Preventive Endodontics by Direct Pulp Capping with Restorative Dentin Substitute-Biodentine: A Series of Fifteen Cases

Abstract

Introduction: Treatment of mechanical exposure of the pulp during caries excavation presents a clinical challenge. In this case series of 15 patients, with a follow-up period of over a year, the outcome of direct pulp capping with Biodentine (septodont) after mechanical pulp exposure was assessed. Aim of Study: The aim of this study is to evaluate the outcome of direct pulp capping with Biodentine in deeply carious teeth when pulp was mechanically exposed during caries excavation and cavity preparation. Vital pulps exposed during caries excavation in molar teeth were treated with 3% sodium hypochlorite for 2 min. If adequate hemostasis was achieved, the pulp tissue was capped with Biodentine, which covered the entire pulpal floor. This was followed by the placement of a layer of resin-modified glass ionomer cement and a final layer of composite resin (Filtek Z350-3M) to complete the restoration. The patients were recalled periodically and evaluated for any evidence of pulpal/periapical pathology. Results: In the follow-up period that ranged from 12 to 24 months, all teeth were asymptomatic. Conclusion: Biodentine appears to be a suitable material for direct pulp capping under clinical conditions. However, long-term follow-up studies and controlled trials involving a large sample size are warranted.

Keywords: Biodentine, endodontics, pulp capping, pulp exposure

Introduction

The core of conservative dentistry and endodontics revolves around the preservation and treatment of the pulp dentine complex. Dentine plays an important role in preserving the vitality of the tooth. Pulp exposure due to trauma or mechanical exposure during cavity preparation in deeply carious teeth is a clinical challenge. Pulp capping is the most conservative restorative procedure for protecting the pulp from further insult, permitting healing and repair. The earliest account of pulp therapy was way back in 1756, where Philip Pfaff packed a piece of gold over an exposed vital pulp to promote healing.[1] Partial removal of caries is a well-established treatment protocol for deep carious lesions. However, there are two conditions that require considering direct pulp capping as a treatment option. One is an accidental mechanical pulp exposure and the other exposure by caries. Many medicaments, antibiotics, and anti-inflammatories have been used as pulp capping agents. If successful, this procedure precludes the need for more invasive, more extensive, and more expensive treatment. There has been a constant research on the factors that may promote/impair healing of pulpal wounds and maintain vitality.

Calcium hydroxide (CH), however, has been the gold standard and generally the accepted agent of choice for pulp capping procedure. It has enjoyed dominance since its introduction by Hermann in 1920 for root canal fillings. Between 1928 and 1930, he studied the reaction of vital pulp tissue to CH to prove that it was a biocompatible material. Since then, CH has been recommended by several authors for direct pulp capping; however, it took until the middle of 20th century until it was regarded as the standard of care.[2]

The phenomenon of pulp healing and hard tissue repair following the application of CH, however, has been intriguing to clinicians. Studies have shown that CH degrades over time, has poor sealing abilities and tunnel defects have been demonstrated through dentinal bridge under the capped material.[3] Research

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has shown that the use of Ca(OH)2 frequently results in the development of chronic pulpal inflammation and internal root resorption.\[4\] Thus, the enjoyed dominance of CH as pulp capping agent has been challenged leading to continuous research to either find improved synthetic materials which promote healing or to identify biological signaling molecules involved in the process of pulp healing.

The ability of transforming growth factor’s and human bone morphogenic protein’s to induce reparative dentinogenesis in pulp capping situation in vivo provides the basis for the development of a possible new generation of biomaterials has a beneficial effect on living cells and interacts with them in a biologically compatible manner.\[5\]

Mineral trioxide aggregate (MTA) was introduced in dentistry by Torabinejad et al.\[6\] in 1993 and is considered as the first bioactive calcium silicate-based material. This material has been extensively studied and researched and has gained enormous popularity. It is currently considered the most promising material for various treatments such as root-end filling,\[7,9\] direct pulp capping,\[10–12\] perforation repair,\[13\] and apical barrier for teeth with necrotic pulps and open apices.\[14\]

However, its complicated handling and slow setting kinetics are a concern. The enormous popularity of this innovative material and research in material science led to the development of other calcium silicate-based materials such as Biodentine and MTA plus.

MTA plus has been recently introduced to the market. The manufacturers (Avalon Biomed Inc. Bradenton, FL, USA) claim that MTA plus is similar in composition to ProRoot and MTA Angelus but is ground finer.\[15\] MTA plus kit has an optional gel as the mixing vehicle to improve its washout resistance.\[16\] To present date, there are no clinical studies that prove the contribution of this material to the profession.

Biodentine with Active Biosilicate Technology was announced by dental materials manufacturer Septodont (developed by Septodont research group) in September of 2010 and made available in January of 2011.\[17\] According to the research and development department of said manufacturer, “a new class of dental material which could conciliate high mechanical properties with excellent biocompatibility, as well as bioactive behavior” (Septodont BiodentineTM scientific file, 2010) had been produced. According to the manufacturer, the material can be used as a “dentine replacement material whenever original dentine is damaged.”

Biodentine is a calcium silicate-based material used for crown and root dentin repair treatment, repair of perforations or resorptions, apexification, and root-end fillings. Biodentine powder is mainly composed of tricalcium silicate, calcium carbonate, and zirconium oxide as the radio-pacifier. The liquid contains calcium chloride as the setting accelerator and water-reducing agent.\[18\] Biodentine shows apatite formation after immersion in phosphate solution\[17\] indicative of its bioactivity.

This article describes a series of fifteen young patients with deep carious lesions in permanent first/second molars and no evidence of pulpal/periapical pathology treated by direct pulp capping with Biodentine on exposure during caries excavation.

Case Reports

The Institutional Ethical Committee approved this study. Included in the study were fifteen molar teeth, which fulfilled the outlined criteria.

Preoperative criteria for selection

Patient selection criteria as follows:
1. Patients in the age group 15–30 years, with deep carious lesion in permanent molar tooth
2. Patients available for follow-up.

Criteria for selection of teeth as follows:
1. Maxillary and mandibular first/second molars with deep Class I caries encroaching the pulp
2. Tooth should test positive to vitality testing (electric pulp tests and cold test-ice stick), the response should be comparable to contralateral same tooth
3. Tooth should be negative on percussion
4. Radiographically, no evidence of periodontal ligament widening or periradicular changes
5. It should be able to achieve meticulous isolation with rubber dam.

Intraoperative criteria

1. Vital pulp tissue should be exposed. In those cases where a thin layer of dentin existed after caries removal – an indirect pulp capping procedure was performed and such cases were followed up separately and not as a part of this case series
2. The pulp bleeding after exposure should be easily and rapidly controllable. (A cotton pellet moistened with 3% NaOCl placed over the exposure for 2 min should obtain adequate hemostasis.

Treatment protocol

Informed written and verbal consents were obtained from all patients. All cases were operated by one of the two authors (author 1 or 3). The suspected tooth was examined clinically. The status of pulp was evaluated. The pulp bleeding after exposure should be easily and rapidly controllable. (A cotton pellet moistened with 3% NaOCl placed over the exposure for 2 min should obtain adequate hemostasis.
to prevent an exposure. However, when an exposure resulted, hemostasis was achieved by applying a cotton pellet soaked in 3% sodium hypochlorite for 2 min. Biodentine was processed according to the manufacturer’s instruction by mixing a single-unit powder part and five drops of a single-unit liquid part for 30 s. This freshly manipulated Biodentine (septodont) was applied to the exposure site and a base of the same material covered the entire pulpal floor. After waiting for 12 min, a layer of resin-modified glass ionomer (RMGIC) was applied followed by a final layer of composite resin (Filtek Z 350-3M). The patient was recalled at 24 h, and further follow-up visits were scheduled at 1, 2, 6, and 12 months and evaluated both clinically and radiographically for evidence of pulpal and periapical pathology. Digital intraoral radiographs were evaluated for evidence of root obliteration, root resorption, or periapical changes.

Results

The details of the clinical observation are summarized in Table 1.

None of the treated teeth showed any radiographic evidence of root obliteration, root resorption, or periapical changes in the follow-up visits.

Discussion

Confusions and misconceptions surround the procedure as well as the evaluation of direct pulp capping. When the radiograph shows carious lesion encroaching the pulp, the decision of the choice of treatment presents a clinical challenge.

Clinical pulp capping studies have traditionally involved performing the procedure on young healthy pulps of noncarious or minimally carious teeth where the pulp is mechanically exposed, and the teeth have to be extracted for orthodontic reasons. Histological studies could be considered as the gold standard, but the treated tooth needs to be sacrificed, and moreover, these studies are typically of short duration.

This study reflects a realistic approach to true clinical situation as direct pulp capping was performed in teeth in which pulp tissue was exposed during clinical caries.

Figure 1: (a) Preoperative photograph showing a defective amalgam restoration and secondary deep caries in mandibular first molar. (b) Preoperative radiograph showing secondary caries in mandibular first molar and probable pulp involvement. (c) Small pulpal exposure seen after caries excavation. (d) Biodentine applied over the exposed pulp and the entire pulpal floor. (e) Immediate postoperative radiograph. (f) Radiograph – at 6 months follow-up. (g) Radiograph – at 12-month follow-up. (h) Radiograph– at 24-month follow-up.

Figure 2: (a) Preoperative photograph showing deep occlusal caries in mandibular second molar. (b) Preoperative radiograph showing deep occlusal caries in mandibular second molar and probable pulp involvement. (c) Small pulpal exposure after caries excavation. (d) Immediate postoperative radiograph. (e) Radiograph – at 12 months follow-up. (f) Radiograph – at 24-month follow-up.
excavation. One important factor that was considered was the ability to control hemorrhage on pulpal exposure. This was with the idea that increased bleeding could be suggestive of a higher degree of inflammation.

Nearly 3% sodium hypochlorite applied by means of a cotton pellet over the exposed pulp tissue was used to control hemorrhage. Hafez et al.[21] demonstrated that 3% sodium hypochlorite is an effective hemostatic agent and is nontoxic to the pulpal tissue and it does not appear to interfere with pulpal healing. They suggested that hemorrhage control, clot removal, and removal of operative dentinal chips with 3% sodium hypochlorite as well as marginal sealing are critical for successful direct pulp capping.

The main goal of preventive endodontics in the form of direct pulp capping is to minimize the incidence and severity of pulpal inflammation and other associated postoperative complications. Healing of the dental pulp is not exclusively dependent on the supposed stimulatory effect of a particular type of medicament but is directly related to the capacity of both the dressing a definitive restorative material to provide a biological seal against immediate and long-term microleakage along the entire restoration interface Murray et al.[22] identified the hierarchical factors to guide the clinicians for successful outcomes of direct pulp capping.

They postulated that the most important variable correlated to pulpal inflammation is bacterial microleakage or factors relating to the microleakage of bacteria. Other variables, such as pulpal exposure width and tertiary dentin formation, were not highly correlated to pulpal inflammation. They concluded that pulp capping with resin composite provided the lowest incidence of bacterial microleakage, the lowest levels of pulpal inflammation, and the lowest incidence of necrosis. In the present study, a good marginal seal was ensured by the placement of resin-modified glass ionomer cement (GIC) over the layer of Biodentine followed by a final restoration of direct restorative composite. All teeth were adequately isolated with rubber dam, thus avoiding any complication due to salivary contamination.

Four out of the 15 (26.66%) operated patients reported with increased sensitivity at 24 h postoperatively but the sensitivity subsided subsequently. A 1-week postoperative telephonic conversation revealed the absence of any symptoms in all the patients, and the findings were further authenticated at the 1-month follow-up recall at the department.

Another important finding is that the reading on electric pulp testing increased at the recall appointment that is more electric stimulation was required to elicit a pulpal response. This could be attributed to the formation of a significant amount of reactionary dentin in response to pulp capping with Biodentine. However, any subsequent loss of pulp vitality in these teeth could complicate subsequent endodontic treatment due to the significant dentinogenesis, which would have occurred by then.

Biodentine is touted to be “Dentine in a Capsule,” because of its excellent biocompatibility[18] physical properties, and bonding to the dental hard tissues.[19] However, there is a lack of peer-reviewed literature and research about this material. One recent report by Villat et al.[23] demonstrated the use of Biodentine to conservatively manage a symptomatic carious immature permanent tooth. The author’s demonstrated successful clinical and radiographic features at 6-month follow-up. In an animal study conducted over 4 weeks, histological analysis indicated favorable therapeutic effects of Biodentine after teeth pulp capping in Vietnamese pigs. Pulp reaction was similar to that caused by ProRoot MTA.[24]

On the biological level, it has shown to be perfectly biocompatible.[18] It is capable of inducing the apposition of reactionary dentin by stimulating odontoblast activity and biological activity.

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**Figure 3:** (a) Preoperative photograph showing a fractured amalgam restoration in mandibular first molar. (b) Pulpal exposure after removal of the restoration and caries excavation. (c) Immediate postoperative radiograph. (d) Radiograph – at 12-month follow-up

**Figure 4:** (a) Immediate postoperative radiograph after direct pulp capping in mandibular first molar. (b) Radiograph – at 1-month follow-up. (c) Radiograph – at 6-month follow-up. (d) Radiograph – at 12-month follow-up. (e) Radiograph – at 20-month follow-up
Table 1: Descriptive data of treatment and postoperative observation (P=Present, A=Absent)

| Tooth involved         | Site of exposure | Post-operative observation (all observations were made at 24 hr, 1, 3, 6 and 12 months and subsequently as available) | Period of follow up |
|------------------------|------------------|-------------------------------------------------------------------------------------------------------------------|--------------------|
|                        |                  | Sensitivity | Pain | Swelling | Mobility | Tenderness on percussion | Presence of sinus tract | Vitality testing | Cold test | EPT            |                |
| Mandibular right first molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 23 months     |
| Mandibular right second molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 23 months     |
| Maxillary left first molar | Distal pulp horn | P (at 24 h and subsided subsequently) | A | A | A | A | A | P | Response was seen at a slightly higher value from three month follow up and remained constant thereafter | 24 months |
| Mandibular right first molar | Mesial pulp horn | P (at 24 h and subsided subsequently) | A | A | A | A | A | A | Response was seen at a slightly higher value at three month follow up and remained constant thereafter | 23 months |
| Mandibular right first molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 23 months     |
| Mandibular left second molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 23 months     |
| Mandibular right first molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 23 months     |
| Mandibular right first molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 23 months     |
| Maxillary right first molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 24 months     |
| Mandibular right first molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 24 months     |
| Mandibular right first molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 23 months     |
| Mandibular right first molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 23 months     |
| Mandibular right first molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 24 months     |
| Mandibular right first molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 23 months     |
| Mandibular right first molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 24 months     |
| Mandibular right first molar | Mesial pulp horn | A           | A    | A        | A        | A                      | A                   | P                |           |                | 23 months     |

Contd...
reparative dentin, by induction of cell differentiation.\cite{19,25}

The use of 3% sodium hypochlorite to control hemorrhage provides an additional advantage of disinfection and the placement of a well-sealed restoration immediately after pulp capping provides protection against ongoing leakage and bacterial contamination that can compromise the success of the pulp cap. The success of these cases can be additionally attributed to these two factors.

The period of observation in this study ranged from 12 to 24 months. Although short, this is one of the primary investigations reported regarding the use of Biodentine as a direct pulp-capping agent. The results of this preliminary study are encouraging. However, it is recommended that the patients be followed up for a longer period and studies involving large number of patients be taken up.

**Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the journal. The patients understand that name and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

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**Conflicts of interest**

There are no conflicts of interest.

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