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Review Article

Biodentine- A Review on its Properties and Clinical Applications

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Abstract

Ever since the introduction of Biodentine it has gained popularity which is because of its superior mechanical and biological characteristics that makes it a versatile material to be use for various clinical applications. The most important properties are its shorter setting time, biocompatibility and lesser possibilities to cause discoloration compared to other calcium silicate based cements because of these characteristics it has been used in various clinical applications such as Pulp capping, Pulpotomy, Apexification, Regenerative procedures, in Internal and External root resorption, for Perforation repair and as Root end filling material. This review article highlights various properties of Biodentine and its clinical applications.

Key words: Biodentine, Biocompatability, Sealing ability, Vital pulp therapy.

Introduction

Biodentine which is a calcium silicate-based cement has recently gained popularity due to its resemblance to MTA in the recent years. It is specifically designed as dentin replacement material to be used for endodontic repair like root perforations, resorptive lesions, apexification re trograde filling and pulp capping in restorative dentistry. It was introduced as commercial product by Septodont in 2009. Ever since then various studies have been conducted on its physical, chemical and biological properties. This article combines the literature evidence that are available on Biodentine till date [1].

Composition

Biodentine has two components: a powder and a liquid. The powder is available in a capsule while the liquid in an ampule [4]. The powder is composed of tricalcium silicate and dicalcium silicate as a core material, calcium carbonate (an oxide filler), iron oxide (for shades) and zirconium oxide (a radiopacifier). The liquid contains calcium chloride (an accelerator) and hydrosoluble polymer which acts as water reducing agent [2, 4].

Setting Time

Initial setting time of Biodentine is about 9-12 min as indicated by the manufacturers. However, in some studies it has been reported that, initial setting time to be 6.5 ± 1.7 min. According to the ISO (International Organization for Standardization) guidelines 9917-1:2007, the setting time of Biodentine was reported as 15 ± 1 min. On contamination with saliva and blood the setting time increases by 1 ± 6.51 min and 16 ± 8.21 min respectively [4].

Setting Reaction

The powder is mixed with the liquid in a capsule and triturated for 30 seconds. The reaction of powder with the liquid leads to the setting and hardening of the cement [4]. The hydration of the tricalcium silicate (by dissolution of tricalcium silicate and calcium hydroxide precipitation) leads to the formation of a hydrated calcium silicate gel (CSH gel) and calcium hydroxide. Unreacted grains of tricalcium silicate are surrounded by calcium silicate hydrated gel [3].

Bond Strength

Biodentine exhibited shear bond strength of 3MPa after 2 days and thrice the initial bond strength within one week. The bond strength of biodentine when used as dentine substitute and permanent restoration has been tested in various studies. Odabas et al. 2013 tested shear bond strength of Biodentine with etch and rinse, two-step and one step self-adhesive and found no difference in the shear bond between adhesive groups [9].

Push Out Bond Strength

Biodentine had a significantly higher push-out bond strength after 24 hours when compared to MTA. However, after 7 days both exhibited similar values in uncontaminated samples [3]. Aggarwal et al. 2013 compared push-out bond strength of Biodentine, Pro root MTA and MTA plus for furcation repair within 24 hours and found that push out bond strength was less for MTA in comparison to Biodentine [10].Blood contamination did not have significant effect on push-out bond strength of Biodentine, irrespective of duration of setting [3].

Compressive Strength

Compressive strength is an important property of Biodentine for it to take up high masticatory load [1]. Compressive strength was found to be 10.6 ± 2, 57.1 ± 12 and 72.6 ± 8 MPa after 35 min, 24 h and 28 days, respectively. The greater strength is due to low water/ cement ratio due to presence of water-soluble polymer in liquid [4]. Gerch et al. 2013 showed that compressive strength of Biodentine was highest when compared to all other material. This is attributed to the reduced water powder ratio [7]. According to Koubi et al. 2013 Biodentine showed favorable surface properties such as good marginal restoration when used as a posterior restoration until 6 months, hence can be used as posterior interim restoration [8].

Flexural Strength, Elastic Modulus, Hardness.

Physical properties of Biodentine such as elastic modulus (22,000 MPa), flexural strength (34 MPa), and Vickers hardness (60 HV) are higher when compared to MTA but found to be similar to dentin [3,4].

Microhardness

Hardness is defined as the resistance to plastic deformation of the surface of a material after indentation or penetration. The mean Vickers micro hardness value for Biodentine was 62.35 (±11.55) HV which is approximately 2.5 times higher than for ProRoot MTA with 26.93 (±4.66) with significantly higher difference [3]. Camilleri et al. 2013 in a study compared the physical properties of Biodentine with a conventional glass ionomer (Fuji IX) and resin modified glass ionomer (Vitrebond). Results showed that Biodentine exhibited higher surface microhardness when compared to the other materials when unetched [6].

Density and Porosity

Porosity has shown to have impact on various factors like adsorption, permeability, strength, and density [1]. Mean porosity percentage for Biodentine is 7.09 ± 1.87 which is lower than ProRoot MTA. Density and porosity of Biodentine is equivalent to Fuji IX [3]. Camilleri et al. 2013 reported that Biodentine is less porous and denser when compared to MTA [6].

Radiopacity

Radiopacity is an important property when used as retrograde or repair material as they are applied in low thickness and they need to be easily detected from surrounding tissues. Zirconium oxide is used as a radiopacifier in Biodentine [1]. All Calcium Silicate cements showed radiopacity above 3mm Al which is 4.1mm Al. ProRoot MTA (6.40 (±0.06) mm Al) was significantly more radiopaque than Biodentine (1.50 (±0.10) mm Al) [3].

Microleakage

Microleakage is to be considered when Biodentine is used in vital pulp therapy and deep caries management as they can cause secondary caries or post-operative sensitivity. Biodentine has the ability to form hydroxyapatite crystals at dentin and restorative interface. Koubi et al.2013 assessed the marginal integrity of Biodentine and resin modified GIC and showed that after one year both had similar sealing ability [8].

Discoloration

Discoloration is due to presence of transitional elements like iron, manganese, copper and chromium which imparts strong color to the material in its oxide form. Bismuth being heavier element cause discoloration due to its yellow oxide. Valles et al. 2013 studied the color stability of Biodentine when placed under esthetic composite resin restoration. Results showed that upto 5 days Biodentine and Portland cement maintained color stability, hence it can be used in esthetic areas [12].

Washout Resistance

It is defined as the tendency of a freshly mixed cement to disintegrate on early contact with fluids such as blood [1]. In a study conducted by Grech et al. 2013 on comparing Biodentine with Bioaggregate and IRM it has been demonstrated that Biodentine demonstrated highest washout resistance [7].

Fluid Uptake, Sorption and Solubility

Compared to IRM Biodentine exhibited considerably lower fluid uptake, solubility and water sorption. It exhibited higher release of calcium ion and solubility when compared to MTA [3].

Resistance to Acid

Resistance to acidic environment is relevant when concerning the durability of water based cements in the oral cavity. Laurent et al. 2011 investigated the acid erosion and the effects of aging of Biodentine in artificial saliva and concluded that the erosion of Biodentine in acidic solution is limited and lower than that of other water based cements (Glass Ionomers) [13]. In reconstructed saliva a crystal like deposition of Biodentine which is due to rich phosphate environment was found in interface between Biodentine and natural dentin [4].

Mechanical Adhesion to Dental Structures

The mechanical adhesion of Biodentine to dental surfaces is a result of crystal growth within dentine tubules leading to a micromechanical anchor. The deposition of apatite structures and the possible ion exchanges between the cement and dental tissues may eventually contribute to the adhesion of the cement [4].

Antibacterial Activity

Zayed et al. 2015 evaluated the antibacterial potential of dental cements on the growth of the colonies of Streptococcus mutans. All bioactive cements when tested had shown zones of bacterial inhibition but with different diameter, however the largest inhibition zone was observed with Biodentine, followed by light cured resin modified glass ionomer group. Light cure Calcium Hydroxide showed the smallest inhibition zone with significant difference between all groups [5].

Biocompatibility

When dental material are used in close proximity to connective tissue and blood vessels cytotoxicity should be assessed before its use [11]. Laurent et al. 2011 in a study showed that Biodentine increased the production of transforming growth factor beta (TGF-ß) which helped in angiogenesis, recruitment of progenitor cells and in vital pulp therapies [13]. Zhou et al. 2013 compared the cytotoxicity of Biodentine with that of GIC, and it was observed that Biodentine was less cytotoxic on fibroblast than GIC, at an interval of 1 and 7 days. Influence of Biodentine on proliferative, migratory, and adhesion effect of different concentrations of the material on human dental pulp stem cells (hDPSCs) obtained from impacted third molars were assessed. Results showed increased proliferation of stem cells at 0.2 and 2 mg/mL concentrations while the cellular activity decreased significantly at higher concentration of 20 mg/ml [14].

Clinical Applications of Biodentine:

Vital Pulp Therapies:

1. **Pulp capping:**

The effectiveness of Biodentine as a pulp capping material is by their Ca^{2+} and OH^- releasing ability. The hydroxyl ions increases the pH which contributes to the antibacterial activity. This alkaline pH also activates the tissue enzymes that take part in mineralization[15]. Biodentine was designed to be a permanent and biocompatible dentin substitute which could be applied in one session with composite resin using sandwich technique[16]. Biodentin formulations has been found to produce satisfactory results both clinically and histologically when used as direct and indirect pulp capping materials. The desirable properties of Biodentine which makes it a good material are that it has

I. Good sealing ability.
II. Short setting time.
III. Biocompatability.
IV. Bioactivity.
V. Biomineralization.
VI. Mechanically stronger.
VII. Less soluble.
VIII. Tighter seal.

It contains desirable properties of Calcium hydroxide and devoid of the disadvantages of calcium hydroxide[17].

2. Pulpotomy:

Compared to the traditional formocresol in primary tooth pulpotomy, Biodentine is considered to be material that maintains the pulp vitality, however formocresol is a devitalising agent which primarily acts as a dressing agent and requires a restorative material to seal the pulp chamber however a filling material is not needed in case of Biodentine[18]. A retrospective study by Caruso et al., where they have evaluated the clinical and radiographical outcomes of Calcium Hydroxide and Biodentine in primary tooth pulpotomies, they had concluded that biodentine had exhibited a higher clinical and radiographic sucess rate compared to Calcium Hydroxide[19].

Apexification:

The major disadvantage of using calcium hydroxide for apexification is that it requires a long term followup, in contrast Biodentine allows for a single visit apexification procedures and this barrier will prevent the penetration of toxins and bacteria from the root canal as well as this barrier allows for compaction of root filling material[20]. Abbas A et al., evaluated the efficacy of MTA and Biodentine as apical barriers in immature permanent Teeth and they found that the sealing capabilities was similar for both MTA and Biodentine irrespective of its thickness and better seal was created when Biodentine was used in increased thickness[21].

Regenerative procedures:

Biodentine has been used as coronal plug in regenerative procedures sucessfully[22]. One of the important property which makes Boidentin a suitable alternative to MTA is that it does not induces discoloration. Other desirable properties of for it to be used for regenerative procedures is that its shorter setting time compared to MTA and ease of handling[23].

Internal root resorption:

Biodentine is considered to reinforce the weakened root structure. A combination of biodentine and thermoplasticised guttapercha obturation leads to a three dimentional obturation along with the induction of remineralisation and healing. Considering the thin and weakened root structure in resorbed root biodentin might reinforce the root and will lead to a better prognosis. The desirable properties which makes it an ideal material for repair of perforations is that, oving to its setting time it is used in single visit obturation along with thermoplasticised gutta percha. It also promotes the growth of apatite crystals thereby increasing marginal sealing of the material[24].

External root resorption:

Biodentine is used to fill the resorptive area in external root resorption after debridement[25]. Biodentine is mostly indicated for those lesions that are closer to pulp or when it is perforated. The properties of the material which makes it useful in cases of external root resorption are its excellent sealing ability, biocompatability and antibacterial properties not only this it also promotes reparative dentin and cementum formation as well as osteoblast differentiation. One other important property which makes it useful in cases of external resorption is that it lesads to the periodontal attachment. It also allows for the placement of a restorative material when the defect happens in a labial direction[26].

Perforation repair:

Biodentine is also being used for the repair of iatrogenic perforations. It has also been found that it does not interact with root canal irrigants. The setting time of biodentin also makes it a suitable material for repair of furcal perforations[27]. Study by Mancino D et al., has shown that biodentine is a highly effective repair material even for old infected perforations with a success rate of 94%[28].

Root end filling material:

The apical circumstances is found to be more complex as compared to furcation area and root canals. The biocompatability of this material with the periodontal ligament cells and the sealing ability is of utmost importance. Biodentine is found to exhibit good biocompatability with the periodontal ligament cells and the sealing ability is also found to be better compared to MTA[29].

Conclusion:

Although long term studies on biodentine is lacking, This calcium silicate based cement with its numerous advantages over the conventionally available materials serves as one of the promising material for various treatment procedures in the primary and permanent teeth, hence further Clinical studies in this material can lead to increase the usage of the material in day to day practice.

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