et al are obtained as, acid etching resulted in erosion of material surface with exposure of glass particles in the glass ionomer based materials, Biodentine exhibited a reduction in the chlorine peak and calcium silicon ratio when etched. Biodentine exhibited leakage both when it was etched and also when the surface was left unprepared. When used as a dentine replacement material in the sandwich technique over layered with composite, significant leakage occurred at the dentine to material interface [37]. Further studies are required to investigate on the usage of biodentine as dentine replacement material.

Conclusions

Biodentine was introduced in 2009, since then it has been a popular material of choice in a lot of clinical aspects. It has been evaluated since its launch in a number of aspects. The disadvantages of the older materials have paved a way for the use of Biodentine which has better properties. Due to major advantages and appreciable properties and ability to achieve biomimetic mineralisation, Biodentine has great potential to revolutionise the management of affected tooth in the operative dentistry and endodontics. The studies that have already been done are generally in favour of this product in terms of physical and clinical aspects despite a few contradictory reports. Though further studies are required to extend the future scope of this material, Biodentine holds promise for clinical dental procedures as a biocompatible and easily handled product with short setting time.

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