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REVIEW ARTICLE

Properties and Applications of Biodentine in Restorative Dentistry and Endodontics: A Review

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ABSTRACT

Recently, a new calcium silicate based cement known as "Biodentine" or "dentin in capsule" has been introduced. It is a biocompatible and bioactive material. It consists of tricalcium silicates, dicalcium silicates, calcium carbonate and zirconium oxide. It has many promising characteristics including antibacterial activity, high compressive strength and chemical bonding to tooth structure. Additionally, it also has the ability to initiate reparative dentine formation. These properties allow their use for various restorative and endodontic procedures such as management of deep carious lesions, vital pulp therapies, perforation repair, retrograde fillings, apexogenesis, and apexification.

Key words: Calcium silicate based cements; Deep carious lesions; Pulp capping

Author`s Contribution
[1,2]Conception, synthesis, planning of research and manuscript writing Interpretation and discussion Data analysis, interpretation and manuscript writing, [3] Active participation in data collection.

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With the advent of biotechnology and its applications in various fields, including medicine; new techniques and materials are constantly formulated for the improvement of health care system. Today, dentists use different synthetic and natural substances for various restorative and endodontic procedures, such as, protection of pulp-dentine complex, management of open root apices, repair of root and furcation perforations and as a retrograde filling material.[1] Ideally, these materials should be bioactive and biocompatible. They should have low solubility, adequate setting time, antibacterial activity, and ability to bind to dental tissues.[2]

In order to develop a material that meets all these requirements, various materials have been introduced over the years which include calcium hydroxide [$Ca(OH)_2$] cement, glass ionomer cement (GIC), zinc oxide eugenol (ZOE) cement, resin composites and mineral trioxide aggregate (MTA).[3]

Although each material has few advantages over the other, no material meets the criteria completely and therefore cannot be used for multiple clinical procedures. Recently, biomaterial scientists have introduced new calcium silicate based cement known as "Biodentine™". Biodentine resembles MTA, but the manufacturer claims better handling and physical characteristics, and therefore better performance than other materials.[4] Since "Biodentine" has gained considerable popularity in recent years, this comprehensive review will evaluate the existing literature about the properties and clinical applications of biodentine in comparison to existing materials and will provide a basic guideline to the clinician in selecting an appropriate material for a particular situation.

Composition

Biodentine is manufactured as powder and liquid. Its chemical composition and properties of each component are shown in Table 1 .[5]

Setting Reaction

Biodentine sets via hydration reaction as shown in equation below.

2(3CaO.SiO2) + 6H2 O→3CaO.2SiO2 .3H2 O + 3Ca (OH) 2

Water interacts with tricalcium silicate and results in the formation of calcium silicate gel (C-S-H) and a calcium hydroxide.[6] The hydrated gel precipitates on the surfaces of the remaining silicate particles (Figure 1) and in the spaces between the particles, gradually filling spaces between the unreacted tricalcium silicate.[6]

Clinical Applications of Biodentine

The integrity of the teeth can be compromised in several ways including trauma, abrasion, attrition, dental caries and iatrogenic factors.[2] Once damaged, restorative and endodontic intervention is required to replace the lost tooth structure, not only to preserve the vitality of pulp but also to restore tooth anatomy and its function. For this reason, many materials have been introduced over the years, making it challenging for a dental clinician to choose the most suitable material for the desired procedure Biodentine has been specifically formulated to be used as a dentine substitute material. However, due to its many promising characteristics compared to other materials, it can also be used for vital pulp therapies and retrograde filling materials.[7]

Biodentine as lining material

Biodentine has been specifically formulated to be used as a dentine substitute material. It has been used as a lining material under direct resin composite restorations. The high compressive strength, color stability and its ability to resist masticatory forces makes it a favorable lining material.[8] It has been reported that enhanced strength is attributed to the low powder/liquid ratios of biodentine.[9] In a study, Kayahan et al evaluated the effect of acid etching on the compressive strength of Biodentine. Acid etching is an important step in the placement of composite restorations. The authors concluded that acid etching did not significantly affect the compressive strength of Biodentine.[10] Therefore, the author suggested that Biodentine could serve as a lining material under light cured resin materials in an esthetically sensitive area.[10]

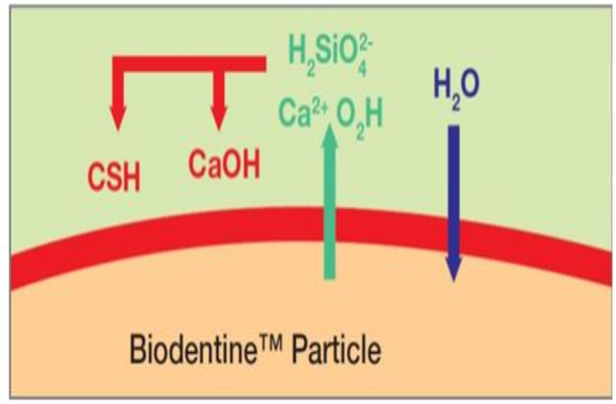

Figure 1: Precipitates of hydrated gel on particles surface

Biodentine in Vital pulp therapies:

Vital pulp therapy includes conservative management of deep carious lesions either by placing biologically compatible material on the residual affected dentin, called indirect pulp capping or on the exposed pulp, called direct pulp capping. Additionally, pulpotomy is another widely accepted vital pulp therapeutic procedure. This method is widely used in pediatric dentistry and involves removal of inflamed and infected pulp tissue, followed by placement of a biocompatible and bioactive material, which not only preserves vitality but also promotes root formation in immature permanent teeth.[1]

Calcium hydroxide is considered as a “gold standard” for vital pulp therapies.[7] Its two most important properties are antibacterial activity and its ability to form reparative dentine. However, it lacks adhesion to dentine, has high solubility and reduced mechanical strength.[11-13] Literature shows that the antibacterial property and enhanced mechanical strength of Biodentine with its ability to attach firmly to underlying dentin induces formation of reparative dentin which makes it superior medicament for vital pulp therapies.[7] Moreover, Biodentine has the ability to stimulate odontoblasts and increase secretion of TGF-B1 from pulp cells that induces reparative dentin synthesis.

In a study, Tran et al. compared Biodentine, MTA and calcium hydroxide in terms of reparative dentine formation when applied to mechanically exposed rat pulps.[14] They noted that reparative dentine induced by $Ca(OH)_2$ had several tunnel defects, as reported previously by Cox et

Table 1: Composition of Biodentine (Septodont, France) according to manufacturer's specification			
Powder		Liquid	
Tricalcium Silicate ($3CaO.SiO_2$)	Main component and regulate the setting reaction	Calcium Chloride ($CaCl_2 2H_2O$)	Accelerator
Dicalcium Silicate ($2CaO.SiO_2$)	Second main component	Superplasticizer (Water reducing agent)	Improves handling
Calcium Carbonate ($CaCO_3$)	Filler	Water	Hydration
Zirconium Dioxide (ZrO_2)	Radio Pacifier		

al. These tunnel defects are described as the presence of porosities or voids in newly formed reparative dentin, which may act as portal of entry for pathogenic microorganisms, thus predisposing tooth to an endodontic infection.[12,15] In contrast, the dentine bridge formation induced by Biodentine showed a much favorable pattern compared to calcium hydroxide.[14] In addition, Biodentine maintains a marginal integrity due to the formation of hydroxyapatite crystals at the surface, thereby reducing risk of microleakage that may jeopardize the success of vital treatment procedures.[8] In another study, the biological effect of Biodentine and MTA on pseudo-odontoblastic and pulp cells was evaluated. It was established that both MTA and Biodentine can alter the proliferation of pulp cell lines and therefore, Biodentine can be considered an alternative to MTA for vital pulp therapies.[16,17]

In a similar study, CBCT analysis of teeth capped with Biodentine and GIC (Fuji IX) showed that majority of teeth with healing / healed lesion received Biodentine while majority of teeth with Fuji IX showed new/progressing lesions.[4] It has been established that the high alkaline nature of biodentine promotes degeneration of the collagenous component of the dentin. This leads to the formation of porosities in developing reparative dentine which permits diffusion of a high concentration of calcium, hydroxyl, and carbonate ions, leading to an increased mineral deposits and a better reparative dentine formation.[18,19] Studies on Biodentine versus formocresol pulpotomy of primary teeth shows that Biodentine requires less procedural time.[20] It also eliminates the use of additional filling material and reduces the risk of recurrence of bleeding during treatment.[1,21] In a study, Biodentine was used for partial pulpotomy in an immature tooth, and Successful formation of the dentinal bridge with root development was observed.[21]

Biodentine for repair of perforations

Perforation is a common procedural error encountered in endodontic procedures and post placement or removal. It results in communication between the root canal system and the surrounding connective tissues, thus compromising the success of the treatment.[22] It is essential that a perforation repair material is biocompatible, easy to place, chemically bond to the tooth structure, has the ability to induce osteogenesis and cementogenesis, is radio-opaque, dimensionally stable and has high push-out bond strength with dentinal walls.[8,22,23] The biocompatibility of a dental material is an important property that must be taken into account when used in direct contact with connective tissue or pulpal tissue and has the potential to affect the viability of periradicular cells and pulp cells.[8] Available data shows that GIC has good biocompatibility, good affinity to bond with tooth structure, provides excellent bacterial seal, but lacks dentin regeneration effect and has low fracture resistance and sensitivity to moisture during setting that has limited its use as a repair and retrograde filling material.[3,24]

Literatures show that Biodentine is a favorable repair material. Its biocompatibility is attributed to the deposition of hydroxyapatite crystals on the surface of the material when it is in direct contact with tissue fluids.[8] In addition, this also contributes to improved dimensional stability as there is no loss of particulate matter.[8] Additionally it has high push-out bond strength with dentinal walls, which guarantees a hermetic seal to prevent microleakage and dislodgement of material from the repair site.[8,22,23]

In one of the study Aggarwal et al. evaluated the push-out bond strengths of Biodentine, Pro Root MTA, and MTA

Plus. It was observed that the 24 h push-out strength of MTA was lower than that of Biodentine. Moreover, it was observed that blood contamination affected the push-out bond strength of MTA Plus irrespective of the setting time whereas no effect on the push-out bond strength of biodentine was observed.[25] In a similar study, Guneser et al. evaluated the effect of different types of endodontic irrigants on the push out bond strength of biodentine and MTA.

They concluded that Biodentine exhibited considerable performance as a repair material even after being exposed to various endodontic irrigation solutions.[26] Radiopacity, another important property for repair and retrograde filling materials, allows differentiation of the material from the surrounding tissues.[8] Biodentine has zirconium oxide as a radio pacifier unlike bismuth oxide, which is preferred radiopacifier for other materials. In a study done by Tanalp et al, the radiopacity of Biodentine was found to be lower than that of the other repair materials(MM-MTA, and MTA Angelus).[27] Despite this, the reason for preferring zirconium oxide was due to its bioinertness and favorable mechanical properties and corrosion resistance.[28]

Biodentine as retrograde filling material

In periradicular surgeries such as apicoectomy, the most important step is to create an adequate apical seal. In the past, several materials were used including, amalgam; reinforced zinc oxide eugenol cements, glass-ionomer cement, and composite resin.[1] Yet, an ideal retrofilling material for endodontic surgeries has not been found. Recently, MTA, a less cytotoxic material with better microleakage protection has been used to give more clinically favorable results over the traditional root-end filling materials.Nevertheless, MTA has some drawbacks including difficult manipulation; extended setting time, and less compressive and flexural strengths than dentin. Biodentinehas similar properties to those of MTA with better manipulation therefore, it is considered as a better alternative to MTA as a retrograde filling material.[8]

Initial setting time of biodentine was determined as 15 minutes. This short setting time was attributed to the addition of calcium chloride to the mixing liquid.[8] Biodentine meets most requirements of retrograde filling materials including biocompatibility, radiopacity, antimicrobial activity, dimensional stability, good marginal integrity, and induction of hard tissue regeneration. It has an added advantage of being less porous. In a study, biodentine showed considerable performance as a retrograde filling material and complete healing of a cystic lesion with an eighteen months of follow up period.[29]

In a similar study with two year follow up period there was complete absence of clinical and radiographic signs and symptoms along with regeneration of the apical tissues.[30] Another in-vitro study evaluated microleakage of biodentine as a retrograde filling material in 60 single rooted human maxillary permanent teeth and concluded minimal microleakage with biodentine.[31]

Conclusion

Although studies on Biodentine are limited and additional research is needed; all literature shows that the material offers a favorable and promising alternative to other commonly used materials. Therefore, Biodentine appears to be a promising material for various restorative and endodontic procedures.

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