International Journal Dental and Medical Sciences Research
Volume 5, Issue 3, May - June 2023 pp 738-742 www.ijdmsrjournal.com ISSN: 2582-6018

Biodentine™- A Review

Dr Ashmi.A, Dr Jyoti. S. Issac, Dr Sheba Mariam Shaji
Post Graduate Student, Dept Of Pediatric And Preventive Dentistry Azeezia Dental College Kollam.
Professor, Dept Of Pediatric And Preventive Dentistry Azeezia Dental College Kollam.
Post Graduate Student, Dept Of Pediatric And Preventive Dentistry Azeezia Dental College Kollam.

Date of Submission: 20-06-2023 Date of Acceptance: 29-06-2023

I. INTRODUCTION

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[1]. Advancements in both biomaterial and cellular level has led to the development and modification of many new dental cements. Calcium silicate based materials have gained popularity in recent years due to their resemblance to mineral trioxide aggregate (MTA) and their applicability in cases where MTA is indicated. Hydraulic calcium silicate cements are bioactive materials showing a dynamic interaction with dentine and pulp tissue interface[2].

Biodentine™ (Septodont Ltd., Saint Maur des Fausse´s, France) is a new tricalcium silicate (Ca_3SiO_5) based inorganic restorative commercial cement and advertised as 'bioactive dentine substitute'. The material is claimed to possess better physical and biological properties compared to other tricalcium silicate cements such as mineral trioxide aggregate (MTA) and Bioaggregate™ (Bioaggregate)[2]. Biodentine™ has a wide range of applications including endodontic repair (root perforations, apexification, resorptive lesions, and retrograde filling material in endodontic surgery) and pulp capping and can be used as a dentine replacement material in restorative dentistry. 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[3]

Composition and setting

Biodentine™ is a powder and liquid system where the powder is composed of tricalcium silicate (main component), calcium carbonate (filler material), zirconium oxide (radio opacifier), dicalcium silicate (traces), calcium oxide (traces), iron oxide (traces). The liquid, on the other hand, is composed of calcium chloride as an accelerator and a hydrosoluble polymer that serves as a water reducing agent[4]. (Table I)

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 working time of Biodentine™is up to 6 minutes with a final set at around 10-12 minutes. This shorter setting time is an improvement compared to other calcium silicate materials [5]. The final setting time of Biodentine™ is assessed to be 45 min[9]. Some authors have indicated that there are few studies on the properties of newly developed materials such as Biodentine[6]. The material is characterized by the release of calcium when in solution[7,8]. Tricalcium silicate based materials are also defined as a source of hydroxyapatite when they are in contact with synthetic tissue fluid[2].

Although tricalcium silicate appears to be a common ingredient in both MTA and Biodentine™, X-ray diffractometry of unhydrated cements revealed that Biodentine™ consisted of triclinic form of tricalcium silicate while MTA consisted of the monoclinic form.Another difference would be the finer particle size of tricalcium silicate in Biodentine™ as shown by the greater value of specific surface area of Biodentine™ (2.811 m2 /g) in comparison to that of MTA (1.0335 m2 /g)[3]

	Biodentine™	Bioaggregate™	Pro-Root White MTA™
Manufacturer	Septodont	Diadent	Dentsply
Powder	Tricalcium silicate Dicalcium silicate Zirconium oxide Calcium carbonate	Tricalcium silicate Dicalcium silicate Tantalum pentoxide Calcium phosphate	Tricalcium silicate Dicalcium silicate Bismuth oxide Calcium sulphate-

	Calcium oxide Iron oxide	monobasic Amorphous silicon oxide	dihydrate(gypsum) Tri calcium aluminate
Liquid	Hydrosoluble polymer Calcium chloride	Deionised water	Water

Table I

The mixing of Biodentine™powder and liquid results in a gel structure, allowing ionic exchanges and polymerisation over time to form a solid network. The reaction product consists of a cementitious phase containing tricalcium silicate, a radio opacifier phase comprising of zirconium oxide, and the authors claim that calcium carbonate acts as a nucleation site which allows the formation of reaction rims around it, thereby enhancing the hydration and producing a denser microstructure.[1]Setting of Biodentine™ is at least partially due to polymerization of the silicate phase to a Q2 chain-like structure, similar to that present in Portland cement but the setting kinetics are faster (12 min) in Biodentine™.[1]

Compressive Strength.

Compressive strength is considered as one of the main physical characteristics of hydraulic cements. Since it is significantly used for vital pulp therapies, it is essential that the cement has the capacity to withstand masticatory forces, in other words, sufficient compressive strength to resist external impacts.[6] In the study by Grech et al., Biodentine™ showed the highest compressive strength compared to the other tested materials. The authors attributed this result to the enhanced strength due to the low water/cement ratio used in Biodentine™. They stated that this mode of the material is permissible as a water soluble polymer is added to the mixing liquid.[9]

The setting of Biodentine™ is illustrated by a sharp increase in the compressive strength. [14] The compressive strength of Biodentine™amounts to 10.6 ± 2, 57.1 ± 12 and 72.6 ± 8 MPa after 35 min, 24 h and 28 days, respectively.[19]

Radiopacity[18]

According to the ISO standard 6876, Biodentine™ displays a radiopacity equivalent to 3.5 mm of aluminium.

Microhardness.

The microhardness of this dentine substitute, at about 60 VHN (Vickers hardness) is virtually the same as that of natural dentine, which is 68 KHN (Knoop hardness).[18]

Grech et al. evaluated the microhardness of the material using a diamond shaped indenter[9]. Their results showed that Biodentine™ displayed superior values compared to Bioaggregate™and IRM. In a studycomparing the physical properties of Biodentine™with a conventional glass ionomer (Fuji IX) and a resin modified glass ionomer (Vitrebond), done by Camilleriet al, showed that Biodentine™ exhibited higher surface microhardness compared to the other materials when unetched. On the other hand, there was no difference in the microhardness of different materials when they were etched[10].

Microleakage

Biodentine™provides adequate marginal seal at the interface of enamel, dentine and dentine-bonding agents (Raskin et al. 2012). However, in another study by Camilleri in 2013, Biodentine™ exhibited leakage at the dentine to material interface either with or without etching and no difference between the micro hardness was noted whether Biodentine™ was etched or not.

Kokate et al demonstrated that Biodentine™ shows less microleakage (0.13 ± 0.006 mm) compared to MTA (0.73 ± 0.13 mm) and Glass Ionomer Cement (1.49 ± 0.23 mm) when used as root- end filling materials.[20]

Density and pH

Biodentine™ is reported to be more dense and less porous when compared to MTA. The pH of Biodentine™ is similar to that of Bioaggregate™ and IRM.[11]Khan et al. evaluated the pH of set Biodentine™ which was 9.14 ± 0.16, 8.88 ± 0.27 and 8.02 ± 0.19 at 3 h, 1 day and 1 week, respectively confirming the alkalinity of the cement.[18]

Endodontic irrigants did not influence the mean pushout bond strength of Biodentine™. Push-out bond strength recorded after immersion of samples in 3.5 % sodium hypochlorite, 2 % Chlorhexidine or saline solution for 30 min was recorded as 7.23 ± 4.22, 7.13 ± 2.17 and 7.22 ± 3.14 MPa, respectively. Immersionin saline solution increased the push-out bond strength of MTA whereas immersion in chlorhexidine reduced it. However, irrespective of the irrigation solution, the force needed for displacement of Biodentine™ from root dentine was significantly higher than the force required for MTA[12]. The bond strength of

Biodentine™ was impaired at low pH values (significantly lower at pH 4.4 in comparison to pH 7.4).[13]

Effect on the Flexural Properties of Dentine.[2]

An important issue related to the usage of calcium silicate-based materials is their release of calcium hydroxide on surface hydrolysis of their calcium silicate components. On the other hand, it has also been indicated that prolonged contact of root dentine with calcium hydroxide as well as MTA has detrimental and weakening effects on the resistance of root dentine. Therefore, it is critical to consider the effects of released calcium hydroxide on dentine collagen, specifically in procedures where there is a permanent contact of dentine with calcium silicate-based materials. Sawyer et al. evaluated whether prolonged contact of dentine with calcium silicate-based sealers would have any influence on its mechanical properties. According to the results of their study where they compared Biodentine™ with MTA Plus, they determined that both materials altered the strength and stiffness of the dentine tissue after aging in 100% humidity. They suggested that though dentine's ability to withstand external impacts and resistance to external forces might not be affected to a critical extent when used in very thin layers such as pulp capping material or as an apical plug, careful consideration is necessary when obturating the entire root canal system with these materials or when using them for the purpose of dentine replacement[2]

Biological Properties

Biodentine™ is non-cytotoxic and non-genotoxic for pulp fibroblasts at any concentration and the specific functions of these cells were not modified when the material was used as either direct pulp-capping agent or as a lining material.[14] Biodentine™ and MTA are rich in calcium compounds and an increase in calcium ion concentration is known to aid hard-tissue formation. X-ray diffractographic (XRD) analysis revealed the presence of calcium hydroxide peaks in set Biodentine™ after 1 day, whereas this compound could not be detected in set MTA. However, both MTA and BiodentineTM exhibited calcium hydroxide peaks after 28 days. This difference could be attributed to the slow ongoing crystallization process of MTA[15]

Biodentine™ and MTA reduce the ability of dentine to resist deformation (strength) and to absorb energy without fracturing[16]. This could be due to the adverse effect of the material on the integrity of the dentine collagen matrix[17]. These in vitro results could represent limitations to the use of Biodentine™ or MTA for the full canal obturation of root canals with thin dentinal walls.

Bioactivity[19]

Pulp capping and pulpotomy studies showed that Biodentine™ was very well tolerated.[22] Moreover Biodentine™ promotes mineralisation, generates a reactionary dentine as well as a dense dentine bridge.The pulp capped with Biodentine™showed complete dentinal bridge formation and an absence of inflammatory pulp response. About et al. concluded that Biodentine™ stimulates dentine regeneration by inducing odontoblast differentiation from pulp progenitor cells.

Clinical implications:

Biodentine™ has been widely used in dentistry clinical applications, including for indirect and direct pulp capping; affected dentin remineralization; direct restorative posterior filling; pulpotomy; retrograde restoration; invasive internal resorption and cervical resorption treatment; root and furcal perforation repair; vertical root fracture treatment; endodontic surgery; regenerative endodontic therapy; apexogenesis, and apexification.

As a direct pulp capping material[19]

Formation of the dentinal bridge is interpreted as a positive reaction to stimulation and a sign of healing. Biodentine™ induces the formation of a dentinal bridge at its interface with the pulp tissue columnar cells.

As a root- end filling material[19]

Biodentine™ exhibits better marginal adaptation to dentin in comparison to MTA and GIC cements. The better handling properties of this material combined with superior biological, mechanical and physical properties suggest the superiority of Biodentine™ over other root end filling materials.

As a dentine substitute[19]

Biodentine™ could be both a temporary enamel restoration and a definitive dentine substitute. Its good sealing properties, high compression strengths and short setting time are suggestive of its potential as a restorative material.

As a perforation repair material[19]

Due to its various physio-chemical and biological properties, Biodentine™ can serve as an excellent perforation repair material.

For external root resorption and obturation of root canal system[19]

When used in cases of root resorption, Biodentine^{TM} has the capacity to develop watertight interfaces both with dental structures and with adhesive systems. Biodentine^{TM} has a better consistency after mixing which allows ease of placement in areas of resorptive defect or obturation of full root canal system.

Biodentine as an Apical Plug Material in Immature Teeth[18]

Based on the review of clinical and radiographic treatment results of 11 case reports, Biodentine^{TM} is effective to use as an alternative apical plug material for nonvital immature teeth apexification treatment with its advantages such as short setting time, supporting the formation of calcified apical barrier, and healing of periapical lesions.[18]

Follow up time[1]

Deep carious lesion	4 months
Direct pulp capping after iatrogenic pulp exposure	6 months
Cervical and apical external root resorption	15 months

II. CONCLUSION

Biodentine^{TM} is a fast-setting tricalcium silicate-based material having extended alkalinizing properties principally able to release ions involved in mineralization processes. Considering the physical (increased compressive strength, push-out bond strength, density and porosity), biological (immediate formation of calcium hydroxide, higher release and depth of incorporation of calcium ions) and handling properties (faster setting time), Biodentine could be an efficient alternative to mineral trioxide aggregate to be used in a variety of indications in the field of endodontics, dental traumatology, restorative dentistry and pediatric dentistry.[19]

REFERENCE

[1]. Biodentine™ material characteristics and clinical applications: A review of the literature, European Archives of Paediatric Dentistry. Official Journal of the European Academy of Paediatric Dentistry · March 2014 DOI: 10.1007/s40368-014-0114-3 ·

[2]. A Review on Biodentine, a Contemporary Dentine Replacement and Repair Material, Özlem Malkondu, BioMed Research International Volume 2014, Article ID 160951

[3]. Biodentine Active Biosilicate Technology Scientific File, Septodont, Paris, France

[4]. Camilleri J, Sorrentino F, Damidot D. Investigation of the hydration and bioactivity of radiopacified tricalcium silicate cement, Biodentine and MTA Angelus. Dent Mater 2013b;29:580–593

[5]. Biodentine Active Biosilicate Technology Scientific File, Septodont, Paris, France.

[6]. M. B. Kayahan, M. H. Nekoofar, A. McCann et al., “Effect of acid etching procedures on the compressive strength of 4 calcium silicate-based endodontic cements,” Journal of Endodontics, vol. 39, no. 12, pp. 1646–1648, 2013.

[7]. J. Camilleri, “Characterization of hydration products of mineral trioxide aggregate,” International Endodontic Journal, vol. 41, no. 5, pp. 408–417, 2008.

[8]. J. Camilleri, P. Kralj, M. Veber, and E. Sinagra, “Characterization and analyses of acid-extractable and leached trace elements in dental cements,” International Endodontic Journal, vol. 45, no. 8, pp. 737–743, 2012.

[9]. L. Grech, B. Mallia, and J. Camilleri, “Investigation of the physical properties of tricalcium silicate cement-based root-end filling materials,” Dental Materials, vol. 29, no. 2, pp. e20–e28, 2013

[10]. J. Camilleri, “Investigation of Biodentine as dentine replacement material,” Journal of Dentistry, vol. 41, no. 7, pp. 600–610, 2013

[11]. Grech L, Mallia B, Camilleri J. Characterization of set intermediate restorative material, Biodentine, Bioaggregate and a prototype calcium silicate cement for use as root-end filling materials. Int Endod J. 2013a;46:632–41

[12]. Guneser MB, Akbulut MB, Eldeniz AU. Effect of various endodontic irrigants on the push-out bond strength of Biodentine and conventional root perforation repair materials. J Endod. 2013;39:380–4

[13]. Poplai G, Jadhav S, Hegde V. Effect of acidic environment on the push-out bond strength of BiodentineTM. World J Dentistry. 2012;3:313–5

[14]. Laurent P, Camps J, de Meo M, Dejou J, About I. Induction of specific cell responses to a Ca(3)SiO(5)-based posterior restorative material. Dent Mater. 2008;24:1486–94

[15]. Camilleri J, Sorrentino F, Damidot D. Investigation of the hydration and bioactivity of radiopacified tricalcium silicate cement, Biodentine and MTA Angelus. Dent Mater 2013b;29:580–593
[16]. Sawyer AN, Nikonov SY, Pancio AK, et al. Effects of calcium silicate-based materials on the flexural properties of dentin. J Endod. 2012;38:680–3
[17]. Leiendecker AP, Qi YP, Sawyer AN, et al. Effects of calcium silicatebased materials on collagen matrix integrity of mineralized dentin. J Endod. 2012;38:829–33
[18]. Irmaleny and et al, Apical Plug Material in Immature Teeth, Journal of International Dental and Medical Research, Volume · 15 · Number · 1 · 2022
[19]. Bansal et al. Biodentine VS MTA: A comparitive analysis, International Journal of Oral Health Dentistry 2020;6(3):201–208
[20]. . Kokate SR, Pawar AM. An in vitro comparative stereomicroscopic evaluation of marginal seal between MTA, glass ionomer cement and biodentine as root end filling materials using 1 % methylene blue as tracer. Endodontol. 2012;24(3):36–42