Review Article

Biodentine as a New Calcium Silicate Based Cement

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Abstract

Biodentine is a new class of dental material which could conciliate high mechanical properties with excellent biocompatibility, as well as bioactive behavior. It exhibits same biological property as MTA. Micromechanical bonding, resistance to acidic environment and resistance to microleakage makes it a better choice for its clinical usage as dentin substitute. Its excellent biocompatibility and bioactivity allows application as pulp capping agent and root end filling material. This paper reviews the setting reaction, physical, chemical and mechanical properties of Biodentine and its applications, advantage and disadvantages.

Key Words: Biodentine, Bioactive material, Dentin substitute, Pulp capping

Introduction

The Portland cements designed for medicine and dentistry,also called hydraulic silicate cements[1], mainly contain tri calcium silicate ($3CaO\text{-}SiO_2$; C_3S), because it is responsible for rapid setting and development of early strength and exhibits higher reactivity than the other calcium silicates[2]. Use of calcium silicate–based materials (CSMs) in dentistry became popularized[3-7] with the advent of mineral trioxide aggregate (MTA) in 1993 as a root-end filling material[8]. The antibacterial properties of CSMs are due to the release of calcium Hydroxide $Ca(OH)_2$ on surface hydrolysis of the calcium silicate components[5,9].

The shortcomings of MTA such as difficult handling characteristics[10], long setting time[11,12], high cost[4], and potential of discoloration[4] led to the development of new CSMs such as Biodentine (Septodont, Saint Maur des Foss es, France) and MTA Plus (Prevest-Denpro, Jammu City, India). Biodentine is a bioactive[13] dentin substitute composed of powder components of tricalcium silicate, calcium carbonate, and zirconium oxide and a water-based liquid containing calcium chloride as the setting accelerator and water-reducing agent (Table 1)[14].

Powder	
Tri-calcium Silicate (C_3S)	Main core material
Di-calcium Silicate (C_2S)	Second core material
Calcium Carbonate and Oxide	Filler
Iron Oxide	Shade
Zirconium Oxide	Radiopacifier
Liquid	
Calcium chloride	Accelerator
Hydrosoluble polymer	Water reducing agent

Table 1 : Chemical composition of Biodentine[15]

This material exhibits the same excellent biological properties as MTA and can be placed in direct contact with dental pulp[14], although its sensitivity to abrasion makes it a poor enamel substitute. However, Biodentine may be a good candidate for a dentin substitute in sandwich restorations[16].

Setting reaction

The calcium silicate has the ability to interact with water leading to the setting and hardening of the cement. This is a hydration of the tricalcium silicate ($3CaO.SiO_2 = C_3S$) which produces a hydrated calcium silicate gel (CSH gel) and calcium hydroxide ($Ca(OH)_2$).

$$\underbrace{2(3CaO.SiO_2)}_{C_3S}+6H_2O \rightarrow \underbrace{3CaO.2SiO_2.3H_2O}_{CSH}+3Ca(OH)_2$$

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 working time of Biodentine is up to 6 minutes with a final set at around 10-12 minutes. Biodentine has a consistency after mixing which enables manipulation with a spatula, with an amalgam carrier or with carriers which are used for endodontic cements in retrograde fillings (Messing gun, MTA gun)[15].

Biodentin interfaces

Electron microscopy revealed there is direct contact without a gap between Biodentine and natural dentin. It also indicates micromechanical adhesion. Resistance to acidic environment was evaluated by Laurent et al.[14] using artificial saliva and they suggested that there was no erosion but deposition of white material on the surface of the Biodentine. SEM analysis revealed needle like crystals with an apatitc appearance and also suggested that erosion of Biodentine in acidic solution is limited and lower than other water based products. Biodentine also exhibits resistance to microleakage both to enamel and dentin compared to Fuji II LC[15].

In addition to the formation of apatite crystals, the nanostructure of the calcium silicate hydrate may also explain the good sealing qualities of the calcium silicate cement[17].

Biocompatibility and bioactivity

Biodentine shows outstanding biocompatibility. Studies performed on pulp fibroblasts have shown that biodentine was non toxic like MTA[18].

Biodentine preserves pulp vitality and promotes its healing process[15]. Laurent et al.[14] tested a new Ca_3SiO_5-based material to evaluate its genotoxicity, cytotoxicity and effects on the target cells specific functions. The study concluded that the new material is biocompatible.

About et al.[19] investigated Biodentine bioactivity by studying its effects on pulp progenitor cells activation, differentiation and dentine regeneration in human tooth cultures. The study concluded that Biodentine is stimulating dentine regeneration by inducing odontoblast differentiation from pulp progenitor cells. Laurent et al.[20] did further a study and reported that Biodentine induces TGF-β1 secretion from pulp cells and induces reparative dentine synthesis.

Han and Okiji[21] compared calcium and silicon uptake by adjacent root canal dentine in the presence of phosphate buffered saline using Biodentine and ProRoot MTA. The results showed that both materials formed a tag-like structure composed of the material itself or calcium or phosphate rich crystalline deposits.

Physical chemical and mechanical properties

The mechanical resistance of calcium silicate based materials is also dependent on their low level of porosity. The lower the porosity, the higher the mechanical strength. The superior mechanical properties of Biodentin been attributed by the low water content in the mixing stage.

Biodentin is an evolutive material which improves its mechanical property with time. The compressive strength at 1 hr is 131.5 MPa and at 24hr is 241.1 MPa and after 7 and 28 days 253.2 and 316.4 MPa respectively[15].

The internal values of the flexural strength were 22 MPa, very similar to glass ionomers and modulus of elasticity is 22.0 GPa. The microhardness for biodentin is 60.9 HVN and for natural dentin are in the range of 60-90 HVN[15].

Applications in dentistry

Boidentine has got all the indication where MTA had been indicated. Biodentine can be used for crown and root dentin repair treatment, repair of perforations or resorptions, apexification and root-end fillings. The material can also be used in class II fillings as a temporary enamel substitute and as permanent dentine substitute in large carious lesions[18].

Boukpessi et al. conducted study on stimulation of reactionary dentin formation in indirect pulp dentin formation on rats and concluded that Biodentine was able to stimulate reactionary dentin formation which is a natural barrier against bacterial invasions. The results also showed that there was moderate inflammation which disappeared after 15 days[22]. Shayegan A studied pulp reaction and calcification following pulpotomy and direct pulp capping using pig model and concluded that it is a suitable material[23].

Advantages

- It can be placed in direct contact with pulp
- It does not require photoactivation so can be placed in bulk
- Easy to handle
- Short setting time
- Good marginal integrity
- Biocompatibility and bioactive

Disadvantages

- Less wear resistance so placed under composite restoration and hence doesn`t withstand occlusal loading.
- Poor flexural strength.

Conclusion

Biodentine has shown similar biocompatibility as MTA and it is also bioactive cement. Better mechanical and physical property strongly suggests its utilization as dentin substitute as a pulp capping material and also as root end filling material.

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