Biodentine - An Alternative to MTA?

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ABSTRACT:

Calcium silicate based materials have got many ideal properties of a pulp capping and endodontic repair material and MTA is a strong representative of the group. But like many other materials it has got certain drawbacks making it less desirable for some clinical situations and the quest for a new material resulted in the introduction of a novel calcium silicate cement-Biodentine ™ (Septodont, Saint Maur des Fosse's France). It is claimed as a superior alternative to MTA by the manufacturers. In this article the important properties and clinical applications of Biodentine are reviewed and compared with MTA, based on the existing literature.

Keywords: Biodentine, MTA, Review.

INTRODUCTION

Calcium silicate based materials have gained popularity in recent years because of their better biocompatibility and tissue repairing abilities. A wide range of materials are available of which MTA is known to be the best as an endodontic repair material as well as an ideal pulp capping agent. MTA was introduced by Torabinejad M in 1990 and it has been used for the past twenty five years due to its excellent biocompatibility and sealing ability.[1] Despite its good physical and biological properties there are some disadvantages like slow setting kinetics and complicated handling properties.[2] Several new calcium silicate based materials have recently been developed aiming to improve some drawbacks of MTA.[3] Biodentine, introduced by Septodont in 2009 is specifically designed as a "dentine replacement material" .Biodentine has a wide range of clinical applications including pulp capping, apexification, repair of root perforations and resorptive lesions, retrograde filling material and as a dentine replacement material in restorative dentistry.

AVAILABILITY AND COMPOSITION

Biodentine is available as a powder in a capsule and liquid in a pipette. The material is actually said to be a modification of MTA to overcome its disadvantages.

Table 1: Composition of Biodentine

Powder	Liquid
Tricalcium silicate – main core material	Calcium chloride - accelerator
Dicalcium silicate – second core material	Hydro soluble polymer - water reducing agent
Calcium carbonate and oxide– filler	
Iron oxide – coloring agent	
Zirconium oxide – radioopacifier	

(Courtesy: Biodentine Scientific File , Septodont 2010)

PROPERTIES OF BIODENTINE

Setting Reaction and Setting Time

The tricalcium silicate particle of the powder reacts with water to form hydrated calcium silicate gel and calcium hydroxide. This is the basic reaction in the formation of biodentine. The final set material consists of unreacted calcium silicate grains surrounded by layers of hydrated calcium silicate gel which is impermeable to water and slows down further reaction. The fast setting time of 9-12 minutes is achieved by decreasing the particle size, addition of calcium chloride accelerator to the liquid component and decreasing the liquid content.[4] The powder also contains calcium carbonate as the filler. According to Grech et al, Biodentine powder had inclusions of large calcium carbonate particles and the set material showed hydration products surrounding calcium carbonate particles. Calcium carbonate acts as nucleation site enhancing the microstructure.[5] Camilleri et al concluded that calcium carbonate was used 15% in the powder component.[6] Biodentine also induces apatite crystal formation indicative of its bioactivity.[7] A long setting time like that of MTA may cause clinical problems because of the cement's inability to maintain shape and withstand stresses during this period.[8]

Compressive Strength

Biodentine is used as a pulp capping agent as well as an endodontic repair material. It should have the capacity to withstand masticatory forces and this property mainly depends on the compressive strength of the material.[9] MTA cannot be used in areas like furcations because of its low compressive strength (40 MPA at 24 hr and 67.3 MPA at 21 days).[10] Biodentine shows compressive strength equal to that of natural dentine. In a study by Grech et al. the decreased water/powder ratio and addition of a hydrosoluble polymer significantly increased the compressive strength of Biodentine.[4] The product sheet of biodentine claims that the active biosilicate technology removes aluminates and other impurities from the powder composition to achieve a significant mechanical strength. Kayahan et al stated that acid etching procedures did not reduce the compressive strength of biodentine after 7 days.[11] According to a study conducted by Naziya et al Biodentine exhibited a compressive strength of 170 MPa at 24 hr and increased substantially to 304 MPa after the material was placed in moisture for 28 days.[12] This value is close to the compressive strength of human dentine (297 ± 24 MPa).[13] The 24 hr push out bond strength of biodentine is significantly higher than MTA, making it better in repairing furcal perforations.[14] According to Guneser et al, Biodentine showed considerable performance as a perforation repair material even after being exposed to various endodontic irrigants such as NaOCl, Chlorhexidine and saline, where as MTA exhibited lower push-out bond strength to root dentine when exposed to the same irrigants.[15]

Biocompatibility

Biocompatibility of a material is an important property when it is used as a pulp capping, perforation repair or as a retrograde filling agent. It was found that Biodentine significantly increased secretion of TGF-β1 from human dental pulp cells and induced the formation of reparative dentine.[16] According to Zhou et al both Biodentine and white MTA (ProRoot) exhibited less toxicity to human fibroblasts compared to glass ionomer cement (FujiIX).[17] A biocompatible material should present low toxicity without promoting an inflammatory reaction or mild when present.[18] The material can be considered biocompatible if the inflammatory reaction is reduced to nonsignificant levels in a reasonable amount of time, such as 14 days.[19] Accordding to a study done by Mori et al. Biodentine exhibited mild inflammatory reaction in the subcutaneous tissue of rats and he concluded that Biodentine showed an initial inflammatory response, but that response was quickly followed by biocompatible acceptance by the contacted tissue after 2 weeks.[20] According to Attik et al. Biodentine a synthetic Portland cement with high mechanical properties and a short setting time, behaved similarly to MTA in terms of surface roughness, cytotoxicity and cell attachment. The study concluded that the biocompatibility of Biodentine to bone cells is comparable to MTA.[21]

Marginal Adaptation and Sealing Ability

The main aim of an endodontic repair material is to prevent the movement of the bacteria and diffusion of bacterial products from the root canal into periapical tissues and vice versa. Sealing ability of a materials is the ability to resist micro leakage through the entire thickness of the material. When calcium silicate cements are mixed with water, several porosities and microchannels are created and porous calcium silicate hydrate (CSH) is formed. Porous CSH hardens to form a solid network within 4-6 hours and complete setting occurs after several days.[22] The sealing ability is determined by many factors such as porosity, marginal adaptation and hydrophilicity. The calcium silicate based cements such as MTA and Biodentine improves their physical properties over time and this may affect the early sealing ability of these cements.

According to Goldberg et al Biodentine is fast setting and exhibits excellent sealing properties as MTA-Angelus.[23] After mixing, the calcium silicate particles of Biodentine, like all calcium silicate materials, react with water to form a high pH solution containing Ca^{2+}, OH^{-}, and silicate ions. As the saturation progresses, the CSH gel precipitates on the surface of the unreacted calcium silicate grains and calcium hydroxide nucleates.[24] The CSH gel hardens over time and the calcium hydroxide increases the alkalinity of the medium. The phosphate ions from the saliva and body fluids cause deposition of hydroxyapatite crystals around the material which increases the sealing efficiency of the material.[25] According to Han and Okiji Biodentine has more prominent biomineralization ability than MTA with wider calcium and silicon rich layer at material-dentine interface.[26] According to a study done by Naziya et al. the marginal leakage produced by WMTA-Angelus at 4 and 24 hour was significantly higher when compared with Biodentine.[12] But there is no significant difference in the seal produced by the two materials at 1,2,4,8 and 12 week intervals and it can be concluded that the immediate seal produced by Biodentine is better than MTA. A SEM study conducted on sealing ability of Biodentine, MTA and GIC to dentine concluded that Biodentine exhibited superior marginal adaptation to dentine in comparison to MTA and GIC cements and also explained the importance of time on marginal adaptation.[27] According to Ravichandra et al. Biodentine exhibited better marginal adaptation than MTA and the material has got better handling properties.[28]

Handling Characteristics

MTA is grainy and has got a poor consistency and difficult to manipulate in clinical situations. Biodentine on the other hand is relatively easy to handle and it can be manipulated in to a dough-like consistency that could be easily condensed.[12] Extended setting time and difficult handling characteristics are the most common drawbacks of MTA.[29] Biodentine has been shown to present with faster setting time as well as better handling and mechanical properties when compared to MTA.[30] The superior handling properties of Biodentine made it more convenient for using the material in various clinical applications.

CLINICAL APPLICATIONS

Pulp Capping Material

Calcium silicate based materials are considered to be ideal in vital pulp therapy because of their high biocompatibility among which MTA is generally known as a gold standard. Direct pulp capping is done to preserve tooth vitality of an injured pulp following trauma or accidental exposure during carious dentin removal. This treatment involves the use of a bioactive material which seals the wound and thus enhancing pulp healing. Pulp healing involves stem or progenitor cell recruitment to the injured site and their proliferation and differentiation into odontoblast-like cells.[31] These cells secrete a tertiary dentin matrix, resulting in the formation of a reparative dentin bridge.[32] Control of infection and biocompatibility of the capping material are important factors in determining treatment outcome.[33] According to Tran et al reparative dentinogenesis induced by calcium silicate cements are at a higher rate and structurally stable compared to the reparative dentine formation induced by calcium hydroxide.[34] Calcium hydroxide is associated with tissue necrosis and inflammation during the initial period of placement but there is no such inflammation or necrosis was seen in the pulp tissue adjacent to calcium silicate based materials.[35] Biodentine can be used as a pulp capping agent as it causes early mineralization by the release of TGF-β1 from human dental pulp cells.[16] Biodentine has a beneficial effect on vital pulp cells and stimulates the formation of tertiary dentine.[16] According to a clinical study done by Nowicka et al. in human dental pulp, Biodentine exhibited a beneficial effect and may be considered as an interesting alternative to MTA in pulp-capping treatment during vital pulp therapy.[36] In the above study majority of the specimens showed complete dentinal bridge formation and absence of inflammatory pulpal response. Handling characteristics are important when considering a material for pulp capping and Biodentine shows good rates for material handling and performance whereas MTA placement was more time consuming and technically difficult.[16]

Endodontic Repair Material and Apexification

Since MTA has been introduced as a root end filling material in early 1990s calcium silicate cements have gradually become the ideal candidates for repair of all types of dentinal defects creating communication pathways between the root canal system and the periodontal ligament.[37-39] These materials play a major role because of their proven biocompatibility and ability to induce hydroxyapatite precipitation at the interface to the periodontal tissue.[39-41] The high quality of the seal created at the material-dentine interface improves over time secures long-term clinical success and reduces the risk of marginal percolation. MTA has its own drawbacks like slow setting kinetics and complicated handling.[39] Like all calcium silicate materials Biodentine has the capacity to induce hydroxyapatite precipitation at the material dentine interface and the sealing ability of Biodentine is superior or equal to MTA.[26] Biodentine is a viable alternative to MTA as an endodontic repair material because of its superior mechanical and handling characteristics.[5,6] It can be used in apexification, repairing perforations and resorptive lesions and also as an ideal root end filling material in periradicular surgery. According to Gunesar et al Biodentine was more resistant to dislodgement forces and showed superior push-out bond strength compared to MTA as a furcation perforation repair material after being exposed to various endodontic irrigants.[15] Biodentine showed significantly less microleakage than MTA as a root end filling material and can be used as an alternative to MTA.[42] Biodentine has an advantage of fast setting time thereby sealing the interface faster avoiding further leakage and reducing the risk of bacterial contamination.[42] Importantly porosity and pore volume in set Biodentine material is also less than MTA which could be a reason for better sealing ability.[43] Both Biodentine and MTA have been widely used for single visit apexification. Biodentine being stable, less soluble, non-resorbable, hydrophilic, easy to prepare and place, needs less time for setting, produces a tighter seal and shows greater radiopacity.[44] Biodentine has a distinct advantage over its closest alternatives like MTA in treatment of teeth with open apex.[45]

Dentine Replacement Material

Many materials have been developed over years to substitute the lost dentine. The sandwich technique using glass ionomer cement as dentine replacement material and composite to replace enamel was introduced and the use of glass ionomer cement in sandwich technique significantly reduced early marginal micro-leakage in Class II restorations.[46] Calcium silicate-based materials like Biodentine used as a dentine replacement material shows leaching of calcium hydroxide from the set material.[47] This calcium hydroxide can act as a liner and the calcium silicate matrix will act as a rigid structure replacing the dentine. Biodentine performs as effective as the resin modified glass ionomer cement in open-sandwich restorations.[48] According to a clinical study by Kaubi et al the tolerance of Biodentine under posterior composite restorations showed Biodentine as an efficient and well tolerated dentine substitute.[49] Biodentine as a dentin substitute in cervical lining restorations or as a restorative material in approximal cavities when the cervical extent is below the CEJ seems to perform better without any conditioning treatment.[50] According to Camilleri et al Biodentine exhibited both structural and chemical changes when etched with 37% phosphoric acid. The material also exhibited lower calcium to silicon ratio and a reduction in the chloride peak height when etched and showed significant leakage at the dentine to material interface when used as a dentine replacement material in the sandwich technique under composite.[51] So further studies are required to investigate the use of biodentine as a dentine replacement material.

CONCLUSION

MTA is a widely used calcium silicate material because of its improved biocompatible and tissue healing abilities. But some of the properties of MTA such as inferior strength, slow setting and difficult handling characteristics are undesirable in certain clinical situations. Based on the available literature and clinical studies, Biodentine has got all the beneficial properties of MTA with the proven advantages of increased strength, fast setting and good handling properties and it can be concluded that this material can be used as an alternative to MTA. However further studies and evidences are required to extend the future scope of this material regarding various clinical applications.

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