Biodentine™, a promising bioactive material for the preservation of pulp vitality in restorative dentistry

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Introduction

Preservation of pulp vitality in cases of deep carious lesions is one of the most critical factors determining the prognosis of teeth after restorative treatment. This is of even higher importance when these teeth are intended to serve as abutments of fixed or removable partial dentures. Previous studies have shown that loss of pulp vitality is one of the major biological complications leading to failure of different types of prosthetic restorations,[1] whereas, on the other hand, use of endodontically treated teeth as abutments for such restorations is associated with a significantly higher number of mechanical (e.g. tooth facture) or biological (e.g. recurrent periapical pathology) complications, overall compromising long-term prognosis of the prosthetic rehabilitation.[2]

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Current treatment modalities on the restoration of deep carious lesions include direct or indirect pulp capping with calcium hydroxide, followed in cases of conservative treatment by application of glass ionomer (GICs) or resin-modified glass ionomer cements (RMGICs) as cavity liners and final restoration with direct composite fillings or composite/ceramic inlays and onlays[3]. In addition, in cases of teeth used as prosthetic abutments, calcium hydroxide is commonly covered by a suitable core build-up material, such as self-curing resin composites or silverreinforced GICs. Despite the fact that calcium hydroxide represents the "gold standard" for such direct or indirect pulp capping cases, it is also linked with several drawbacks, mainly poor bonding to dentin, reduced mechanical strength and chemical instability. The latter has been considered as the main cause of pulp complications, usually occurring within the first two years after application, due to its gradual dissolution below composite fillings.[4] GICs, on the other hand, present chemical and mechanical stability, adhesive anchoring to the dentin and very acceptable biocompatibility, which are considered as very significant advantages. However, they lack the required and particularly necessary dentin-forming effect that is to be expected.[5] Finally, resin composite materials have a very questionable biological behavior in deep caries cases, as several studies have shown that pulp

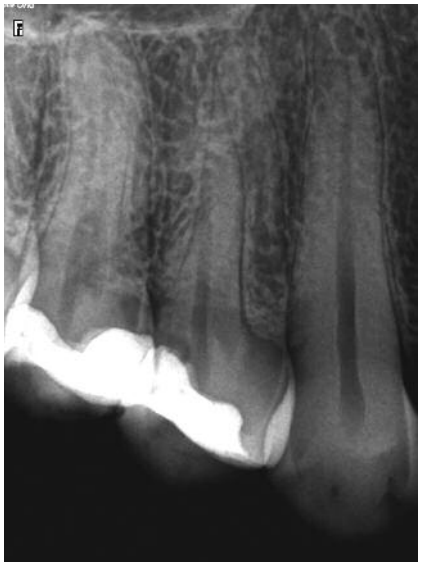


Figure 1: Preoperative radiograph showing recurrent caries below existing amalgam restorations in teeth # 14 and 15.

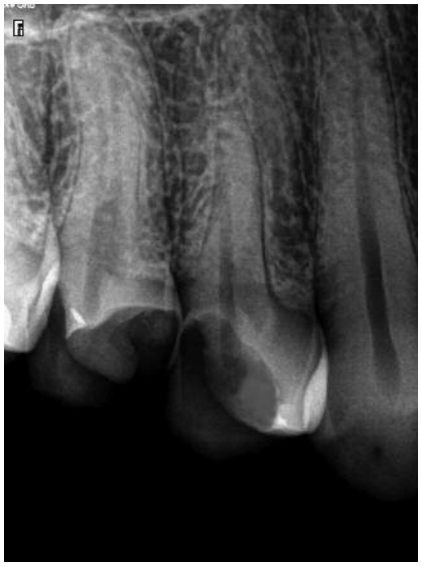


Figure 2: Radiograph taken after caries removal, showing close proximity of the cavity walls to the pulp, especially for tooth # 15.

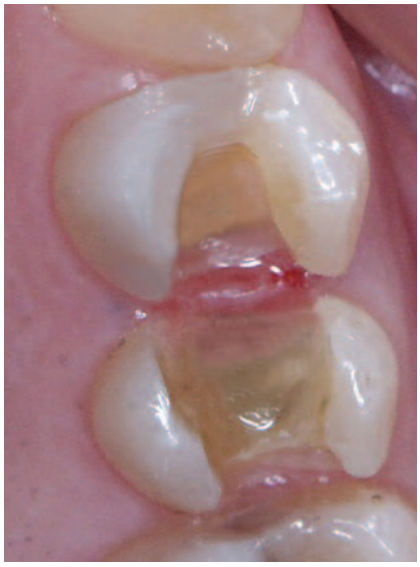


Figure 3: Clinical picture after caries removal.

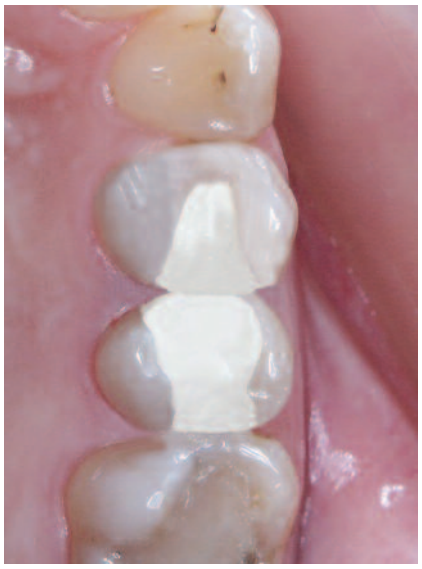


Figure 4: Biodentine™ was placed as a bulk material to restore both cavities and left in place for 6 weeks. The material has a smooth surface after setting.

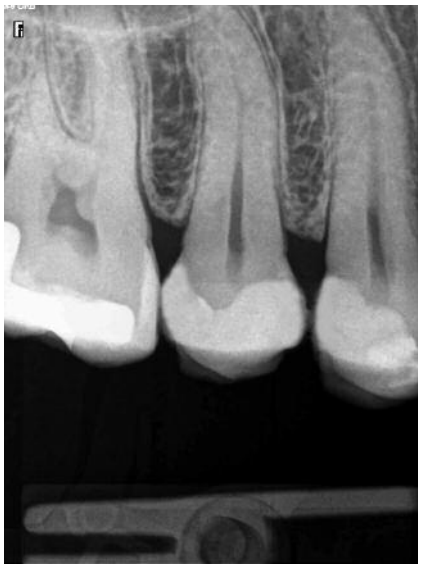


Figure 5: Radiograph after Biodentine™ placement.

inflammation leading to irreversible pulp damage may be developed when these materials are used for direct or indirect pulp capping.[6, 7]

For all these reasons, there is a need for a new bioactive pulp capping material ensuring the long-term preservation of pulp vitality after restorative treatment of deep carious lesions. Most recently, a calcium-silicate based cement (Biodentine™, Septodont) has been proposed, among other clinical applications, as a dentin substitute for direct and indirect pulp capping. As main advantages of this material have been reported its ability to create a firm anchorage to dentin, its bioactivity leading to reparative dentin formation, its antibacterial properties which are highly required in deep carious lesions and its improved mechanical properties, which are similar to dentin.[8] Here we present two clinical cases of successful use of Biodentine™ in deep carious

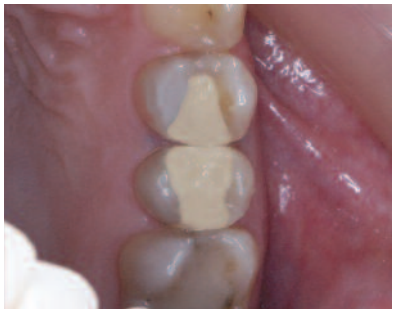


Figure 6: Biodentine™ restorations 6 weeks after placement. Marginal integrity of both restorations was fully preserved and no fractures were observed. A slight discoloration of both restorations could be recorded.

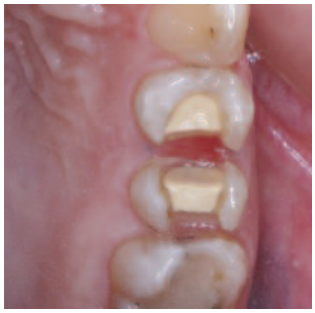


Figure 7: Biodentine™ was partially removed to serve as a dentin substitute.

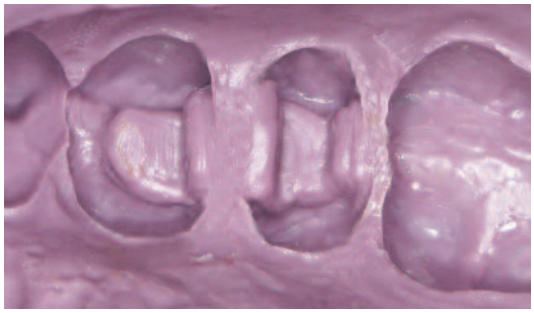


Figure 8: Final impression with one-phase polyether material.

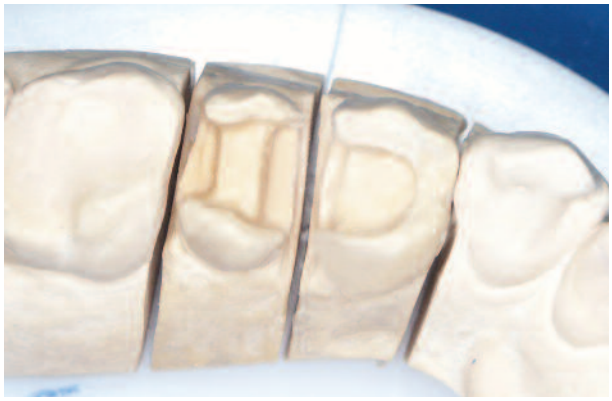


Figure 9: Final cast for the inlays build up with a laboratory composite.

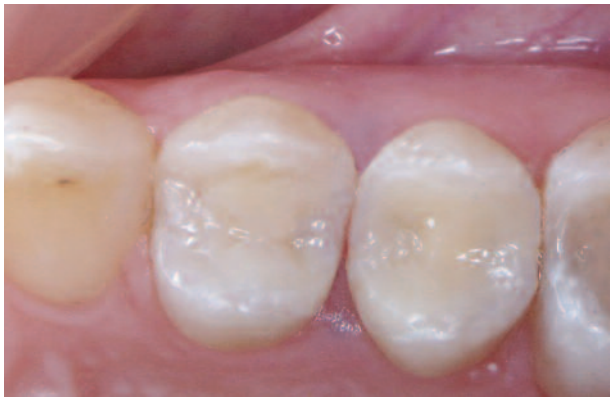


Figure 10: Final inlay restorations in place cemented with a dual cure resin cement.

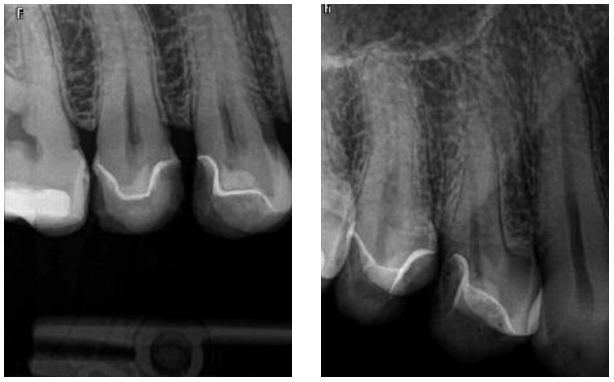


Figure 11: A, B Radiograph A. six months and B. 1 year posttreatment.

lesions of patients with a previous history of pulp complications after restoration of deep caries with conventional protocols.

Case Report no.1

A 38 year-old female patient, with free medical history, came complaining of tooth sensitivity at the upper right maxilla, after consuming cold and hot beverages. Diagnostic assessment and radiographical examination revealed secondary carious lesions below existing amalgam restorations in teeth # 14 (distally) and # 15 (interproximally) (Fig. 1). Both teeth were tested positive on CO2 snow sensitivity and negative on percussion. The patient was informed about the need of having the carious lesions treated and the amalgam fillings replaced.

After patient consent, local anesthesia was performed (Articaine HCL 4% and 1:200000 adrenaline, Ubistesin, 3M ESPE), the amalgam restorations were removed and the carious dentin was completely excavated (Fig. 2). At the proximal cavity area of tooth # 15 a very thin pulp facing layer of remaining dentin could be observed (Fig. 3).

Biodentine™ (Septodont) was chosen as a provisional filling material of the entire cavity of both teeth (Fig. 4, 5). The material was handled according to the manufacturer's instructions. This decision to use Biodentine™ was based on a previous history of unsuccessful outcome of indirect pulp capping after caries removal in teeth # 24 and 25 of the same patient, by using calcium hydroxide capped by a GIC as a cavity liner and final restoration with resin composites, which resulted to irreversible pulp inflammation 2 months after restoration. Biodentine™ was left in place for 6 weeks in order to ensure that pulp sensitivity would be eliminated while preserving pulp vitality (Fig. 6). The patient reported that she remained symptom free during the six week period, whereas both teeth were positive on CO2 snow sensitivity and negative on percussion. Biodentine™ was then partially removed to serve as a cavity liner (Fig. 7) and both teeth were restored with indirect composite restorations. Briefly, after final cavity preparation with Biodentine™ remaining as a dentin substitute, final impression was taken using a one-phase polyether material (Impregum, 3M ESPE) (Fig 8, 9). The teeth were restored with composite inlays (SR Adoro, Ivoclar Vivadent) that were cemented with a dual cure resin cement (Variolink II, Ivoclar Vivadent) (Fig. 10).

At the follow-up visit at 6 months and 1 year after treatment (Fig. 11 A, B) both teeth were free from any symptomatology and again tested positive for sensitivity and negative for percussion. Radiographical examination showed no signs of periapical pathology (Fig. 11 B).

Case Report no.2

A 28 year-old female patient, with free medical history, came after fracture of her first upper left molar (# 26), which occurred during chewing (Fig. 12). Clinical and radiographical examination revealed deep caries at a very high proximity to the pulp in both upper molars (# 26 and # 27) (Fig. 13). Tooth # 26 had already a composite resin filling that was placed 2 years earlier.

Clinical examination also showed that both teeth were positive on CO2 snow sensitivity and negative on percussion. The patient did not mention any previous symptomatology derived from these teeth in her dental history. However, she mentioned that her two lower molars (# 36 and # 46) were endodontically treated due to deep caries that were symptom-free and therefore could not be diagnosed until they reached the pulp cavity. The patient was informed about the need of having the carious lesions treated and the possibility that an endodontic treatment would be required after caries removal. After patient consent, local anesthesia was performed (Articaine HCL 4% and 1:200000 adrenaline, Ubistesin, 3M ESPE) and a rubber dam was placed to avoid contamination with saliva in case a pulp exposure would occur. After excavation of the carious dentin, the pulp was exposed iatrogenically in tooth # 26, whereas a very thin pulp facing layer of dentin could be observed in the distal area of 26, as well as the proximal area of 27, both requiring indirect pulp capping (Fig. 14, 15). Clinically the pulp of the tooth # 26 at the exposure

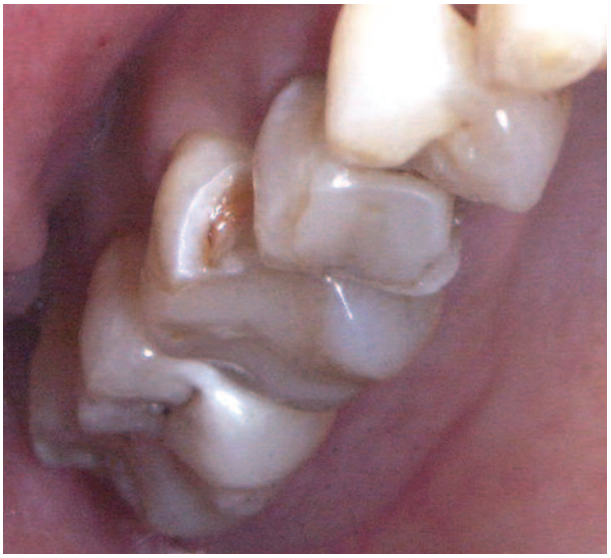


Figure 12: Preoperative clinical picture showing fracture of tooth # 26 Preoperative radiograph showing deep caries in teeth # 26 and 27 in close proximity to the pulp.

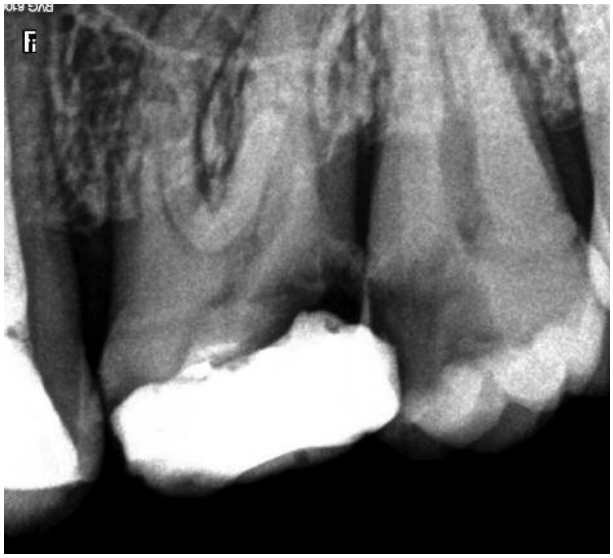


Figure 13: Preoperative radiograph.

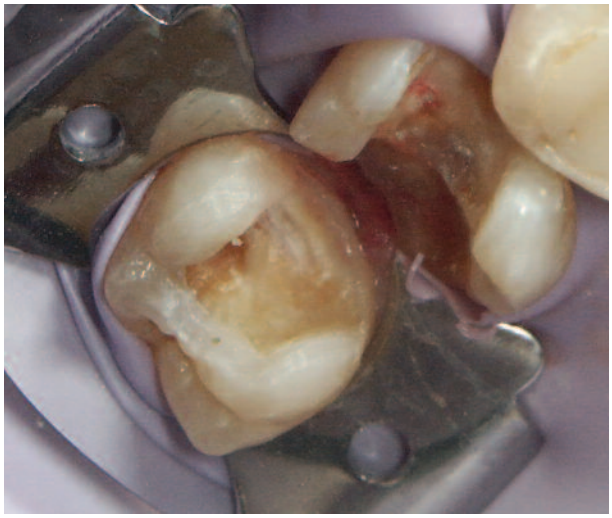


Figure 14: After caries removal the pulp was exposed iatrogenically in tooth # 26, whereas a very thin pulp facing layer of dentin could be observed in the distal area of 26, as well as the proximal area of 27.

site was vital without any major bleeding, so the maintenance of tooth vitality by direct pulp capping was decided upon. Cavity disinfection and control of the hemorrhage in tooth # 26 was performed with sodium hypochloride. Biodentine™ (Septodont) was chosen as a provisional filling material of the entire cavity of both teeth (Fig. 16). The material was handled according to the manufacturer's instructions. Biodentine™ was left in place for 6 weeks after which the patient came to receive her final restorative treatment (Fig. 17). During this period of 6 weeks the patient was symptom-free, whereas both teeth remained positive on CO2 snow sensitivity and negative on percussion. Biodentine™ was then partially removed in tooth # 27 and kept as a base/dentin substitute that was capped by a direct composite resin filling (Tetric EvoCeram, Ivoclar-Vivadent), following normal procedures (acid etching of the cavity with phosphoric acid and application of single step adhesive of the same company) (Fig. 18, 19). Tooth # 26, on the other hand was prepared for a full coverage metal-ceramic crown due to the significant loss of dental hard tissues after caries removal. The tooth was prepared without removing Biodentine™ that remained and served as an abutment core build-up material (Fig 18). The final metal-ceramic crown was cemented with a conventional GIC (Fuji I, GC) (Fig. 19). At the follow-up visit after 6 months both teeth were free from any symptomatology and again tested positive for sensitivity and negative for percussion. Radiographical examination showed no signs of periapical pathology (Fig. 20).

Discussion

Biodentine™ is a bioactive material mainly composed of tricalcium silicate and a radiopacifier phase of zirconium oxide. Calcium silicate-based cements are known to release during setting and for a long period of time thereafter significant amounts of calcium hydroxide ions, responsible for triggering pulp reparative processes[9]. Histological studies have shown the formation of a homogeneous dentin bridge at the pulp exposure site after direct or indirect capping with Biodentine™.[10, 11] Mineralized tissue formation was found to express markers of odontoblasts.[12] The ability of

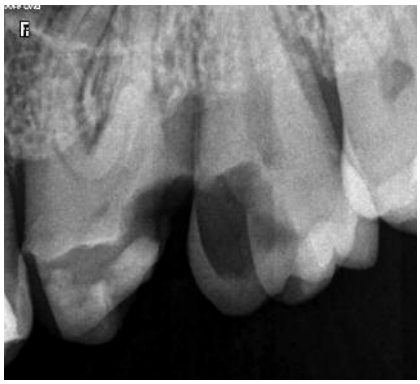


Figure 15: Radiograph after caries removal.

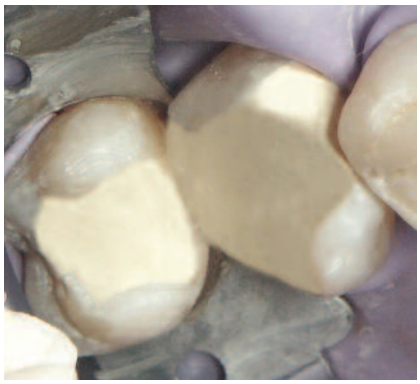


Figure 16: Biodentine™ was placed as a bulk material to restore both cavities and left in place for 6 weeks. A rubber dam was used to avoid bacterial contamination after pulp exposure.

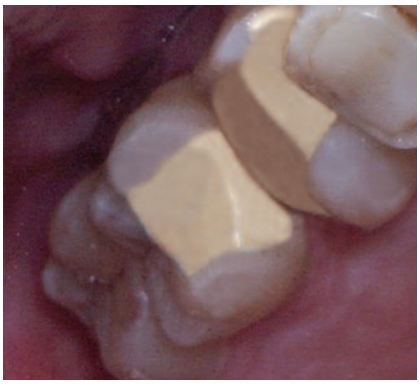


Figure 17: Biodentine™ restorations after 6 weeks of placement. Marginal integrity of both restorations was fully preserved and no fractures were observed.

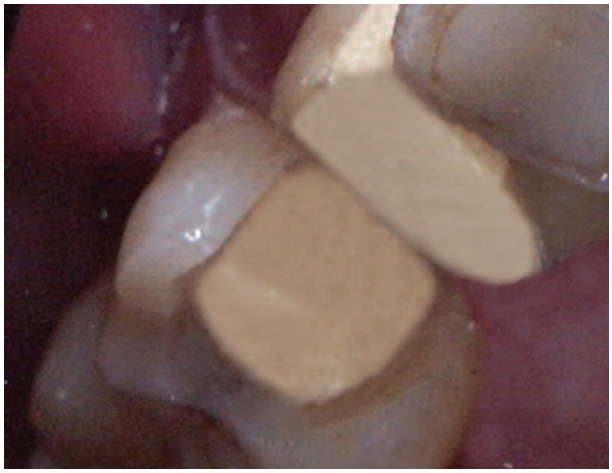


Figure 18: In tooth # 27 Biodentine™ was then partially removed and kept as a base/dentin substitute that was capped by a direct composite resin filling (Tetric EvoCeram, Ivoclar-Vivadent). Tooth # 26 was prepared for full coverage and Biodentine™ remained as an abutment build-up material.

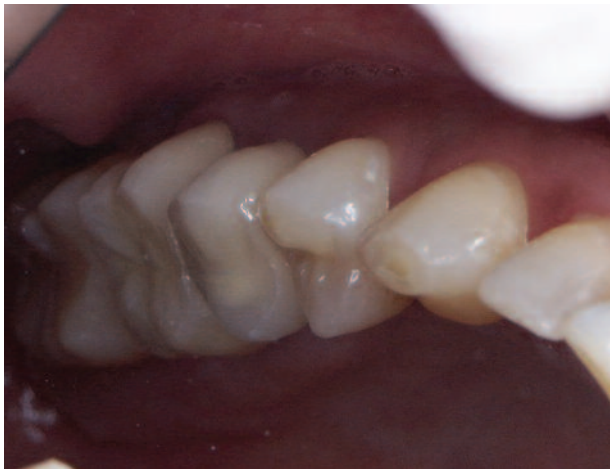


Figure 19: Post-operative clinical picture with a direct resin composite filling in tooth # 27 and a metal ceramic crown in tooth # 26.

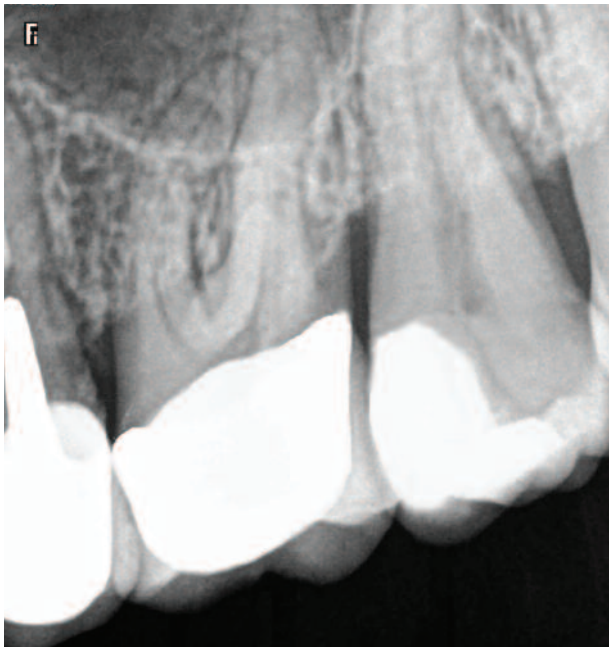
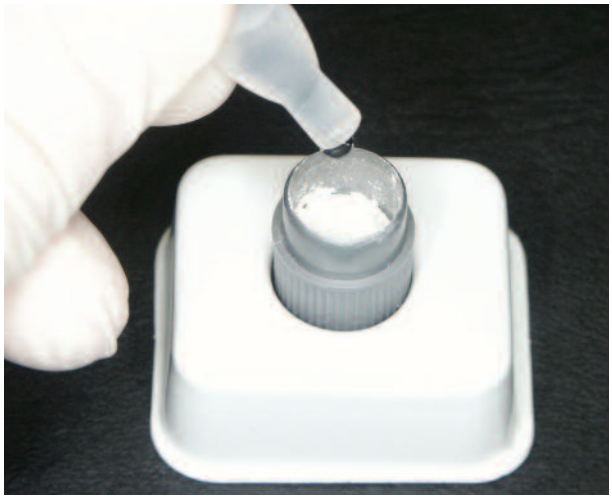


Figure 20: Radiograph six months post treatment. No signs of periapical pathology could be observed.

Biodentine™ to trigger reparative dentin formation together with its antibacterial properties are two critical factors ensuring long-term preservation of pulp vitality. While the antibacterial activity may be due to the alkaline pH, the induction of reparative dentin seems to be due to a release of TGF-ß1 growth factor from pulp cells. This factor attracts pulp stem cells to Biodentine™ application site where it induces their differentiation into odontoblastic cells secreting reparative dentin.[13] The resulting pulp vitality preservation is highly required in restorative dentistry, especially when the restored teeth will be used as abutments of long-span prosthetic restorations.

Compared to conventionally used pulp capping materials, such as calcium hydroxide, Biodentine™ presents significantly higher mechanical properties which are very similar to those of dentin (elastic modulus of 22 GPa, compressive strength of 220 MPa and microhardness of 60 VHN)[14]. This allows the preservation of the material as a base underneath resin fillings or even its use as a core-build up material in vital abutment teeth. Moreover, the ability of the material to create a firm bond with the underlying dentin substrate is highly required for core buildup materials, to ensure the preservation of the abutment integrity and therefore to lower the risk for crown or bridges detachment. Future studies are, however, required to evaluate the behavior of Biodentine™ as a core build-up material of vital abutment teeth in long-span fixed partial dentures, especially in teeth that serve as terminal abutments for such restorations that are normally subjected to higher masticatory forces. Although the handling properties of the material present some difficulties, this can be easily overcome by strict compliance to the manufacturer's instructions. It is important to add exactly 5 drops of liquid into the powder capsule and allow it to mix at a speed of 4000 - 4200 rotations/min for 30 seconds (Fig. 21-23). In case a lower amount of liquid is added the material is very dry and brittle, whereas a higher amount of liquid will give



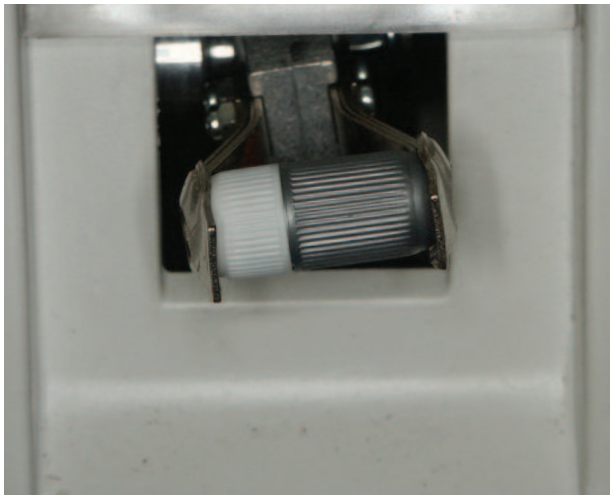


Figure 21, 22, 23: The material should be handled according to the manufacturer's instructions. It is important to add exactly 5 drops of liquid into the powder capsule and allow it to mix at a speed of 4000 – 4200 rotations/min for 30 seconds.

the material a runny consistency making its handling very difficult. Correctly mixed material must have a creamy consistency (Fig. 24). It is also important to allow Biodentine™ to set for at least 12 min before matrix band and wedge removal (Fig. 25), otherwise the risk of material fracture is very high. Biodentine™ should not come in contact with liquids during its setting and for this reason application of a rubber dam is mandatory whenever possible. Moreover, the material should be applied into the cavity with light pressure, avoiding excessive carving of the restoration during its setting, because this may disturb its crystalline structure and lead to loss of marginal integrity or fracture.

Finally, occlusal adjustment after the material's setting should be performed by light biting on occlusion paper and premature contact removal by a curving hand instrument or excavator and not by rotary instruments.

In conclusion, Biodentine™ seems to be a very promising material for the preservation of pulp vitality in cases of deep caries. It has a unique set of properties which are highly desirable in restorative dentistry and prosthodontics. Randomized control clinical trials substantiate the improved clinical performance of this new bioactive material compared to conventionally applied treatment protocols. However, other randomized clinical trials are needed to confirm the clinical performance of this new dentin substitute.

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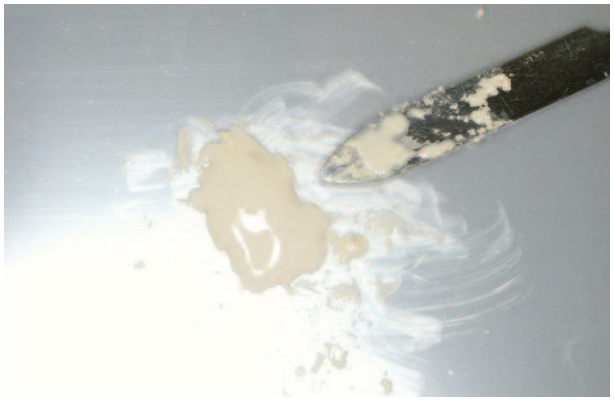

Figure 24: Correctly mixed material must have a creamy consistency.

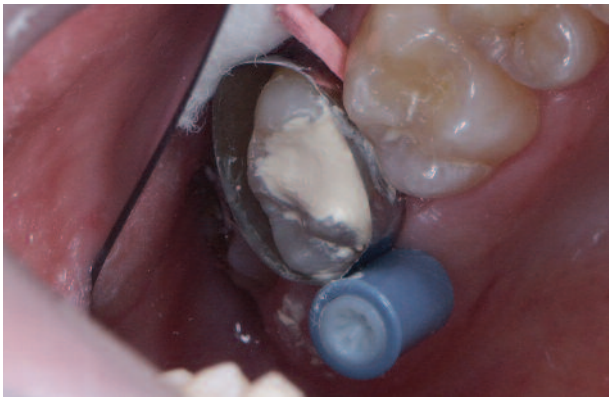

Figure 25: It is important to allow Biodentine™ to set for 12-15 min before matrix band and wedge removal.

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