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Review Article

Biodentine: an effective pulp capping material

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Abstract: Dental Materials have been Evolving enormously. Calcium Silicate cement has changed the world of endodontics and restorative dentistry. Since MTA is considered as ideal calcium silicate cement but it has drawbacks like long setting time and also poor handling properties. Biodentine is new calcium silicate cement developed by Septodont group in order to improve the handling properties and also shorter setting time thus eliminating the drawbacks of MTA. Biodentine can be used in pulp capping, apexification and perforation repair. This article describes the properties and advantages of biodentine as Pulp Capping agent.
Keywords: Dental Materials, Calcium Silicate, Pulp Capping agent

Introduction:

Management of exposed Pulp in vital permanent teeth is accomplished by pulp capping procedure which remains a controversial issue [1].

Excessively deep carious lesion results in the destruction of odontoblastic layer on the periphery of pulp. The regeneration of pulp dentin complex occurs through the recruitment of progenitor cells, their differentiation into secreting cells and hence stimulation of reparative dentinogenesis [2].

Following are the factors on which the success rate of Pulp Capping agents depends - the clinical situation under which it is performed, age, type, site and size of pulp exposure [3] with an average success rate of 72.9% to 95.4% [4].

Since its introduction to dentistry, the material of choice to maintain the vitality of pulp has remained Calcium hydroxide. It is capable of stimulating tertiary dentin formation [5].

Introduction of MTA in 1990's was a breakthrough replacement of $Ca(OH)_2$ and became the gold standard of pulp capping agent due to its advantages like biocompatibility, less pulpal inflammation, predictable hard tissue barrier, antibacterial property, radio opacity, release of bioactive dentin matrix proteins and absence of any tunnel defect as seen with calcium hydroxide [6].

Biodentin was developed by Septodont's Research Group as a new class of dentin material which could conciliate high mechanical properties, excellent biocompatibility and bioactive behavior. It was developed as a silicate based restorative material. Due to its good sealing ability with dentin, it is used as a dentin replacement material [7].

Biodentin has its use both in coronal part of tooth and in roots. Its coronal uses are pulp protection, temporary restoration, cervical filling, direct and indirect pulp capping and pulpotomy [7].

Materials used for direct Pulp Capping:

Many Materials have been used for direct pulp capping. Following are the few Materials which are used : Calcium Hydroxide, Collagen, Bonding Agents, Calcium Phosphate, Hydroxyapatite, Lasers (CO_2), Glass Ionomer / Resin Modified Glass ionomer, Mineral Trioxide Aggregate, MTYA1-Ca, Growth Factors (BMP, Recombinant Insulin Like Growth Factors-I etc), Bone sialoprotein, Enzymes like (Heme Oxygenase-1, Simvastatin), Stem Cells, Propolis, Novel Endodontic Cement, Calcium Enriched Mixture, Enamel Matrix Derivative, Odontogenic Ameloblast Associated Protein, Bioceramic, Castor Oil Bean Cement and Biodentin.

Ideal Properties of Pulp Capping Materials:

- Stimulate reparative Dentin formation,
- Maintain Pulp Vitality,
- Release Flouride to prevent secondary caries

- Bactericidal or bacteriostatic
- Adhere to dentin
- Adhere to restorative material
- Resist force during restoration placement and during the life of restoration.
- Sterile
- Radioopaque
- Provide bacterial seal [3].

Setting Mechanism of Biodentin:

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

$2(3CaO.SiO_2) + 6\ H_20 \dashrightarrow 3CaO.SiO_2.3\ H_20 + 3\ Ca(OH)_2$

C_3S **CSH**

This dissolution process occurs at the surface of each grain of calcium silicate. The hydrated calcium silicate gel and the excess of calcium hydroxide tend to precipitate at the surface of the particles and in the pores of the powder, due to saturation of the medium. This precipitation process is reinforced in systems with low water content.

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 C-S-H gel formation is due to the permanent hydration of the tricalcium silicate, which gradually fills in the spaces between the tricalcium silicate grains. The hardening process results from of the formation of crystals that are deposited in a supersaturated solution.[7]

Bonding Between Biodentin and Human Dentin:

A material used as a base or base build-up should provide an adequate seal, be able to prevent leakage and remain in place under dislodging forces, such as chewing pressure or the application of other restorative material, thus having adhesive properties to dentin. Hence, the bond strength of restorative materials is an important factor in clinical practice [8].

The Biodentine in contact with dentin results in the formation of tag-like structures alongside an interfacial layer called the ‘‘mineral infiltration zone,’’ where the alkaline caustic effect of the calcium silicate cement’s hydration products degrades the collagenous component of the interfacial dentin[9].

The shear bond strength for Biodentine after 2 d was nearly 3 MPa and three times within one week to more than 9 MPa

Biodentine possess shear bond strength to dentine comparable to GIC, which was higher than that of ProRoot MTA but lower than that of composite resin in combination with a dentine adhesive. The shear bond strength of CSCs increases with time as the material cures [8].

Bonding Between Biodentin and Composite:

Biodentine is recommended for use as a dentine substitute under restorations. The bond strength between restorative materials and Biodentine is important for the quality of filling.

Biodentine is weak in its early setting phase. Placing the overlying composite is best delayed for at least 2 wk to allow adequate setting/maturation of the Biodentine to withstand sufficiently the contraction forces of the resin composite. This would also allow sufficient time to review the tooth if Biodentine was placed on symptomatic pulps [10].

Pulp Response to biodentin

Formation of the dentinal bridge at the interface between the pulp and pulp-capping material is a controversial issue because it can be a sign of healing or a reaction to irritation [11].

The pulp responses to biodentine were similar to MTA. The dentin bridge was seen be formed directly underneath the capping materials at the injury site with both materials. Dentin was associated with an irregular hard tissue, but occasionally the reparative tissue appeared heterogenous with cell inclusions. The mean thickness of the hard-tissue dentin bridge in the Biodentine and MTA groups were 211.56 mm and 230.31 mm, respectively [12].

A clinical study was conducted to compare the response of the pulp-dentin complex in human teeth after direct capping with biodentine and MTA. Pulps in 28 caries-free maxillary and mandibular permanent intact human molars, scheduled for extraction for orthodontic reasons, were mechanically exposed and assigned to one of two experimental groups, Biodentine or MTA, and one control group. Assay of periapical response and clinical examination were performed. After 6 weeks, the teeth were extracted, stained with hematoxylin-eosin, and categorized using a histological scoring system. The majority of specimens showed complete dentinal bridge formation and an absence of inflammatory pulp response. Layers of well-arranged odontoblast and odontoblast-like cells were found to form tubular dentin under the osteodentin and there was no significant difference between the Biodentine and MTA experimental groups. They concluded that biodentine had similar efficacy in the clinical setting and may be considered an interesting alternative to MTA in pulp-capping treatment during vital pulp therapy [13].

Micro leakage or sealing ability of Biodentin:

Bacterial micro leakage remains a major factor to determine the pulpal response after direct pulp capping, [14], due to their ability to stimulate inflammatory response. This decreases the dentin bridge thickness [16].

Biodentine has been evaluated by "diffusion of glucose" method to compare micro leakage in open sandwich. Biodentine restorations placed in Class II preparations in extracted human teeth and corresponding open sandwich restorations utilizing an RMGI material (Ionolux; Voco, Cuxhaven, Germany) and the same composite resin (TetricEvo Ceram; Ivoclar Vivadent, Schaan, Principality of Liechtenstein).No significant difference was found between Biodentine and RMGIC [17].

Raskin *et al.* compared Mean micro leakage scores comparing Biodentine and the Fuji II LC and found that they were equivalent [18].

Properties of Biodentine:

Compressive Strength:

Compressive strength of Biodentin as evaluated by Grech *et al.* came out to be 67.18 Mpa after 28 days of immersion in Hank's balanced salt solution.[19] Biodentine is claimed to have superior compressive strength as compared to MTA [7].

Flexural Strength:

The value of the bending obtained with Biodentine™ after 2 hours is 34 MPa, compared with that of other materials: 5-25 MPa (conventional Glass Ionomer Cement), 17-54 Mpa (Resin modified GIC), 61-182 MPa (composite resin) , it shows clearly that the bending resistance of Biodentine™ is superior to conventional GIC, but still much lower than the composite resin [7].

Microhardness:

Hardness can be defined as the resistance to the plastic deformation of the surface of a material after indentation or penetration.

The mean Vickers micro hardness for Biodentine was with 62.35 (±11.55) HV approximately 2.5 fold higher than for ProRoot MTA with 26.93 (±4.66). The differences between Biodentine and ProRoot MTA were highly significant [20].

Setting Time:

Markus *et al.* determined setting time of biodentine according to ISO 6876:2001 and it came out that final setting time is 85.88 min, and Setting time when evaluated using the procedure set out in ISO 9917-1; 2007 by Grech *et al* it came out to be 45 min [19]. Initial setting as found by Setbon *et al* for biodentine by measuring modulus of rigidity where it started increasing in 3 min after mixing and for Pro Root MTA it was found to be 165 min [21].

Density and Porosity:

The mechanical resistance of calcium silicate based materials is also dependant on their low level of porosity. The lower the porosity, the higher the mechanical strength.

Biodentine™ exhibits lower porosity than ProRoot MTA. The density and the porosity of Biodentine and Fuji IX are equivalent [7].

Radiopacity:

All materials lose some radiopacity over time. All Calcium Silicate cements showed radiopacity above 3mm Al which is 4.1mm Al [19] ProRoot MTA (6.40 (±0.06) mm Al) was significantly more radiopaque than Biodentine (1.50 (±0.10) mm Al) [20].

Resistance to Acid:

Considering durability of water based cements, in the oral cavity; one of relevant characteristics of the dental materials is the resistance to acidic environment.

Lauren *et al.* tested resistance of Biodentine to acid and found that the erosion of Biodentine™ in acidic solution is limited and lower than for other water based cements (Glass Ionomers) [22].

Antibacterial Activity:

MM Zayed *et al.;* evaluated the antibacterial potential of dental cements on the growth of the colonies of Streptococcus mutans.

All bioactive cements tested showed zones of bacterial inhibition but with different diameter. The largest inhibition zone was with Biodentine, followed by that of light cured resin modified glass ionomer group. Light cure Calcium Hydroxide showed the smallest inhibition zone with significant difference between all groups [23].

Fluid Uptake, sorption and Solubility:

The Fluid uptake and water sorption of Biodentine is considerably lesser and also similar to IRM while also exhibiting low solubility [19]. While Biodentin exhibit higher release of calcium ion and exhibited higher solubility as compared to MTA [20].

Push Out Bond Strength:

Biodentine had significantly higher push-out bond strength than MTA after 24 hours setting time. After 7 days, MTA and Biodentine had similar push-out bond strength in uncontaminated samples. Blood contamination had no effect on the push-out bond strength of Biodentine, irrespective of the duration of setting time [24].

Washout Resistance:

Biodentine when compared to Bioaggregate and IRM demonstrated the highest washout with consecutive steps [19].

Tooth Staining by Biodentin vs MTA

Biodentine exhibits color stability over a period of 5 days and can serve as an alternative for use under light cure restorative materials in highly esthetic areas [25].

Also Camilleri *et al*. conducted a study to find Staining Potential of Neo MTA Plus, MTA Plus, and Biodentine Used for Pulpotomy Procedures and concluded that Biodentine is suitable alternatives to MTA, and they do not exhibit discoloration [26].

Durability as Posterior interim Restoration:

Koub *et al.* evaluated by a prospective study the performance and safety of Biodentine, in the restoration of posterior teeth. This interim analysis was conducted on 212 cases that were seen for the 1-year recall. It was concluded that Biodentine is able to restore posterior teeth for up to 6 months [27].

Advantage as a Direct Pulp Capping Agent:

- Fast setting
- Better handling characteristics
- Better mechanical properties
- Bioactivity

Drawbacks

Drawbacks of Biodentine™ include mixing two separate components which can prove to be a hassle, its high cost and the fact that the patient needs to be called back for another appointment. Its use is still not indicated for use in root caries and requires more research in the area.

Conclusion:

Biodentine™ is an interesting and promising p roduct, which has the potential of making major contrib utions to maintain pulp vitality in patients judiciously se lected for direct pulp capping. The singlestage approach in pulp capping simplifies and improves the clinical use of Biodentine™.

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