Apical Closure in Apexification: A Review and Case Report of Apexification Treatment of an Immature Permanent Tooth with Biodentine

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Abstract

Materials such as calcium hydroxide paste and mineral trioxide aggregate are used in apexification treatment of immature permanent teeth, but the search for improved materials with higher characteristics of biocompatibility results in different materials. Biodentine is a tricalcium silicate cement that possesses adequate handling characteristics and acceptable mechanical and bioactivity properties. This report describes the case of a 9-year-old boy who was referred to the Department of Dental Clinic of Querétaro Autonomous University of Mexico. One month prior the patient had suffered a dental trauma of his upper left central incisor and had been treated by another dentist. The clinical diagnosis was previously initiated therapy and symptomatic apical periodontitis. The treatment was apexification with Biodentine. At follow-ups performed at 3, 6, and 18 months after treatment the tooth was asymptomatic. The cone-beam computed tomography scan at 18-month postoperative follow-up revealed continuity of periodontal ligament space, absence of periapical rarefactions, and a thin layer of calcified tissue formed apical to the Biodentine barrier. On the basis of sealing ability and biocompatibility, apexification treatment with Biodentine was applied in the present case report. The favorable clinical and radiographic outcome in this case demonstrated that Biodentine may be an efficient alternative to the conventional apexification materials. (J Endod 2016;42:730–734)

Key Words
Apexification, bioactivity, Biodentine

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pexification treatment of immature permanent teeth with pulp necrosis is an endodontic procedure to achieve apical closure (1). For many years, calcium hydroxide paste was used to induce a calcified barrier followed by root canal therapy (2) until 1993 when mineral trioxide aggregate (MTA) became the chosen material to induce the formation of the apical barrier (3) because of its sealing properties and biocompatibility (4). Several studies demonstrated its capacity to induce odontoblastic differentiation (5), good radiopacity, low solubility, high pH (6, 7), expansion after setting (8), and antimicrobial activity (9). However, the prolonged setting times, handling difficulties, and possible coronal staining associated with MTA (10, 11) had led to a search for other alternative materials. In recent years there has been a persistent search for improved biocompatible materials applicable to endodontic practice, such as calcium silicate cements.

In 2009 Biodentine (Septodont, St Maur des Fosses, France) was introduced as a tricalcium silicate cementum. Biodentine is supplied in individual powder capsules composed of tricalcium silicate, calcium carbonate, and zirconium oxide that are mixed with liquid containing water, calcium chloride to accelerate setting, and modified polycarboxylate as a plastifying agent (12–14). The powder is mixed with the liquid for 30 seconds with an amalgamator. Biodentine possesses adequate handling characteristics because of its excellent viscosity and short setting time, which is about 12 minutes. This material can be used for substitution of dentin in coronal restorations, pulp linings, pulpotomies, reparation of root perforations, internal and external resorptions, formation of apical barriers in apexification treatment, regenerative procedures, and as retrofilling material in endodontic surgery (15). Regarding its mechanical properties and biocompatibility, Camilleri et al (15) have reported superior results compared with MTA, because greater apposition of hydroxyapatite was observed on the Biodentine surface when exposed to tissue fluids (15). These biological properties, together with the good color stability of the product (16), its lack of genotoxicity (17), and low cytotoxicity (18), make it an ideal material for use in endodontic practice. Biodentine preserves ginglyval fibroblast viability (19), with stimulation of tertiary dentin formation (12–14), induction of pulp cell differentiation toward odontoblastic cells in culture (13), and formation of mineralized tissue similar to that formed when using MTA (14). In contrast, a possible disadvantage of Biodentine is its low radiopacity (12, 13).

Most studies involving calcium silicates have focused on pulp therapies such as direct linings and pulpotomies in human and animal models (20–22). To our knowledge, there is little clinical evidence of the effect of Biodentine on the
formation of apical barriers in immature necrotic teeth. The present clinical case is a report of a symptomatic immature permanent tooth #9 with pulp necrosis and apical periodontitis that was treated after the apexification procedure with Biodentine.

**Case Report**

A 9-year-old boy was referred to the Dental Clinic of Querétaro Autonomous University of Mexico for the treatment of tooth #9. One month prior the patient had suffered a dental trauma, and tooth #9 had been treated by another private practice dentist. The patient reported pain on mastication in the maxillary left incisor. Clinical examination showed that tooth #9 had a complicated oblique fracture of the crown, and the probing depth was within normal limits (Fig. 1). Sensitivity tests (heat, cold, and electrical pulp testing) of the tooth gave no response. The tooth was tender to percussion, and mobility grade I was observed. A periapical radiograph of the tooth showed that the coronal fracture appeared to reach the distal pulp horn of tooth #9, and no radiolucency was observed at the periapical area of the root. The root apex was not fully formed (Fig. 1). The clinical diagnosis of tooth #9 was previously initiated therapy and symptomatic apical periodontitis. The apexification treatment was explained to the patient’s parents, and the decision for apexification instead of revascularization was made primarily because the diameter of the open apex was not more than 1 mm, which may be difficult to induce bleeding. Another reason was that the radiographic analysis comparing both central incisors showed that root’s length and thickness of walls were similar for both teeth. The apexification treatment with Biodentine was elected with the informed consent of patient’s parents.

**First Session**

Local anesthesia with 3% mepivacaine (Scandonest; Septodont) was administered, and after isolation with a rubber dam, the material that had been placed by another dentist was removed. The previous access cavity was rectified by using an Endo-Z drill (Dentsply Maillefer, Ballaigues, Switzerland), and #15 K-file was introduced into the canal to ensure the patency of the canal. Reciproc R25 (VDW GmbH, Munich, Germany) was used in brushing motion only to remove possible remnant tissue in dentinal walls. The canal was irrigated with copious amounts of 2.5% sodium hypochlorite ultrasound activated irrigation with negative apical pressure by using EndoVac (Kerr Corporation, Orange, CA) system and dried with NaviTip tips (Ultradent, South Jordan, UT). A calcium hydroxide (CH) paste (Metapex; Meta Biomed, Chungju, Korea) was placed into the apical portion of canal with a spiral lentulo as intracanal medication. The access cavity was closed with a cotton pellet and glass ionomer. The patient was scheduled for a second visit after 2 weeks.

**Second Session**

The tooth was asymptomatic during the entire postoperative period, and the temporary filling was intact. Local anesthesia was accomplished with 3% mepivacaine (Scandonest). After isolation with rubber dam, the glass ionomer and cotton pellet were removed from the access cavity. A copious amount of 2.5% sodium hypochlorite ultrasound activated irrigation with negative apical pressure by using EndoVac system was used to remove the CH paste from the canal. A final rinse of 17% EDTA for 1 minute was performed. The canal was dried with NaviTip tips (NaviTip FX Tips; Ultradent Products Inc), and a small piece of absorbable collagen membrane (Gelfoam; Pfizer Inc, Groton, CT) was placed at the apical portion of the canal. The membrane was introduced thorough the root canal and gently compacted by using prefit ted hand plungers slightly beyond the apex to achieve a matrix. Biodentine was prepared according to the manufacturer’s instructions. The powder was mixed with 5 drops of liquid and activated in the dental triturator for 30 seconds. It was carried into the canal with an amalgam carrier and condensed with hand plungers to form apical plug of 5 mm in thickness. The excess material from the walls was removed with paper points, and after 12 minutes, the rest of the canal was obturated with thermoplasticized gutta-percha and AH Plus resin sealer (Dentsply De Trey, Konstanz, Germany) by using the continuous heat wave technique (B&L Alpha II and Beta; B&L Biotech, Inc, Fairfax, VA). The access cavity was closed temporarily with glass ionomer (Fig. 2). After 1 week, the glass ionomer was replaced by a bonded resin restoration (Filtek Z350XT; 3M ESPE Dental Products, St Paul, MN).

**Follow-up**

At follow-ups performed at 3, 6, and 18 months (Fig. 3) after treatment the tooth was asymptomatic, and the color of the crown did not

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**Figure 1.** (A) Preoperative intraoral view and (B) preoperative radiograph.
change. The continuity in the periodontal ligament space with absence of periapical radiolucency was observed at 3-month, 6-month, and 18-month radiographs. At 18 months, a cone-beam computed tomography scan was done (Fig. 4).

**Discussion**

Apexification is defined as a method of inducing a calcified apical barrier or continued apical development of an incompletely formed root in teeth with necrotic pulp (2). Traditionally, the apexification method involves application of CH until completion of root-end closure (23, 24). However, the disadvantages of this long-term technique include delayed treatment, difficulty in following up with patients, unpredictability of an apical seal, and the risk of root fractures because of the presence of thin walls (1). Filling of the root canals with CH dressing for extended periods may weaken tooth structure (25).

In most apexification protocols involving human immature permanent teeth with apical periodontitis, the placement of an apical plug is crucial for sealing and preventing bacterial leakage (26). Because MTA had been introduced by Torabinejad and co-workers for use in pulp capping, pulpotomy cases, and sealing accidental perforations of the root canal (27), it became the material of choice for apexification therapy because of excellent biocompatibility and sealing ability (28). MTA is a bioactive cement with the capacity to induce the formation of new cementum and periodontal ligament, which makes this material biologically acceptable for closing a root canal with an open apex (29). The mechanism of action of MTA lies in releasing calcium ions that activate cell attachment and proliferation, and at the same time, the high pH creates an antibacterial environment (4). MTA produces apical hard tissue formation with significantly greater consistency than CH (30). A systematic review comparing the efficacy of MTA and CH as material used for apexification of immature teeth revealed no significant differences between both groups regarding success and apical barrier formation (31), although the time taken for formation of apical biological calcified barriers in immature teeth treated with MTA was significantly less than the time for those treated with CH (32). Eli-Meligy and Avery (33) compared MTA and CH clinically and radiographically as materials to induce apexification in 15 children, each with 2 necrotic immature permanent teeth. The 12-month follow-up revealed failure in only 2 teeth treated with CH because of persistent periradicular inflammation and tenderness to percussion. None of the MTA-treated teeth showed any clinical or radiographic pathology. The thickness of dentin walls was not increased in any of the groups. These observations are in line with findings of Shah et al (34), who observed that the newly formed mineralized tissue covered only the root surface.

Biodentine is a new bioactive dentin substitute cement, which is composed of powder that consists of tricalcium silicate, dicalcium silicate, calcium carbonate, calcium oxide, zirconium oxide, and CH. The liquid for mixing with the cement powder consists of a water-soluble polymer and calcium chloride, which accelerates the setting reaction (35). Biodentine has a shorter setting time of 12 minutes, as compared with that of MTA, which is 2 hours 45 minutes. The powder is mixed with 5 drops of liquid and activated in the dental triturator for 30 seconds. This material is clinically indicated for permanent dentin replacement, direct and indirect pulp capping, pulpotomy, repair of furcation and root perforations, retrograde root-end filling, and apexification.

Biodentine is considered a suitable pulp-capping material. Zanini et al (13) suggest that Biodentine is bioactive because it induces differentiation of odontoblast-like cells and increases murine pulp cell proliferation and biomineralization. The response of dental pulp after direct capping with Biodentine revealed a complete dentinal bridge formation and a layer of odontoblast-like cells under the osteodentin (20, 22). Biodentine has been shown to lack cytotoxicity, and it is able to stimulate collagen fiber and fibroblast formation. A histologic study showed nonsignificant inflammatory reaction in the connective tissue in contact with Biodentine in the subcutaneous tissue of rats (36).

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**Figure 2.** Immediate postoperative radiograph.

**Figure 3.** Follow-up radiographs at (A) 3 months, (B) 6 months, and (C) 18 months. (A and B) Healing process is evident radiographically 3 and 6 months after apexification treatment. (C) At 18 months there is no evidence of periapical radiolucency and adequate root-end development.
Many authors have demonstrated the viability of a fibroblast cell line in contact with Biodentine and MTA. Examination by scanning electron microscopy revealed cells adhering to most of the Biodentine surface after 24 hours (37). Zhou et al (19) showed that human gingival fibroblasts in contact with Biodentine and MTA attached to and spread over the material surface at 7 days of culture.

The biocompatibility of Biodentine has also been demonstrated on human bone marrow stem cells. This bioactive cement increased the expression level of runt-related transcription factor 2 and stimulated osteoblast differentiation. Several studies underscored the importance of the combination of specific local biological microenvironment and circulating soluble calcium and inorganic phosphate levels to achieve bone regeneration (40, 41). This microenvironment, in the presence of calcium silicate cements, can induce stem cells from apical papilla and signaling factors to specific cell differentiation pathway (42, 43). The calcium ions and presence of Si-OH groups of calcium silicate cements induce apical sealing through the deposition of apatite onto the surface of the root cement (44). Furthermore, the Hertwig epithelial root sheath is involved in regulating differentiation of periodontal ligament stem cells and forming cementum-like tissue (45).

Comparative studies between MTA and Biodentine revealed that both materials offer excellent sealing performance after direct pulp capping prevents the risk of subsequent microbial contamination (20–22). The marginal sealing properties of calcium silicate–based cements are due to its ability to produce CH during hydration, which in contact with the phosphates of tissue fluids form a calcium phosphate phase (46). The alkaline caustic effect of CH degrades the collagenous component of the interfacial dentin, leading to the formation of a porous structure that facilitates the permeation of high concentrations of Ca(2+), OH(−), and CO3(2−) ions. The tag-like structures alongside an interfacial layer called the mineral infiltration zone increase mineralization in this region (47).

Several authors describe case reports of apexification procedures in immature permanent teeth with an apical plug of Biodentine. The first case was reported by Nayak and Hasan (48), who used Biodentine as an apical barrier and a synthetic collagen membrane to serve as matrix after 1 month of CH dressing. Sinha et al (49) had used a triple antibiotic paste in the root canal for a week before placing an apical plug of Biodentine. A 12-month follow-up with cone-beam computed tomography exhibited progressive involution of periapical radiolucency, with evidence of good healing of the periapical tissues and absence of clinical symptoms. A single-visit apexification procedure of a traumatically injured tooth with Biodentine revealed that this bioactive and biocompatible calcium-based cement can regenerate damaged dental tissues and represents a promising alternative to the multi-visit apexification technique (50). In all case reports the thickness of the apical plug was 5 mm, and the canal was back-filled with gutta-percha and resin-based sealer.

Physical properties of Biodentine are important when considering it as material for crown restorations. Recent studies have demonstrated that teeth treated with Biodentine did not exhibit crown discoloration (46, 51). Biodentine is easy to prepare and to handle, and time required for setting is shorter than other silicate-based cements.

On the basis of sealing ability and biocompatibility, apexification treatment with Biodentine was applied in the present case report. The favorable clinical and radiographic outcome in this case demonstrated that Biodentine may be an efficient alternative to the conventional apexification materials.

Acknowledgments

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References

Regenerative Endodontics


