Clinical Applications of Biodentine in Pediatric Dentistry: A Review of Literature

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Abstract

Biodentine is a calcium-silicate based material that has drawn attention in recent years and has been advocated to be used in various clinical applications, such as root perforations, apexification, resorptions, retrograde fillings, pulp capping procedures, and dentin replacement. There has been considerable research performed on this material since it’s launching; however, there is scarce number of review articles that collates information and data obtained from these studies. The purpose of this article was to review the clinical applications and advantages of biodentine in the pediatric dental practice. Electronic search of English scientific papers from 1992 to 2015 was accomplished using Pub Med search engine. The following search terms used were clinical applications, biodentine, pediatric dentistry, children, advantages, dentin substitute, pulp therapy, root filling, and tooth repair. Due to its major advantages and unique features as well as its ability to overcome the disadvantages of other materials, biodentine has great potential to revolutionize the different aspects of managing both primary and permanent in endodontics as well as operative dentistry.

Keywords: Clinical applications; Biodentine; Pediatric dentistry

Introduction

The need for more and more new materials is never ending especially in the field of dentistry. Various materials have been formulated, tested and standardized to obtain maximum benefit for good clinical performance. One such new material is the latest bioactive calcium-silicate based material (biodentine), which was recently introduced by Septodont Company and could consolidate high mechanical properties with excellent biocompatibility, as well as a bioactive behavior [1].

The commercialized tricalcium silicate of biodentine is different from the usual dental calcium silicate "Portland Cement" materials. The manufacturing process of the active biosilicate technology eliminates the metal impurities (such as aluminates and other impurities) seen in the "Portland Cement" calcium silicates. Therefore, the mechanical properties are improved in biodentine by controlling the purity of the calcium silicate through this Active Biosilicate Technology. Therefore, it has been developed and produced with the aim of bringing together the high biocompatibility and bioactivity of calcium silicates, with enhanced properties, which make it more unique than any other calcium silicate-based materials [2-5].

Biodentine is available as powder in a capsule and liquid in a pipette. There are two types of boxes available in the market. Box is containing 15 capsules & 15 single-dose containers and another smaller box which contains only 5 capsules & 5 single-dose containers [6]. The powder is mainly composed of tricalcium silicate (main core), dicalcium silicate, calcium carbonate, and iron oxide as well as zirconium oxide as the radiopacifier. The liquid contains water, calcium chloride (as setting accelerator) and a modified polycarboxylate (as superplasticising or water reducing agent) [5-8].

Biodentine was developed based on the most biocompatible chemistry available for dental materials: calcium silicate, which can set in the presence of water [5]. The calcium silicate will interact with water leading to the setting and hardening of the cement. This hydration process will produce hydrated calcium silicate (CSH) gel. As part of its chemical setting reaction, calcium hydroxide is also formed [5,9]. In contact with phosphate ions, it creates precipitates that resemble hydroxyapatite [6].

This dissolution process occurs at the surface of each grain of calcium silicate. The non reacted tricalcium silicate grains are surrounded by layers of CSH gel, which are relatively impermeable to water, thereby slowing down the effects of further reactions. Gradually, the CSH gel fills in the spaces between the tricalcium silicate grains. Later on, the hardening process results from the formation of crystals that are deposited in a supersaturated solution [5].

Biodentine attracted attention in the field of dentistry due to its fast setting time, high biocompatibility, high compressive strength, excellent sealing ability, and ease of handling as well as its versatile usage in both endodontic repair and restorative procedures without causing any staining of the treated teeth [4-6,10]. However, it has also been proved that biodentine has an excellent antimicrobial properties due to its very high pH (pH=12). In addition to that, it is much more cost effective in comparison to similar materials [1,4,5,10,11].

Many in vivo and in vitro studies support its bioactivity as well as its successful performance in many clinical applications [1,10-23]. On the
other hand, all the available clinical studies and case reports revealed excellent results for its use in human primary teeth [9,24-36].

Due to its improved material properties (short setting time, better mechanical properties, and easy and ergonomic use) as well as its ability to overcome the drawbacks of many other materials, biodentine might be an interesting and promising alternative to the existing materials for dentin-pulp complex regeneration. Biodentine has the potential of making major contributions in the field of dentistry by maintaining the teeth in a healthy state through numerous exciting clinical applications [1]. Therefore, biodentine promises to be one of the most versatile materials of this century in the field of dentistry.

The purpose of this article was to review the clinical applications and advantages of biodentine in the pediatric dental practice.

Materials and Methods

Electronic search of English scientific papers from 1992 to 2015 was accomplished using Pub Med search engine. The following search terms used were clinical applications, biodentine, pediatric dentistry, children, advantages, dentin substitute, pulp therapy, root filling, and tooth repair.

Results

One hundred and eighteen articles were reviewed as well as some references of selected articles. Thirty-eight recent studies described the clinical applications of biodentine in pediatric dentistry.

Discussion

Clinical applications

Biodentine uniqueness not only lies in its innovative bioactive and “pulp-protective” chemistry, but also in its universal application on both crown and root. In the area of the dental crown, it is indicated for pulp capping, pulpotomy, treatment of deep carious lesions using the external resorption, apexification and retrograde root canal to tooth repair.

Due to its improved material properties (short setting time, better mechanical properties, and easy and ergonomic use) as well as its ability to overcome the drawbacks of many other materials, biodentine might be an interesting and promising alternative to the existing materials for dentin-pulp complex regeneration. Biodentine has the potential of making major contributions in the field of dentistry by maintaining the teeth in a healthy state through numerous exciting clinical applications [1]. Therefore, biodentine promises to be one of the most versatile materials of this century in the field of dentistry.

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Discussion

Clinical applications

Biodentine uniqueness not only lies in its innovative bioactive and “pulp-protective” chemistry, but also in its universal application on both crown and root. In the area of the dental crown, it is indicated for pulp capping, pulpotomy, treatment of deep carious lesions using the sandwich technique, and also as temporary enamel restoration or permanent dentine replacement [9,25-27,37,38]. Its use in root includes managing perforations of furcation or root canals, internal and external resorption, apexitification and retrograde root canal obturation [35,36,39]. In addition to that, it could be used also as bone substitute material for implant stabilization [40]. On the other hand, biodentine is not recommended in large or esthetic build-ups [5].

Dentin substitute

In comparison to the other calcium silicate based materials, biodentine possess better biological and physico-chemical properties such as material handling, faster setting time, biocompatibility, stability, increased compressive strength, increased density, decreased porosity, tight sealing properties, and early form of reparative dentin synthesis [1,12,13,27,41]. It is sufficiently stable so that it can be used both for pulp protection and temporary fillings [5,6]. Accordingly, these improved properties of biodentine together with its excellent biological behavior suggested its use as permanent dentin substitute [13].

Biodentine was used safely as a dentin substitute in class I and class II composite restorations without any complication or post operative pain [24]. Clinically, a 6 month follow up study of biodentine in nineteen class I and II posterior restorations showed a very good marginal adaptation and surface finish along with absence of pain and sensitivity [25]. In evaluating the in vitro marginal integrity, koubi et al. in 2012 concluded that biodentine performed as well as resin modified glass ionomer cement in open-sandwich restorations covered with a light-cured composite [15]. Additionally, biodentine did not require any specific preparation of the dentinal walls [15]. In comparing the leakage of biodentine with a resin modified glass ionomer, as dentin substitutes in cervical restorations or as restorative materials in approximal cavities, Raskin et al. showed that biodentine performed well without any conditioning [41]. On the other hand, the resin modified glass ionomer had shorter operating time than biodentine [41]. In another multicentric, randomized, 3-year prospective study by Koubi et al, 146 class I and II posterior restorations and 24 direct pulp capping cases showed no clinical complications after 6 months [27]. Upon further follow up for up to 3 years, all teeth maintained vitality and symptom free. These results indicated that biodentine could be used under composite as a dentin substitute for posterior restorations [27]. In 2013, Gjorgievska et al. compared the interfacial properties of 3 different bioactive dental substitutes. They found that both glass ionomers and biodentine yielded favorable results as dentin substitutes. However, biodentine crystals appeared firmly attached to the underlying dentin surface during scanning electron microscopy analysis. They referred this excellent adaptability between biodentine and the underlying dentin to its micromechanical adhesion [18].

Through the combination of light and anaerobic conditions in vitro, Valles et al., showed that biodentine demonstrated color stability. Based on their results, they suggested that “biodentine could serve as an alternative for use under light-cured restorative materials in areas that are esthetically sensitive” [42]. On the other hand, the erosion of biodentine in acidic solution was observed to be limited and lower than other water based cements [13]. However, in reconstituted saliva (containing phosphates), no erosion was observed. Instead, a crystal deposition on the surface of biodentine occurred, with an apatite-like structure [13]. This deposition process of apatitic structures might increase the marginal sealing of the material [13]. However, its high acid resistance was demonstrated with less surface disintegration presented in acid erosion tests [6].

Since biodentine is indicated for use as a dentin substitute under permanent restorations, studies were performed also to assess the bond strength of the material with different bonding systems. In 2013, Odabaş et al. evaluated the shear bond strength of an etch-and-rinse adhesive, a 2-step self-etch adhesive and a 1-step self-etch adhesive system to biodentine at different intervals. They did not found any significant differences between all of the adhesive groups at the same time intervals (12 minutes and 24 hours). When different time intervals were compared, the highest bonding value was obtained for the etch-and-rinse adhesive at the 24-hour period, whereas the lowest was obtained for the etch-and-rinse adhesive at a 12-minute period [43].

In 2013, El-Ma’aita et al. assessed the effect of smear layer on the push-out bond strength of biodentine. They showed that the removal of the smear layer significantly reduced the push-out bond strengths of biodentine [44]. Thus, the smear layer was a critical issue that determines the bond strength between dentin and biodentine. Also, this study successfully demonstrated the bonding characteristics of this popular calcium silicate based material which is unique in contemporary dental applications [44].
On the other hand, biodentine is not as stable as a composite resin. Therefore, it is not suitable for a permanent enamel replacement [6]. But, in comparison to other Portland cement-based products, biodentine is stable enough to be used as a temporary filling even in the chewing load bearing areas [5].

Additionally, biodentine has a mechanical behavior similar to glass ionomers and is comparable to that of natural dentin [5,6,10]. Both the elasticity modulus of the cement and microhardness as well as compressive and flexural strengths are comparable with dentin [6]. The sealing ability of this biomaterial was also assessed to be equivalent to glass ionomers, without requiring any specific conditioning of the dentin surface [5,41].

Therefore, biodentine can be used safely and successfully as dentin substitute especially with its dentin like mechanical properties [5].

Pulp capping

Due to its high biocompatibility, biodentine has been proposed as a potential medicament for pulp capping procedures [6]. In comparison with the routinely used calcium hydroxide, biodentine is much superior regarding the tissue reaction as well as the amount and type of dentin bridge formation [5,6,19]. Because of its faster setting time, easier handling, and more enhanced mechanical properties, biodentine can be used safely and effectively as pulp capping material especially with its ability to initiate early mineralization by releasing Transforming Growth Factor- beta from pulpal cells to encourage pulp healing [6]. A clinical evaluation over 6 to 35 months of biodentine, as a base and pulp capping, demonstrated excellent biocompatibility and longevity [9]. In examining the inflammatory cell response and hard tissue formation of biodentine in pulp capped primary pig teeth, biodentine showed normal pulp tissue without any signs of inflammation [22]. Additionally, Dammaschke showed a successful result after 6 months of using biodentine as direct pulp capping of iatrogenic pulp exposure [26]. In 2012, Tran et al demonstrated in vivo that biodentine induced an effective dental repair (pulp healing) when applied directly to mechanically exposed rat pulps [19]. They observed the formation of a homogeneous reparative dentin bridge at the injury site with biodentine which was significantly different than the porous reparative tissue induced by calcium hydroxide [19].

In an interesting clinical and histological study, Nowicka et al. investigated the response of human dental pulp capping with biodentine [20]. They found that the majority of specimens showed complete dentin bridge formation without any inflammatory pulpal response [20]. Therefore, biodentine showed good efficacy in the clinical settings and can be considered as an interesting and promising pulp capping material.

Pulpotomy

Pulpotomy is another widely used vital pulp therapy method in which biodentine is advocated to be used [6]. This treatment method is the most frequently accepted clinical procedure in pediatric dentistry when the coronal pulp tissue is inflamed and a direct pulp capping is not a suitable option [45].

In comparison to formocresol in primary teeth pulpotomy, biodentine is a regenerative material that maintains pulp vitality whereas formocresol is a devitalizing agent [6,45]. However, biodentine required less time for the pulpotomy procedure [22]. While formocresol acts only as dressing material, which needs a restorative material to seal the pulp chamber, biodentine acts simultaneously as both dressing and filling material [6,45]. Thus, biodentine eliminates the need for a filling material in the pulp chamber of pulpotomized teeth. While formocresol requires 3–5 minutes application before the cotton pellet is removed, with biodentine the pulp chamber is filled immediately [6,45]. Moreover, during the removal of formocresol-soaked cotton pellet, there is a possibility of the cotton fibers adhering to clot, resulting in reoccurrence of bleeding. This does not occur with biodentine as it is applied directly without cotton pellet [1,2,5,6,10,45].

In 2012, Shayegan et al investigated the inflammatory cell response and hard tissue formation after biodentine pulpotomy in primary pig teeth. After 90 days, they found that the pulp tissue was normal without any signs of inflammation and 9 out of 10 teeth showed thick calcification under the pulpotomy site. They concluded that biodentine has bioactive properties, encourages hard tissue regeneration, and provoke no signs of moderate or severe pulp inflammation response [22].

In support to the aforementioned favorable biological results, Marijana et al. concluded that the therapeutic effects of biodentine after vital pulp therapy in Vietnamese pigs are favorable [21]. Biodentine has the potential of making major contributions to maintaining pulp vitality in patients judiciously selected for pulpotomy treatment [21]. Therefore, this unique material might be an interesting alternative to the existing materials for dentin-pulp complex regeneration [21].

A survey of the available literature shows that there are yet few published case reports and clinical trials with many non-published ongoing clinical trials that include the usage of biodentine in pulpotomy [28-31,33,38]. All these studies showed biodentine as a favorable and promising alternative for the existing pulpotomy medicaments.

In multiple case reports, Lavaud et al. showed a successful results of biodentine without any clinical or radiological symptoms when it is used for primary teeth pulpotomy (9 months of follow up), indirect capping on a hypomineralized molar (12 months of follow up), and apexogenesis (14 months of follow up) [38]. In another published case report, Villat et al. performed a partial pulpotomy in an immature second right premolar of a 12-year-old patient [33]. After 6 months, the patient did not report any pain or complains along the observation period. Furthermore, the authors detected homogeneous dentin bridge formation as well as continuation of root development [33]. Accordingly, they commented that fast favorable pulpal response render this material a suitable choice compared to other materials [33].

Recently at the 12th Congress of European Academy of Pediatric Dentistry (EAPD) in Poland, Rubanenko et al. presented their preliminary results of comparing biodentine versus formocresol as dressing agents in pulpotomized primary molars [29]. They demonstrated a success rate of 100% for biodentine while that of formocresol was 94% [29]. Additionally, Cuadros et al confirmed these interesting preliminary results of biodentine in humans and stressed that biodentine seems to be a promising alternative for use in pulpotomies of primary molars with 100% clinical and radiographic success after 6 months of follow up [30]. On the other hand, Rajasekharan et al. presented the results of their randomized control clinical trial and showed clinical as well as radiographic success in 94.73% of biodentine treated teeth [31]. They concluded, “there was no significant difference between the new product biodentine in comparison to the well-known products (mineral trioxide aggregate (MTA) or Temprophore)” [31]. In evaluating the current preference
endodontic material in children amongst Flemish pediatric dentists, Vandenbulcke et al. found that biodentine was the most preferred pulpotomy material in both primary and immature permanent teeth [46].

Apexification (Apical Plug in teeth with necrotic pulps and open apices)

Treating a tooth with an open apex and a necrotic pulp has always been a challenge for dental practitioners [47]. The main goal in this type of treatment is to prevent the extrusion of the obturation material [47]. Since a long time, calcium hydroxide has been used widely as an apical plug in teeth with necrotic pulps and open apices [47]. After that, most of the drawbacks of calcium hydroxide apexification such as multiple scheduled visits and susceptibility of treated roots to fracture have been solved with the use of 4 mm thickness MTA plug in the apical part of the root [47-49]. On the other hand, MTA has its own drawbacks of low mechanical properties, difficult handling, slow setting, and relatively high cost [48]. After the introduction of biodentine, all these drawbacks of MTA have been solved with keeping of all its benefits [5,6]. Unlike MTA, biodentine handled easily and need much less time for setting with better mechanical properties and acceptable cost [50]. As the setting is faster, there is a lower risk of bacterial contamination than with MTA. The mechanical resistance of biodentine is also much higher than that of MTA. Biodentine does not require a two step obturation as in the case of MTA [6]. In a series of cases, Cauwels et al. found that necrotic immature teeth can still achieve continued root development after proper regenerative endodontic treatment with biodentine [32]. Furthermore, the main benefits of using biodentine in this procedure is obtaining a combination of a tight bacterial seal in the apical foramen as well as inducing the formation of new cementum and periodontal ligament (PDL) [5]. Therefore, biodentine can be advised successfully in weakened necrotic immature teeth [5,50].

Retrograde root end filling

At the apical end of the root canal system, establishing an impermeable hermetic seal by adequate root end filling material is one of the most important aspects of the periapical surgery [51]. Many materials have been used as root end fillings such as amalgam, zinc oxide eugenol, glass ionomer cements, and MTA [52-54]. Recently, Septodont introduced the short setting calcium silicate based material (biodentine) who has better consistency and handling properties and therefore, it can be considered the best interesting alternative as root end filling material [5,6,55].

In a case report, Pawar et al. assessed biodentine as a retrograde material in the management of a large periapical lesion associated with previously traumatized maxillary right central and lateral incisors [34]. After 18 months of apical surgery, they found an evident progressive periapical healing. On the other hand, Soundappen et al. concluded “both MTA and IRM were significantly superior when compared to biodentine in terms of marginal adaptation as retrograde filling materials” [56].

Repair of resorption

With their proven biocompatibility and ability to induce calcium-phosphate precipitation at the interface to the periodontal tissue, calcium silicate cements play a major role in bone tissue repair [57,58]. They have gradually become the materials of choice for the repair of all types of dentinal defects creating communication pathways between the root-canal system and the periodontal ligament [6,54]. After its introduction as fast setting calcium silicate cement, biodentine with its ease of manipulation and handling can be considered as an interesting and promising resorption repair material [5]. Biodentine has a better consistency after mixing which allows ease of placement in areas of resorptive defect or obturation of full root canal system [6].

In two case reports, Nikhil et al. and Ali et al. showed successful results of biodentine when it is used in treatment of cervical and apical external root resorption with more than 1 year of follow up [35,36]. On the other hand, there is some difficulty in removal of biodentine in case of retreatment [5].

Repair of perforations

Perforation is a procedural complication that can occur during endodontic treatment or post space preparation of teeth [59]. An ideal perforation repair material should provide a tight seal between the oral environment and periradicular tissues [59]. It also should remain in place under dislodging forces, such as mechanical loads of occlusion or the condensation of restorative materials over it [60,61]. Although many dental materials have been tried including amalgam, cavity composite resin, glass ionomer cement, calcium hydroxide, IRM, and MTA [59-61]. Most of these materials show significant shortcomings in 1 or more of the following areas: solubility, leakage, biocompatibility, handling properties, and moisture incompatibility [58,62,63].

Biodentine has its own unique properties that make it preferred for perforation repair either in root canal or pulp chamber floor [23]. These unique properties include its ease of handling, short setting time, and high push out bond strength as well as its acceptable cost [64,65]. Many studies demonstrated in vitro the high push out bond strength of biodentine even after being exposed to various endodontic irrigation solutions [6,23,65]. Additionally, Aggarwal et al. in 2013 found that the blood contamination had no effect on the push-out bond strength of biodentine [23]. Due to its high push out bond strength, biodentine is preferred for perforation repair either in the root canal or pulp chamber even after being exposed to various endodontic irrigants [6,23].

Advantages of biodentine (unique features)

High purity: It contains high-purity, monomer-free mineral ingredients [5].

Highly biocompatible and bioactive: It stimulates the pulp cells to build a high quality and quantity of reactionary dentin. The dentin bridges are created faster and are thicker than with similar dental materials and represent the necessary condition for optimal pulp healing without any threat on body tissues [5,66].

Short setting time: It sets within 10-12 minutes, which allows full restorations to be completed in one office visit. This unique advantage is due to increasing particle size, adding calcium chloride to the liquid, and decreasing the liquid content [5,6].

Easily material handling: The improved physic-chemical properties, ease of manipulation, better consistency, and favorable setting kinetics make biodentine clinically easy to handle [5,6].

Versatile: Useable for bulk fill in vital pulp therapy, does not stain, and there is no surface preparation or tedious bonding required due to the micro-mechanical anchorage [5].
Superior mechanical properties: it has mechanical properties comparable to the sound dentin and can replace it both in the crown and in the root, without any preliminary conditioning of mineral tissues. Therefore, biodentine saves teeth by preserving the pulp and promoting pulp healing as well as eliminating the need for root canal therapy in most cases [10].

Excellent sealing properties: Biodentine has an excellent sealing ability with mineral tags in the dentin tubules with outstanding microleakage resistance, enhanced by the absence of shrinkage due to the resin-free formula [5].

Excellent antibacterial properties: Since calcium hydroxide is resulting from the setting reaction of biodentine, the released calcium hydroxide ions result in high alkaline pH (pH of 12) of biodentine. This alkaline change promotes an unfavorable environment for bacterial growth and leads to the disinfection (basification) of surrounding hard and soft tissues [5,6].

Universal: Besides the usual endodontic indications of this class of calcium-silicate cements (vital pulp therapy, repair of perforations or resorption, apicification, root-end filling), biodentine is suitable as a permanent dentin substitute and temporary enamel substitute [9,25-27,37,38].

Conclusion
The clinical applications of biodentine material have been discussed. Biodentine is an excellent material with innumerable qualities required of an ideal material. The important applications of biodentine in pediatric dentistry include dentin substitute, pulp capping, pulpotomy, apicification, and repair material of perforation and resorption as well as root end filling material. It can be an alternative to formocresol in pulpotomy because of the tissue irritating, cytotoxic and mutagenic effects of formocresol which are solved with biodentine. However, it can be an alternative to calcium hydroxide or MTA in pulp capping, pulpotomy, and apicification because biodentine is very successful in the formation of a dentin bridge that is faster and thicker with lesser defects. While it is stronger mechanically, less soluble and produces tighter seals than calcium hydroxide [5,6], biodentine also avoids the drawbacks of MTA, i.e., extended setting time, difficult handling characteristics, high cost, and potential of discoloration [5,54]. Accordingly, biodentine might be an interesting alternative to the existing materials for dentin-pulp complex regeneration [1].

Due to its major advantages and unique features as well as its ability to overcome the disadvantages of other materials, biodentine has great potential to revolutionize the different aspects of managing both primary and permanent in endodontics as well as operative dentistry. On the other hand, further studies are needed to extend the future scope of this material regarding the clinical applications. 7

References


