International Journal Dental and Medical Sciences Research
Volume 3, Issue 5, pp: 1308-1312 www.ijdmsrjournal.com ISSN: 2582-6018

Biodentine a Bandage to Dentine: A Review

Darshil Sodha

Date of Submission: 12-11-2021 Date of Acceptance: 28-11-2021

I. INTRODUCTION

Over the last few decades, there has been a surge of interest in restorative materials. Direct composite restorations were used to replace amalgams in small anterior restorations and medium-sized posterior restorations. In contrast to amalgams, resin composites can achieve micromechanical retention through the use of different adhesives.Although, a few disadvantages have been reported with resin-based materials such as wear resistance under high load, shrinkage due to polymerization leading to microleakage and toxic monomers release.[1;2]Calcium hydroxide-based materials have been commonly used in direct pulp capping procedures to shield the pulp from the harmful components of resin-based materials. Despite the material's highly alkaline pH, a dentin bridge may develop within 3 months, protecting the underlying pulp from mild to moderate inflammation. However, several tests have shown that this bridge has partial dissolution and tunnel defects. Mineral trioxide aggregate (MTA) was developed as a root-end filling material and direct pulp capping as a result of the recent emphasis on biocompatible materials such as Portland. Tricalcium and dicalcium silicates make up the majority of this material.[5]When used for pulp capping, it stimulates the development of reparative dentin, resulting in the formation of a normal tubular dentin bridge in two months with no signs of inflammation. When used for pulp capping, it stimulates the development of reparative dentin, resulting in the formation of a normal tubular dentin bridge in two months with no signs of inflammation.[4]However, this content has been accused of having certain flaws. These are due to its 2 h 45 min long setting time, poor mechanical properties, and difficult handling properties.[6]Additionally, when this material is used for revascularization, tooth discoloration has been identified.[7;8] Biodentine is a tricalcium silicate-based material that was recently released as a permanent dentin replacement to replace damaged dentin.

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II. BACKGROUND

Due to their similarity to mineral trioxide aggregate (MTA) and their applicability in cases where MTA is indicated, calcium silicate-based materials have gained popularity in recent years. While a number of calcium silicate-based products have recently been introduced to the market, one in particular has gotten a lot of attention and has been the subject of a number of studies. This is the "Biodentine" calcium silicate-based product, which was introduced to the market in 2009 and was created primarily as a "dentine replacement" material. The material is created by combining MTA-based cement technology with the enhancement of some of these cement's properties, such as physical qualities and handling.[9] Since "Biodentine" has been mentioned frequently in recent literature and is a significant representative of tricalcium silicate-based cements, a review of studies on its properties would aid in forming a clearer picture of the general characteristics of this widely recognised material.

Composition[10]

Powder

Tri-calcium silicate- as the main core material.
Di-calcium silicate- as the second core material
Calcium carbonate & oxide- it works as a filler.
Iron oxide-it acts as a colouring agent.
Zirconium oxide- it acts as a radioopacifier.

Liquid

Calcium chloride- it acts as an accelerator.
Hydrosoluble polymer- it works as a water reducing agent.

Manipulation

In the triturator, the powder is mixed with the liquid in a capsule for 30 seconds. The default timer is set to 9-12 minutes.[11]

Setting reaction

As Biodentine powder and liquid are combined with an amalgamator, a hydration reaction occurs, which causes the substance to set. When calcium silicates are partially dissolved in liquid, a hydrated silicate hydrogel is formed. This will precipitate on the surface of the remaining Silicate particles as well as in the spaces between them, resulting in a substantial reduction in porosity and an increase in compressive strength over time.[12]

Mechanism of Action

Following its process, biodentine causes mineralization.By expressing markers of odontoblasts and increasing TGF-Beta1 secretion from pulpal cells, early mineralization occurs in the form of osteodentine.Calcium hydroxide is formed during the cement setting process. Calcium hydroxide causes inflammation at the site of contact due to its high pH. This region of coagulation necrosis is thought to induce precursor cell division and migration to the substrate surface, as well as addition and cytodifferentiation into odontoblast-like cells.[13]Biodentine stimulates odontoblasts to cause reactionary dentine apposition and cell division to cause reparative dentin apposition.[14] It is Because of its high alkality it has inhibitory effects on microorganism.

Properties

Setting time

Grech and colleagues evaluated the setting time of Biodentine using an indentation technique while the sample was immersed in Hank's solution.The Biodentine setting time was estimated to be 45 minutes.[15] The addition of calcium chloride to the mixing liquid was credited with the fast setting time. Mineral trioxide aggregate has also been shown to set faster when calcium chloride is added.[16]Biodentine's product sheet states that the setting time is 9 to 12 minutes, which is less than the time found in Grechetalreport. .'s However, the product sheet states that the initial setting time is 9–12 minutes, while Grech et al. measured the final setting time.[15]

Specific property of biodentine as dentine substitute

Elastic modulus is 22.0 Gpa, which is very similar to dentine's 18.5 Gpa. Dentine has a compressive power of 290 MPa, which is around 220 MPa. Biodentin has the same microhardness as natural dentin at 60 HVN. Acid tolerance testing revealed that the tricalcium silicate content has a lower rate of surface disintegration. Apatite-like calcium phosphate crystals were deposited on the soil. As a result, the interface between Biodentine, the dentine

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replacement, and the adjacent phosphate-rich hard tooth material is strengthened.[17]

Bond strength

Biodentine has a slightly stronger push-out bond than MTA(p<o.5).DyractAP>amalgamIRM Biodentine>MTA is the mathematical ranking of the push out bond power values. When immersed in sodium chloride, chlorhexidine, and saline solution, the push out bond strengths of Dyract AP, amlgam, IRM, and biodentine were not substantially different, while MTA lost its strength when exposed to chlorhexidine. As a result, even after being exposed to multiple endodontic irrigants, biodentine performs admirably as a perforation repair material.[18]

Porosity and material dentine interface analysis

In cases where a hermetic seal is needed, such as perforation repair, critical pulp treatments, and retrograde filings, tricalcium silicate-based materials are recommended. As a result, since porosity is a crucial element that decides the amount of leakage, it plays a critical role in the ultimate performance of treatments done with these materials. In cases where the process involves retrograde filing in a constantly damp setting, Biodentine's lower porosity is beneficial.[18]However, in processes such as liners, bases, or dentine repair, the substrate is typically kept dry, which may cause porosity issues and the forming of holes at the interface, allowing bacteria to move through. This points to the conclusion that in many clinical situations where moisture is not always available, care should be practised when selecting Biodentine.

Radiopacity

In contrast to bismuth oxide, which is used in other components as a radiopacifier, Zirconium oxide is used in Biodentine. It is favoured to bismuth oxide because of its biocompatibility, good mechanical properties, and corrosion resistance.[19]The disadvantage of using Zirconium oxide is that it is not well visible on radiographs, which makes Biodentine impossible to use in practise.[20]

Solubility

Negative solubility was shown by Grechet al.[15]Bioaggregate, and costs for a prototype cement In an analysis of the physical properties of biodentine, the supplies. This was due to the accumulation of compounds such as hydroxyapatite on the material surface when it came into contact with synthetic tissue fluids, according to the researchers. This property is advantageous since it indicates that the composite would not lose particulate matter, which will cause dimensional instability.

Microleakage

As Biodentine is used as a filler or base material, leakage should be taken into account, as leakage can cause postoperative sensitivity and secondary caries, leading to treatment failure. Koubiet al.[21] explained Biodentine's strong marginal integrity by the capacity of calcium silicate materials to form hydroxyapatite crystals at the surface.They attributed Biodentine's fine marginal integrity to calcium silicate materials' ability to form hydroxyapatite crystals at the soil. These crystals may have the potential to improve sealing efficiency, especially when shaped at the material-dentinal wall interface. Furthermore, the interaction of saliva's phosphate ions with calcium silicate-based cements can result in the formation of apatite deposits, enhancing the material's sealing ability. These materials had a slight extension, which added to their greater adaptability.

Discoloration

Biodentine was exposed to varying oxygen and light conditions, along with four other compounds, in one sample, and spectrophotometric analysis was conducted at various intervals until five days had passed. Portland Cement (PC) and Biodentine achieved favourable effects, and both materials showed colour consistency over a 5-day cycle.[22]

Wash-Out Resistance

The propensity of freshly prepared cement paste to disintegrate upon early contact with fluids such as blood or other fluids is known as washout of a substance. The findings of the available analysis on these characteristics of Biodentine were not promising, as the content showed a high washout rate for each decrease used in the technique.[23]

Tissue Regeneration & Early Mineralisation

Following its use, biodentine causes early minerlization by increasing TGF-1 secretion from pulpal cells.[12]It also promotes reactionary and tertiary dentin production by stimulating odontoblasts and cell differentiation. Majorie et al. (2012) found that biodentine promotes bio mineralization and causes immortalised Murine Pulp Cell Differentiation into odontoblast-like cells. The findings of the study indicated that biodentine is bioactive because it improved OD- 21 cell

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proliferation, and it should be used in therapeutic indications of dentine-pulp complex regeneration.[24]

Anti bacterial properties

Biodentine has an inhibitory effect on microorganisms due to its elevated alkaline pH. Furthermore, the alkaline alteration disinfects the underlying hard and soft tissues.[25]

Good material handling

It has Manipulation ease, accuracy, and safety handling with favourable environment kinetics – approximately 12 minutes.[26]

Bio compatibility

Biodentine helps to keep the pulp alive and facilitates the healing process. Laurent et al investigated the genotoxicity, cytotoxicity, and effects on the basic role of target cells using a new Ca3SiO5-based substance.[27]The Biodentine substance was found to be biocompatible in the analysis. The substance was shown to have little effect on the target cells' basic functions, indicating that it should be used safely. About et al studied biodentine activity in human tooth cultures by looking at the effects on pulp progenitor cell activation, differentiation, and dentine regeneration.[12]Bio dentine stimulates dentine regeneration by inducing odontoblast differentiation from pulp progenitor cells, according to the findings.[28]Laurent et al. looked into the ability of biodentine to influence TGF-1 secretion from pulp cells and trigger reparative dentine synthesis. In a human tooth culture model, biodentine was added directly to the dental pulp, causing a substantial increase in TGF-1 secretion from pulp cells and thereby inducing an early form of dental pulp mineralization shortly after application.[29]It has no effect on the functions of human pulp fibroblasts, collagen1, dentine sialoprotein, or Nestin expression.[30;31;32] It has no genotoxic properties.

Clinical Applications of Biodentine

Several factors can damage the integrity of teeth, including trauma, abrasion, attrition, dental caries, and iatrogenic factors.[33]Once a tooth has been injured, restorative and endodontic surgery are needed to repair the missing tooth structure, not only to maintain the vitality of the pulp but also to restore tooth morphology and function. As a result, many formulations have been adopted over time, making it difficult for a dental clinician to choose the most appropriate substance for the desired treatment. Biodentine is a dentine replacement drug that has been specially manufactured.

Biodentine as lining material

Biodentine is a dentine replacement material that has been specially manufactured. Under direct resin composite restorations, it has been used as a lining material. It's a good lining material because of its high compressive strength, colour stability, and resistance to masticatory forces.[34]The fact that biodentine has a low powder/liquid ratio has been linked to increased pressure.[35]The investigators discovered that acid etching has little effect on the compressive power of Biodentine. As a result, the author hypothesised that Biodentine could be used as a lining material underneath light-cured resin materials in a visually sensitive environment.

Biodentine in Vital pulp therapies

The treatment of deep carious lesions with vital pulp therapy involves applying biologically stable content on the remaining infected dentin (indirect pulp capping) or on the exposed pulp (direct pulp capping). Furthermore, pulpotomy is a well-known critical pulp therapeutic treatment. The removal of inflamed and polluted pulp tissue is accompanied by the placement of a biocompatible and bioactive substance in this process, which is commonly used in paediatric dentistry.

For essential pulp treatments, calcium hydroxide is regarded as the "gold standard."[37]Antibacterial behaviour and the ability to shape reparative dentine are two of the most essential properties. It does not adhere to dentine, has a high solubility, and has a low mechanical ability.[38-40]Biodentine's antibacterial properties and increased mechanical efficiency, together with its capacity to adhere securely to underlying dentin, have been shown to trigger the development of reparative dentin, making it a superior medicament for essential pulp therapies.[37] Biodentine-induced dentine bridge formation has a slightly better trend than calcium hydroxide-induced dentine bridge formation.[41] There was a study in which Biodentine was used for partial pulpotomy in an immature tooth, and the dentinal bridge formed successfully with root growth.[42]

Repair of root perforations, apexification

Calcium hydroxide is not used for root perforation, apexification, or retrograde root filling due to weak bonding to dentin, material resorption, and mechanical instability. As a result, MTA has been widely used in endodontics since 1990. MTA, on the other hand, has weak setting kinetics and

handling properties. Biodentine is used to solve many of these disadvantages because of its desirable properties such as ease of handling, quicker setting kinetics, biocompatibility, and early mineralisation. (Dr. Francois Bronnec and colleagues,)[43]

Biodentine as retrograde filling material

MTA, a less cytotoxic substance with improved microleakage safety, has recently been used in place of conventional root-end filling products to produce more clinically beneficial effects. MTA, on the other hand, has some disadvantages, such as difficult manipulation, a longer setting time, and lower compressive and flexural capabilities than dentin. Biodentine is a safer alternative to MTA as a retrograde filling substance because it has comparable properties to MTA but is easier to manipulate.[34]Biodentine satisfies the majority of retrograde filling content criteria, including biocompatibility, radiopacity, antimicrobial activity, dimensional resilience, strong marginal ntegrity, and induction of hard tissue regeneration. It also has the benefit of being less brittle. In one trial, biodentine performed admirably as a retrograde filling material, resulting in complete healing of a cystic lesion after an eighteen-month follow-up cycle.[44]

Disadvantages Of Calcium Hydroxide[45]

1. Dentin bonding is weak.
2. In the long term, it does not preclude microleakage.
3. The porosities (“tunnel defects”) of the new formed hard tissue may act as a portal of entry for microorganisms.
4. Mechanical Instability and Material Resorption

Disadvantages OfMta

1. Potential for discoloration-Iron and manganese have been suggested as possible culprits for the discoloration phenomenon.[46-48]
2. Characteristic that is difficult to handle[49]
3. Since the content takes 45 minutes to 2 hours to completely set, it must be secured before it can be used.[50]
4. Material costs are high (single use)[51]

III. CONCLUSION

Biodentine was first introduced in 2009, and it has since become a common alternative in a variety of clinical settings.The drawbacks of older materials have paved the way for Biodentine, which has superior properties. Biodentine has the capacity to revolutionise the treatment of damaged teeth in operative dentistry and endodontics due to its significant advantages and appreciable properties, as well as its ability to achieve biomimetic mineralisation. According to the literature, the content is a good and promising alternative to other widely used fabrics. Biodentine, as a result, proves to be a promising material for a variety of restorative and endodontic procedures. As a biocompatible, quickly managed substance with a quick setting period, biodentine holds promise for clinical dental procedures.