Biodentine™ as direct pulp capping material in teeth with mature apices.

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Introduction

Awareness of the importance of preserving the vitality of the pulpo-dentinal complex has resulted in conservative management of pulpal pathologies becoming more and more popular over time; this is due in part to current advances in regard to protocols and appropriate materials for vital pulp therapy procedures, and the economic factors that influence decision-making in many countries and lead many patients to opt for premature tooth extraction because of the costs involved in root canal treatment and subsequent restoration (1, 2).

Pulp tissue may become exposed to the oral environment, whether due to dental caries, or mechanically as a result of restorative or prosthetic procedures. One treatment option for pulp exposure is the application of conservative vital pulp therapy procedures, which may include direct pulp capping, indirect pulp capping if the tissue is not fully exposed, and partial or total pulpotomy; this permits the preservation of the vitality of the tooth, its nociceptive functions, and the defense system of the body itself. Thanks to the abovementioned items, among others, it has been shown that longer survival time is achieved in teeth without root canal treatment when compared with endodontically treated teeth (1, 3-5).

Included amongst the materials used to perform pulp therapy procedures are bioceramic cements; these biocompatible materials are divided into three basic groups: 1. High strength bio-inert cements; 2. Bioactive cements, which form chemical bonds with mineralized tissue; and 3. Biodegradable materials that participate actively in the body's metabolic processes (6). Multiple bioceramic materials are currently available on the market; the most well known of these materials are MTA and Biodentine™, both of which belong to the bioactive cements group. Biodentine™ is a dentin substitute and dentinogenesis promoter with the following properties: alkaline pH, biocompatibility, antibacterial action, release

of calcium and hydroxyl ions, radiodensity similar to dentin, setting time of approximately 12 minutes, insolubility, outstanding sealing properties, and causes no tooth discoloration (7-11); this last property makes it the material of choice when treatments need to be performed involving the coronal and cervical areas whether of anterior or posterior teeth.

At the dental undergraduate clinics of the Faculty of Dentistry of the Mariano Gálvez University of Guatemala and at the Argueta-Orellana private dental clinic, 20 direct pulp-capping procedures were performed on teeth with mature apices clinically diagnosed with reversible pulpititis and with no history of spontaneous pain; all pulp exposures were performed mechanically via the removal of caries ***(Fig. 1)*** in patients between 16 and 45 years of age. All procedures were performed by the same operator (an endodontist with over eight years' clinical experience), following the same protocol in each case. Clinical and radiographic examinations were performed on each of the patients at 3, 6 and 12 months post-treatment; after 12 months' monitoring, a high percentage of the cases presented radiographic evidence of dentin bridge formation ***(Fig. 2)***. Below we present a clinical case intended to show the pulp-capping protocol applied for all patients.

Fig. 1

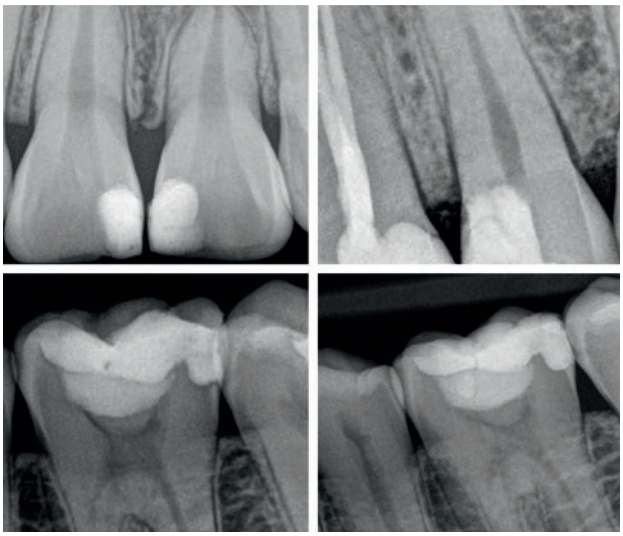
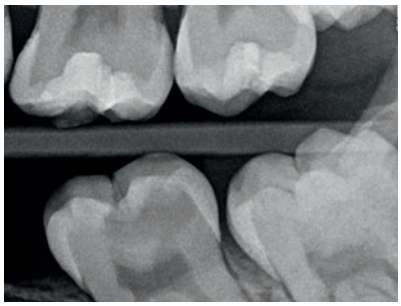


Fig. 2

Clinical case

Patient, 22 years of age, visits the dental clinic presenting short-duration elicited pain in tooth no. 19 ***(Fig. 3 and 4)***; having established a diagnosis of reversible pulpitis, we proceeded to caries removal under absolute isolation ***(Fig. 5)*** producing a slight pulpal exposure with no hemorrhaging; this type of exposure may go unnoticed if a correct assessment of the preparation floor is not performed with an endodontic explorer ***(Fig. 6)***. In the cases where hemorrhage did occur, it was stopped by the application of sustained pressure for 10 seconds with a cotton swab moistened with sterile saline solution; in this particular case this step did not need to be performed, so the cavity was disinfected with sodium hypochlorite 2.5%, and Biodentine™ was placed to serve as a direct pulp-capping material ***(Fig. 7)*** using the "MAP System" dental materials micro-applicator. Approximately 75% of the cavity was filled with Biodentine™ ***(Fig. 8)***; Cavit-G was then placed over this to serve as a provisional restorative material, and seven days after the procedure the patient was evaluated to confirm that he was completely asymptomatic and that the tooth was responding normally to sensitivity tests so that we could proceed to final restoration ***(Fig. 9 and 10)***.



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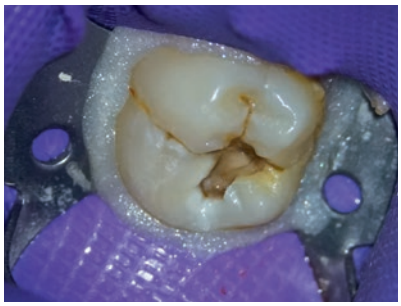

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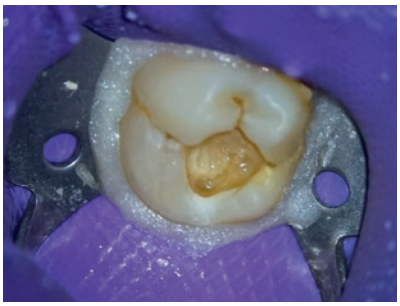

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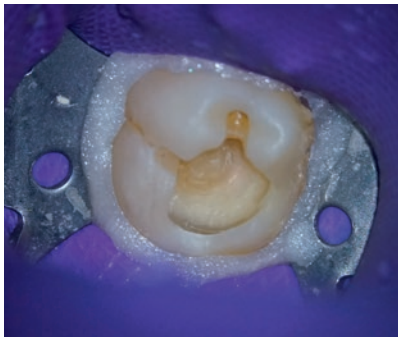

Fig. 6

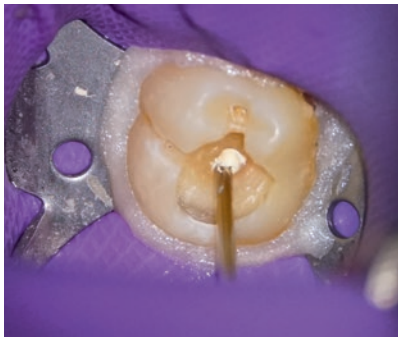

Fig. 7

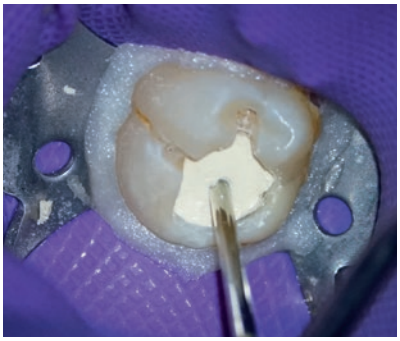

Fig. 8

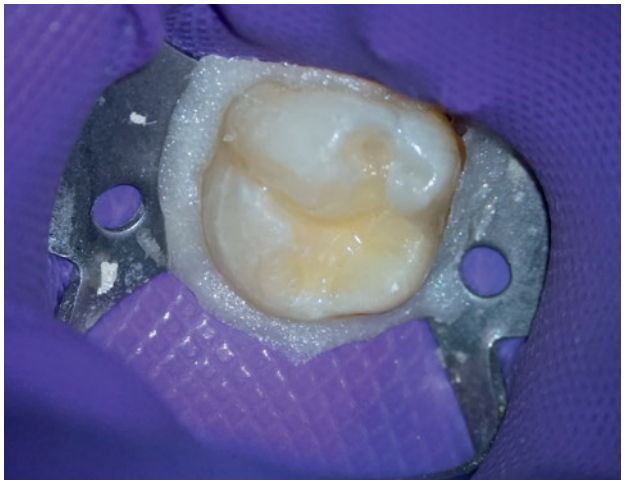

Fig. 9

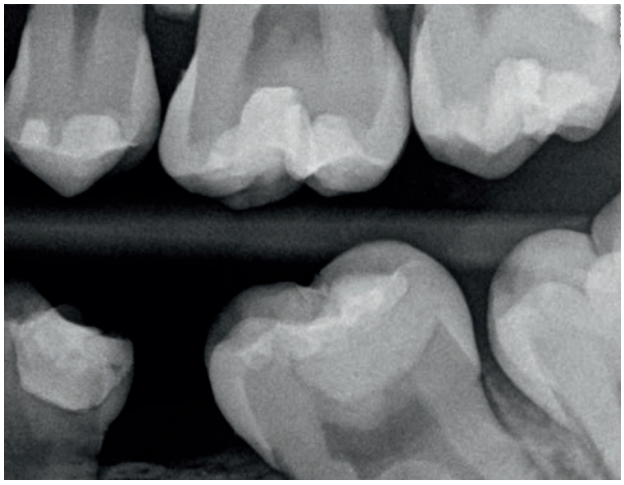

Fig. 10

Follow-up

All patients were re-evaluated at 3, 6 and 12 months after their pulp-capping appointment. In clinical situations such as this, we hope to see radiographic evidence of mineralized tissue formation under the cap between six and nine months post-procedure (12).

All 20 cases were re-examined at 12 months of follow-up, and in all cases the response to the sensitivity tests was normal; all teeth went on to final restoration in acceptable conditions, and in 14 of the 20 cases (70%) it was possible to clearly observe radiographic evidence of mineralized tissue formation under the pulp capping material; a supplementary examination is planned at 24 months post-procedure for all these cases.

Discussion

From an entirely optimistic perspective, the ultimate goal of any dentist when performing restorative and/or endodontic procedures should be the maintenance of the pulp vitality and functionality of the tooth, with no discomfort for the patient (13).

Obtaining an adequate diagnosis is key to the success of conservative pulpal therapy; an ideal case is one where we have a diagnosis of reversible pulpitis with no history of spontaneous or long-lasting dental pain(14), as it is generally accepted that a history of spontaneous or nocturnal pain is associated with the presence of an irreversible pulp inflammation process(15, 16). In these cases, the success of direct pulp capping may be questionable (17), although some studies have shown that even in these types of situations vital pulp therapy may achieve a successful outcome (1, 18-20).

In regard to the long-term success of conservative pulp procedures, it is extremely important that the tooth be provided with a definitive final restoration that guarantees an adequate marginal seal, since this last factor, in conjunction with the absence of bacterial contamination during the procedure, is among the most important factors to be taken into consideration in view of preventing subsequent pulp inflammation (21, 22). The reported success rate for vital pulp therapy procedures using bioactive cements is greater than 80% in examinations at up to 10 years (23); this is a very high percentage for a dental procedure in such operational time frames.

Conclusion

Based on the clinical results obtained in the present series of cases and taking into consideration the limitations inherent in the study, we can conclude that direct pulp capping with Biodentine™ teeth presenting reversible pulpitis is highly effective for the maintenance of pulp vitality.

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Direct pulp capping in immature permanent teeth

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Introduction

Direct pulp capping (DPC) is a procedure that is usually performed on children or young persons with permanent teeth that have open apices and are showing dental lesions close to the pulp tissue. This loss of dental structure can be caused by deep caries, trauma or mineralization defects in the tooth structure.

In these cases, the patient may notice some degree of discomfort to stimuli (primarily the cold or sugary foods), although not showing any signs of spontaneous sensitivity. X-rays usually show lesions close to the pulp without indications of pulpal degeneration, so there is likely to be pulpal exposure if the decayed tissue is completely removed during the operation.

The purpose of direct pulp capping is to stimulate reparative dentin formation which maintains the vitality of the pulp and, as a result, allowing the apex to continue developing. This is achieved by removing any microorganisms present and ensuring the lesion is properly sealed using a material that is well-tolerated by the dental pulp.

Throughout history, different materials and techniques have been used for direct pulp capping in immature permanent teeth.

Traditionally, calcium hydroxide has been used as a material for pulp capping, due to its effective antibacterial properties. However, there are some long-term disadvantages due to its high solubility and inability to adhere to dentin. Subsequently, etching techniques have been used on the pulp for dentin bonding and sealing it with a permanent filling material, but several studies have shown poor biocompatibility of these resin-based materials with the pulp. (1,2)

The arrival of new bioactive materials has led to an increased success in direct pulp capping. Among them, MTA® and Biodentine™ are well-

known options. MTA has been used since 2000 due to its biocompatibility with the pulp and its insolubility, with numerous studies showing higher percentages of long-term success when using this material than when calcium hydroxide was used. (3)
Biodentine™ was introduced in 2010 and has very similar physical and biological properties to dentin, as it is a biocompatible and bioactive material that induces pulp repair. It has simpler handling properties to MTA, such as a shorter setting time (12 minutes), and it does not cause dental discoloration because it does not contain bismuth oxide. (4-6)
Currently, there are numerous clinical studies on the effectiveness of Biodentine as a direct pulp-capping material. (7-11)
In our clinical practice, the direct pulp capping procedure consisted of caries removal up to the pulpal chamber, filling in the cavity with Biodentine™ and sealing it with, in our case, a composite resin.

Clinical case report

An 8-year-3-month-old patient visits our surgery for the first time. The clinical examination showed a deep caries lesion in molar 3.6. with clinical signs of reversible pulpitis.
The periapical X-ray confirms the proximity of the lesion to the pulp and the teeth with open apices. The proposed treatment plan was to remove the caries (with a high risk of pulpal exposure) and to protect the remaining healthy pulp for the apical closure to progress naturally.
The clinical procedure was as follows:

1. Clinical and X-ray diagnosis. ***(Fig 1)***
2. Local anesthesia is administered, and the tooth is isolated with a rubber dam.
3. The caries lesion is initially cleaned using a high-speed rotary instrument (Komet® 0.10 mm round diamond bur) and then complete caries removal is performed using a slow-speed rotary instrument (Komet® 0.10 mm round tungsten-carbide bur). ***(Fig. 2)***
4. The cavity and the area where the pulp is exposed are cleaned for one minute using a cotton ball moistened with 5% sodium hypochlorite, checking there is no bleeding where the pulp tissue is exposed. ***(Fig. 3)***
5. Biodentine™ is applied to the cavity close to

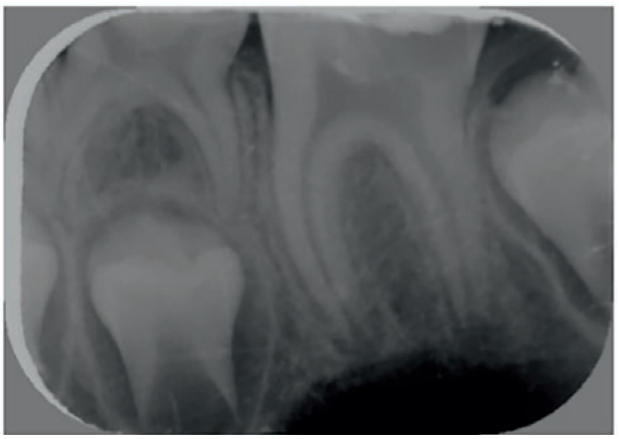

Fig. 1: Pre-operative X-ray showing the radiolucent image indicating caries near the pulp in tooth 3.6 with open apices.

Fig. 2: Clinical view after the caries removal.

Fig. 3: The cavity and exposed pulpal cavity is disinfected using a cotton ball with 5% sodium hypochlorite.

Fig. 4: Appearance after the application of Biodentine™.

Fig. 5: 37% orthophosphoric acid applied to the enamel.

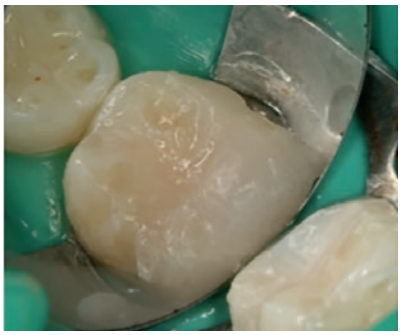

Fig. 6: Cavity filled with a hybrid resin composite.

the pulpal exposure using a plastic instrument according to the manufacturer's instructions. ***(Fig. 4)***

6. 12 minutes after mixing the Biodentine™, following the manufacturer's instructions, the etch-and-rinse procedure is carried out using an enamel etchant (Scotchbond™ Etchant 3M™ ESPE™) which is then washed and dried, before an adhesive (Scotchbond™ Universal) is applied, then cured and sealed with a hybrid composite (Filtek Supreme XTE 3M™ ESPE™) using a layering technique. ***(Figs. 5 and 6)***
7. The rubber dam is removed, and the bite is checked, and a post-operative X-ray is performed. ***(Figs. 7 and 8)***

It is important to inform the patient that they need to return for follow-up appointments to check the apical closure and assess the pulp vitality. If these follow-up appointments, vitality tests and X-rays are not carried out, failure of the treatment due to a pupal necrosis following the treatment could go unnoticed. ***(Figs. 9 and 10)***

Fig. 7: Clinical view after the rubber dam is removed.

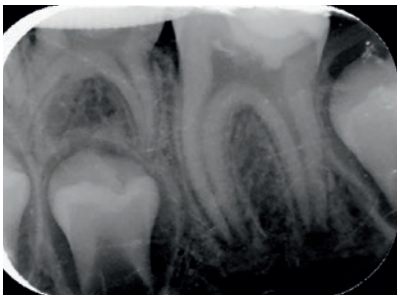

Fig. 8: Post-operative X-ray.

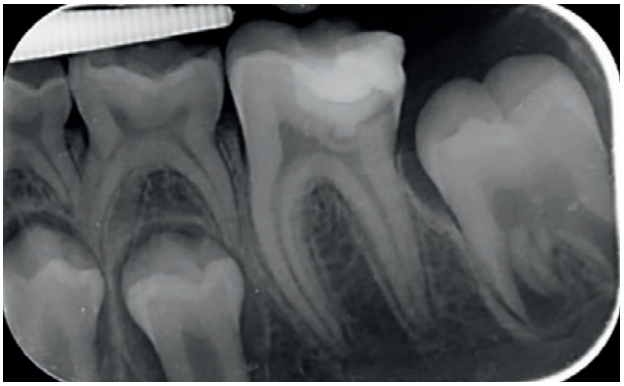

Fig. 9: X-ray at 18-month follow-up appointment showing dentin bridge formation underneath the Biodentine™, as well as apical closure.

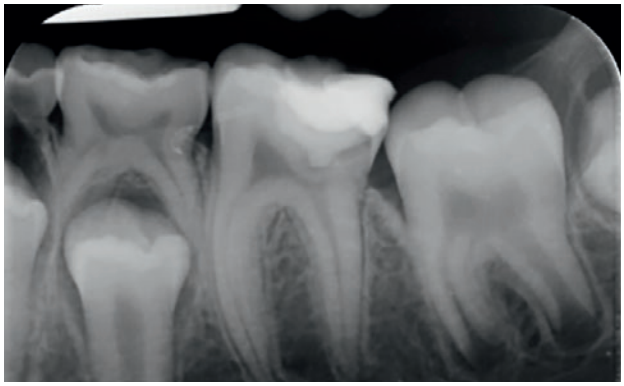

Fig. 10: X-ray at 30-month follow-up appointment showing the positive progression of the treatment.

Conclusion

In this clinical case study, the clinical and radiographic findings reveal that Biodentine™ exhibits good clinical and radiographic behavior in direct pulp capping treatment in immature permanent teeth.

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Pulpotomy in primary teeth using Biodentine™: 18-month follow-up

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Introduction

The pulpotomy treatment is performed on the primary tooth with deep caries or traumatic lesions, provided that it only affects the pulp in the pulpal chamber. In these cases, the radicular pulp is able to form tertiary dentin as a reparative response from the dentin-pulp complex. The purpose of this procedure is to preserve the vitality and function of the remaining radicular pulp until the primary tooth's physiological exfoliation. (1, 2).

The degree of damage to the primary tooth must be taken into account, because the pulpotomy treatment could fail if it is not possible to adequately reconstruct the tooth and seal the crown. (3,4).

Throughout history, different materials have been used to perform pulpotomies in primary teeth with different mechanisms of action in many cases. These materials had to meet the following requirements: present a bactericidal effect, be innocuous to the pulp and surrounding tissues, as well as possess the ability to stimulate the healing of the radicular pulp without interfering with the physiological process of resorption, keeping the radicular pulp alive and healthy (4,5).

The pulpotomy procedure is frequently categorized according to different treatment objectives: devitalization (mummification, cauterization), preservation (minimal devitalization) or regeneration (repair) (6).

Devitalization refers to the destruction of vital tissue, an effect achieved using formocresol, which, for decades, was considered the material of choice in pulpotomies in primary teeth. However, its cytotoxicity and its potential mutagenicity and carcinogenicity caused it to fall into disuse.

Preservation is achieved using materials that try to maintain the vital pulp, but without inducing the formation of reparative dentin. This can be

achieved with ferric sulphate or glutaraldehyde.
Lastly, there is *regeneration* which is when the material used is able to maintain the vital pulp tissue as well as stimulate the formation of reparative dentin (7). The materials are made from calcium silicate, based on "Portland Cement"; MTA® being the most well-known product in this category. Pulpotomy studies with this material have reported very positive results (8-10).
Recent studies show that Biodentine™ has very similar physical and biological properties to dentin, as it is a biocompatible and bioactive material that induces pulp repair. It has simpler handling properties than other bioactive materials with its shorter setting time. Additionally, its radiodensity is due to the fact that it contains zirconium oxide rather than bismuth oxide, so it doesn't discolor the tooth (11-13).
The working time is about 6 minutes, with the setting time being between 10 and 12 minutes after mixing. This allows the pulpotomy treatment and reconstruction to be carried out during the same clinical appointment, which is very advantageous when treating the child patient (13).
Below we present two clinical cases. In the first clinical case, we will provide a systematic review of the pulpotomy procedure using Biodentine™.

Clinical case report 1

A 5-year-7-month-old patient visits our surgery for the first time. The clinical examination showed a deep caries lesion in molar 8.5. with clinical signs of reversible pulpitis ***(Fig. 1)***. The bite-wing X-ray confirms the proximity of the lesion to the pulp, with no signs of lesions in the furcation or periapical areas ***(Fig. 2)***.

In our clinical practice, the pulpotomy procedure consisted of removing the coronal pulp and applying Biodentine™ over the root canal entry through performing the following steps:

1. Local anesthesia is administered, and the tooth is isolated with a rubber dam ***(Fig. 3)***.
2. The carious lesion is initially cleaned using a high-speed rotary instrument (Komet® 0.10 mm round diamond bur) and then complete caries removal is performed using a slow-speed rotary instrument (Komet® 0.10 mm round tungsten-carbide bur). This step precedes the dentin removal from the chamber roof and opening to avoid pulp contamination.
3. A (Komet® 169L bur) is used to cut and (3M™ ESPE™) is used to adjust the preformed crown, prior to opening the pulp chamber to avoid contaminating the pulp chamber with residues.
4. The chamber roof is completely removed using a high-speed rotary device (Komet® 0.10 round diamond bur), with the opening wide enough to see the top of the root canals, taking into account the anatomy of each molar and the characteristics of the tooth being treated.

Fig. 1: Clinical view of molar 8.5.

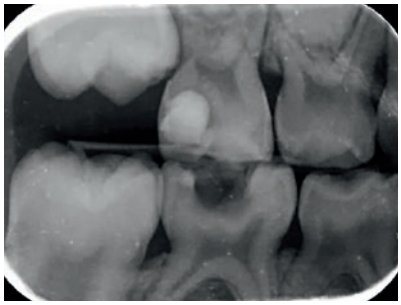

Fig. 2: Initial right bitewing X-ray.

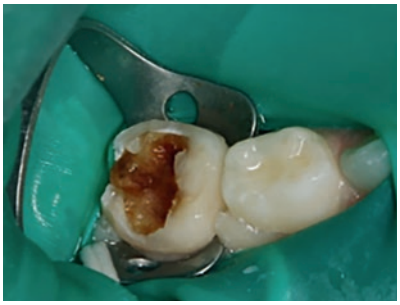

Fig. 3: Complete isolation of the fourth quadrant using a rubber dam.

Fig. 4: Once the caries lesion was removed, the pulp chamber was dried with a cotton ball, the crown was then cut and adjusted, and the dental pulp was removed.

Fig. 5: Appearance of the opening to the root canals once it has clotted.

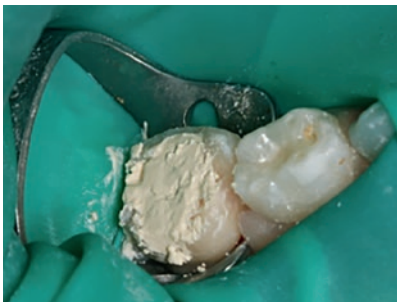

Fig. 6: Image after Biodentine™ has been applied.

Fig. 7: Clinical view of the molar with the cemented crown, once the isolation was removed.

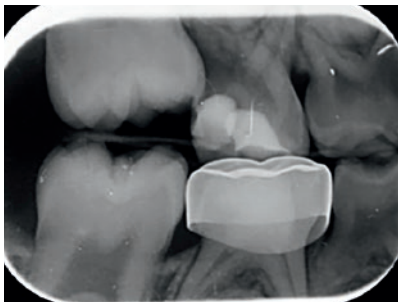

Fig. 8: Right bitewing X-ray after 6 months.

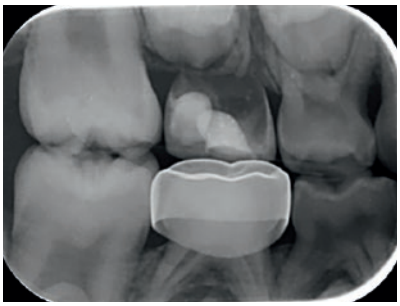

Fig. 9: Right bitewing X-ray after 18 months.

5. The dental pulp is cut out using a slow-speed rotary instrument with a large round bur (Komet® 0.21mm round tungsten-carbide bur), so that a clear and tear-free section of the pulp stumps remains at the opening to the radicular pulp.
6. The chamber is cleaned with water and dried with a piece of a cotton ball and checked to ensure that no pulp remains in the chamber ***(Fig. 4)***.
7. The pulp stumps are compressed using a cotton ball to clot the wound. Gentle pressure should be applied, and the lesion should be visually checked for clotting ***(Fig. 5)***.
8. Biodentine™ is applied to the pulp stumps and is used to fill the cavity ***(Fig. 6)***.
9. The preformed metal crown is adapted and cemented in (3M™ ESPE™) with self-curing glass-ionomer cement (Ketac™ Cem Easy Mix).
10. The isolation device is removed, the bite is checked, and the residual cement is cleaned up ***(Fig. 7)***.

In the follow-up appointments scheduled 6 and 18 months after the treatment, no clinical or radiographic signs or symptoms were found ***(Figs. 8 and 9)***.

Clinical case report 2

A 3-year-9-month-old patient visits our surgery for the first time. The clinical examination showed a deep caries lesion in molar 7.5. with clinical signs of reversible pulpitis. The periapical X-ray confirms the proximity of the lesion to the pulp without indicting any signs of lesion in the furcation or periapical areas, so the decision was to perform the pulpotomy treatment and reconstruct the tooth using a preformed crown ***(Fig. 10)***. The clinical procedure was carried out using a system similar to the one previously described in Clinical Case Report 1 ***(Figs. 10, 11 and 12)***.

Figs. 13, 14, 15 and 16 show the X-rays taken immediately after the treatment, as well as those taken at the 6-month and 18-month follow-up appointments, which show dentin bridge formation.

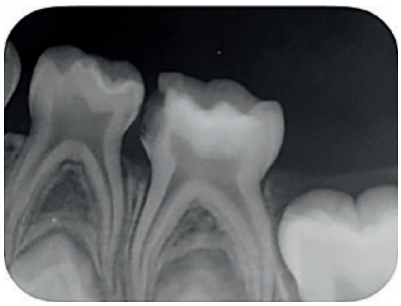

Fig. 10: Initial periapical X-ray of tooth 7.5 showing mesial-occlusal caries.

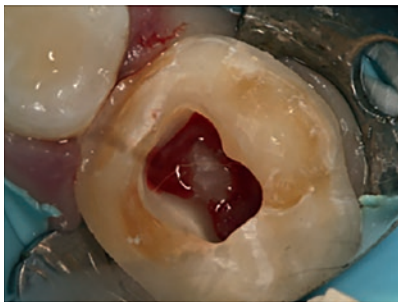

Fig. 11: Appearance of the opening to the root canals after clotting.

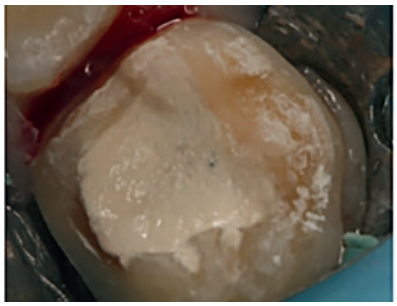

Fig. 12: Biodentine™ applied to the pulp chamber.

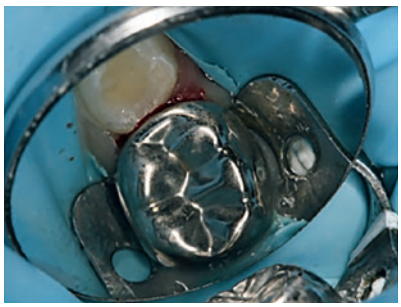

Fig. 13: Clinical view of the molar with the cemented crown, after the isolation system was removed.

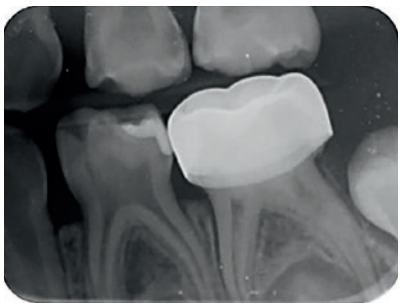

Fig. 14: Pulpotomy X-ray after Biodentine™ treatment.

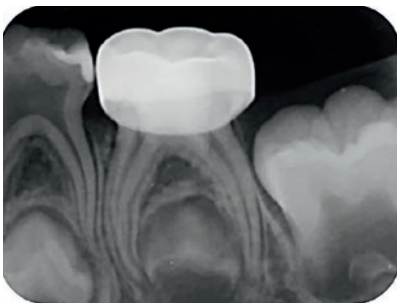

Fig. 15: X-ray taken at the 6-month follow-up appointment after Biodentine™ pulpotomy treatment.

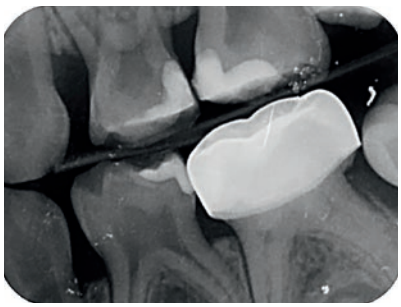

Fig. 16: X-ray taken at the 18-month follow-up appointment after Biodentine™ pulpotomy treatment. Dentin bridge formation can be seen in the mesial root.

Conclusion

In this clinical case study, the clinical and radiographic findings reveal that Biodentine™ exhibits good clinical and radiographic behavior in pulpotomies in primary teeth. However, more long-term randomized controlled clinical trials which support these observations would be desirable.

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