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Endodontic treatment of trauma-induced necrotic immature teeth using a tricalcium silicate-based bioactive cement.

A report of 3 cases with 24-month follow-up

ABSTRACT

Background Pulp necrosis is the second most common complication after traumatic dental injuries and occurs mostly within the first 6–24 months of follow-up period, depending on the type of dental trauma.

Case report Three cases with endodontic treatment scenarios of trauma-induced necrosis in immature permanent anterior teeth. All cases were treated by full canal obturation with Biodentine (Septodont, Saint Maur des Fosses, France) and documented for a follow-up period of 24 months.

Conclusion Copious irrigation of the root canal, minimal mechanical preparation, use of calcium hydroxide for a short period of time and complete obturation of these immature teeth with a bioactive cement with superior mechanical properties such as Biodentine were the prominent reasons attributed to the success of these three cases.

Keywords Biodentine; Dental trauma; Immature teeth; Necrosis.

Introduction

Boys in the age groups 7–9 years and girls in the age group 5–6 years show a higher incidence of traumatic dental injuries (TDI) [Glendor et al., 1996; Andersson, 2013]. Pulp necrosis is the second most common complication after traumatic dental injuries and occurs mostly within the first 6–24 months of the follow-up period, depending on the type of dental trauma and the maturity of the tooth [Bucher et al., 2013]. The treatment of pulpal injury during this period provides a significant challenge for the clinician as a conventional endodontic treatment protocol for these immature teeth is significantly more difficult to perform because of the open apex [Rafter, 2005]. Root development consists of 3 aspects, viz. an increase in root wall thickness, an increase in root length, and the narrowing of the canal leading to the formation of the root apex [Nosrat et al., 2013]. Pulp necrosis in immature teeth affects all the above mentioned aspects of root development, but vital pulp tissue inside the root canal is presumably necessary only for an increase in root wall thickness, whereas an increase in root length and the formation of the apex are functions of the apical papilla and Hertwig epithelial root sheath. Periapical disease following pulp necrosis, is thus truly responsible for the retardation of root development [Nosrat et al., 2013]. Hence, if periradicular disease is eliminated, apexogenesis may be possible even without pulp regeneration or revascularisation therapy.

Apexification by induction of a calcified barrier or revascularisation/regenerative endodontic treatment aiming at regeneration of pulp tissue are the choice of treatments currently available for retaining an immature necrotic permanent tooth [Nosrat et al., 2012; Shabahang, 2013]. Endodontic therapy aiming at elimination of periradicular disease followed by apexification asks for an alternative treatment approach in the young, immature pulpless tooth. These teeth frequently present with thin, fragile walls, which makes it difficult for adequately cleaning. Moreover, the open apex makes it challenging to obtain the necessary apical seal [Shabahang, 2013].

Tricalcium silicate cements have been successfully employed in the biomedical field as bioactive materials, with widely acclaimed osteoactive properties [Eid et al., 2014]. Biodentine (Septodont, Saint Maur des Fosses, France) is one such highly purified tricalcium silicate (Ca₃SiO₅) based inorganic restorative cement. The superior physical and biologic properties suggest Biodentine™ to be an efficient material in the field of paediatric endodontics and dental traumatology [Rajasekharan et al., 2014].

Case series

The following case series consists of three case reports with endodontic treatment scenarios of trauma-induced

pulp necrosis in immature teeth. All cases were treated by full canal obturation with Biodentine and documented for a 24-month follow-up period. All patients reported herein were treated according to the approved university protocol in the Department of Paediatric dentistry and special care, University hospital, Ghent, Belgium.

Case One

An eight year old Caucasian male was referred to the dental hospital by his general dental practitioner for endodontic treatment of an immature maxillary central incisor (tooth 21) under general anaesthesia. Medical history of the patient did not reveal any relevant information and dental history revealed that the tooth had suffered a luxation injury some weeks before. Clinical dental examination showed a buccal swelling and a pseudo-pocket depth of 10 mm. Percussion and palpation revealed negative results and the tooth was asymptomatic. Digital radiographic examination disclosed a radiolucency along the periapical region. The tooth was diagnosed as necrotic and absolute non-cooperation of the patient necessitated the endodontic treatment to be performed under general anaesthesia. Access to tooth 21 was obtained using a high speed bur. Black pulp tissue indicative of complete necrosis was noted. Working length was manually determined (Fig. 1A), followed by irrigation with 2.5% sodium hypochlorite. Subsequently, complete drying of the canal using paper points (Absorbent points, Dentsply Maillefer, Tulsa, Oklahoma, USA) was obtained and the root canal was filled with calcium hydroxide (Fig.

1B) (Ultracal XS, Ultradent, South Jordan, Utah, USA). The access cavity was sealed with a glass ionomer cement (Ketac-Fil Plus Aplicap, 3M Espe, St. Paul, Minnesota, USA). Six weeks later, calcium hydroxide in the root canal was removed by irrigation with saline and 2.5% sodium hypochlorite. The root canal was dried with paper points and completely obturated with Biodentine (Fig. 1C). Two days thereafter, the patient reported buccal swelling and pus discharge from the buccal sulcus of 21 (Fig. 1D). Antibiotic therapy (Amoxicilline 1500 mg) was prescribed alongside chlorhexidine mouthwash for one week. In the following visit, the glass ionomer restoration was replaced by composite resin (A2 shade, Clearfil, Kuraray, New York, USA).

Subsequently, the swelling and pus discharge disappeared and the patient remained symptomless for the rest of the observation period. The patient was initially followed-up at three-month interval and then at six-month interval for up to 24 months at present. Radiographically, normal periodontal ligament and apexification indicative of complete healing was noted at the follow-up appointments (Fig. 1E and Fig. 1F).

Case Two

A nine year old Caucasian male was referred to the dental hospital by his general dental practitioner for treatment of a persistent buccal fistula with respect to the immature maxillary central incisor (tooth 11). Anamnesis revealed that the patient was medically fit. Dental history showed that the patient had suffered from a traumatic

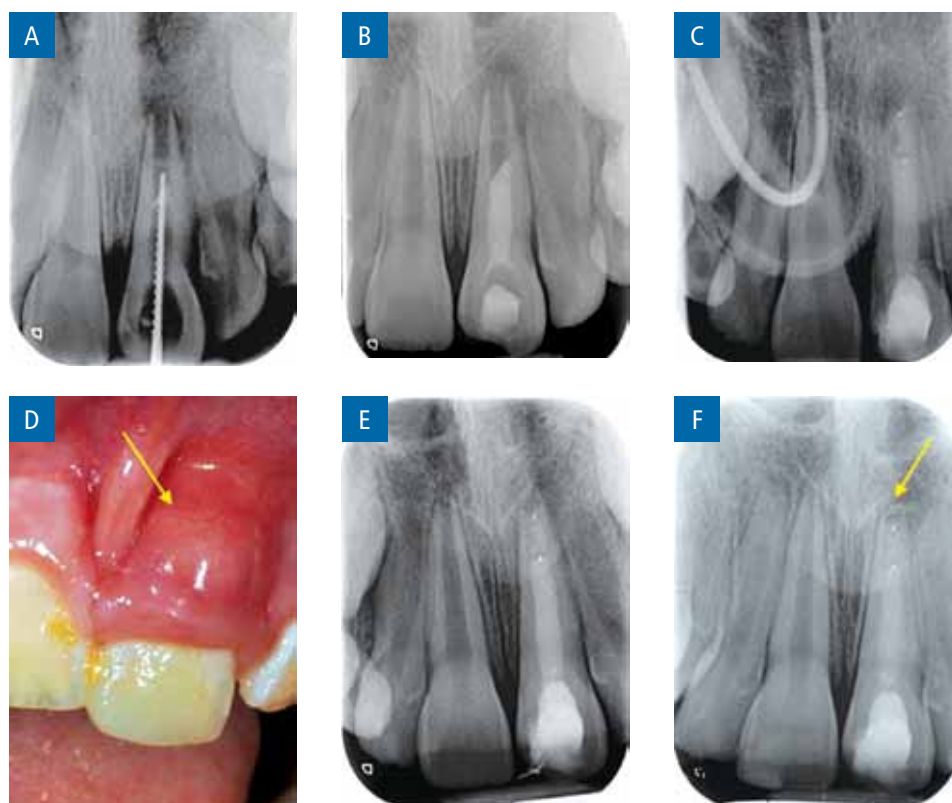


FIG 1

- A: Working length determination.
- B: Temporary obturation with calcium hydroxide.
- C: Complete obturation with Biodentine.
- D: Swelling and pus discharge from the buccal sulcus of 21.
- E: Radiographic follow-up at 12 months.
- F: Radiographic follow-up showing apexification at 24 months.

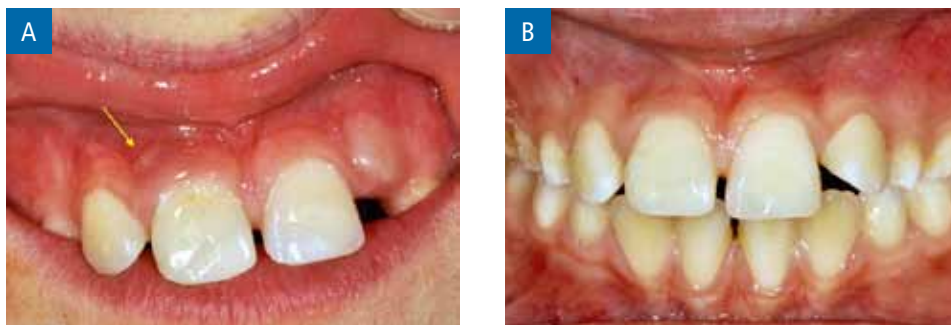


FIG 2
A: Buccal fistula with respect to 11.
B: Clinical follow-up at 24 months.

dental injury at the age of eight (ten months previously). Tooth 11 had undergone a luxation and tooth 21 an uncomplicated enamel dentine fracture (without pulp exposure) with increased mobility. Both teeth were then splinted for two weeks with a semi-flexible splint and eventually restored with composite resin.

Present clinical dental examination confirmed the presence of a buccal fistula (Fig. 2A) with respect to 11. Percussion and palpation revealed negative results and the tooth was asymptomatic. Digital periapical radiograph displayed asymmetric development of maxillary central incisors with apical radiolucency around 11 (Fig. 3A). In comparison to the contralateral central incisor (tooth 21), tooth 11 showed arrested root development as a consequence of pulp necrosis. The tooth was diagnosed as necrotic and endodontic treatment was planned.

During the first appointment, access to the pulp chamber of tooth 11 was obtained using a high speed bur and later irrigated with 2.5% sodium hypochlorite to remove all necrotic pulp tissue from the root canal. Subsequently, working length was manually determined

(Fig. 3B) followed by complete drying of the canal using paper points. The root canal was filled with calcium hydroxide (Fig. 3C) for two weeks and the access opening was sealed with glass ionomer cement. At the second appointment, the calcium hydroxide was removed by means of saline and 2.5% sodium hypochlorite irrigation. A complete dry root canal was obtained by using paper points. Subsequently, the root canal space was completely obturated using Biodentine. An immediate periapical radiograph displayed apical perforation with Biodentine exudation (Fig. 3D). However, there were no complaints from the patient and it was decided to follow-up at regular intervals. Two months later, disappearance of the buccal fistula with respect to tooth 11 was observed in the clinical examination. During subsequent follow-up, a gradual resorption of the apical Biodentine exudate was noticed (Fig. 3E). The glass ionomer cement was replaced with composite resin at this visit. The tooth remained asymptomatic during the entire follow-up period and after 24 months, complete clinical and radiographic healing of the tooth and periapex was established (Fig. 2B and 3F).

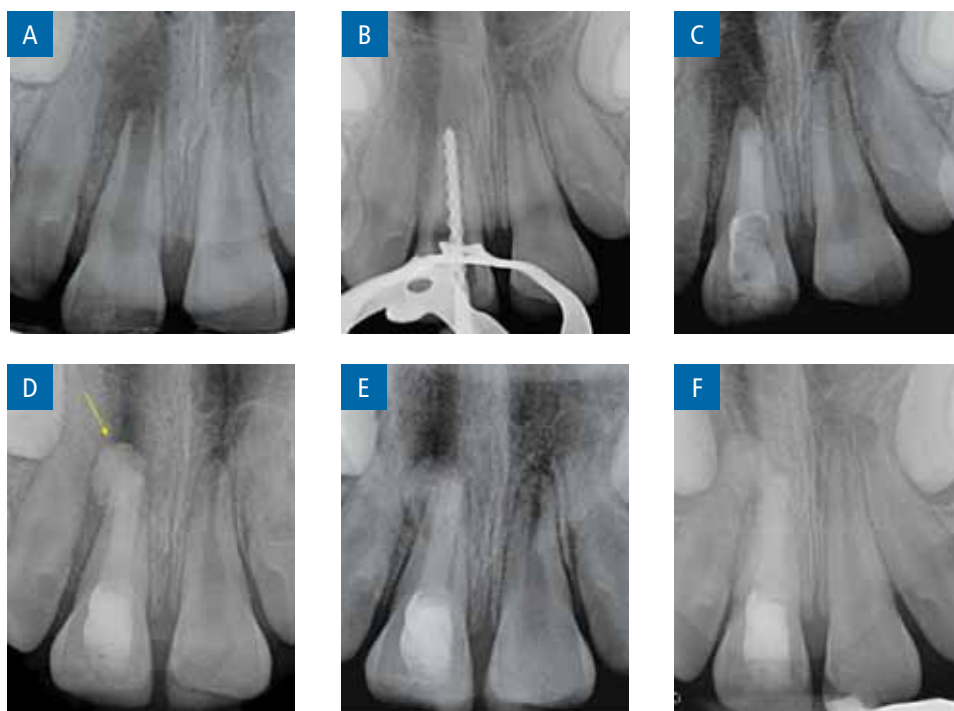


FIG 3
A: Asymmetric development of maxillary central incisors with apical radiolucency around 11.
B: Working length determination.
C: Temporary obturation with calcium hydroxide.
D: Complete obturation and apical exudation with Biodentine.
E: Gradual resorption of the apical Biodentine™ exudate.
F: Radiographic follow-up at 24 months.

Case Three

A nine year old Caucasian male was referred to the dental hospital by his general dental practitioner for treatment of probable pulp necrosis with respect to an immature maxillary central incisor (tooth 21). Medical history of the patient revealed negative relevance. Dental history disclosed a dental traumatic injury of teeth 11 and 21. Although tooth 11 suffered from an avulsion and the parents attended several emergency care centres in the province, the tooth became not replanted due to unknown reasons. As a consequence, the general dental practitioner used the crown of the avulsed tooth 11 as a space maintainer between teeth 12 and 21 with fibre reinforced composite splint.

Clinical dental examination displayed probable symptoms of tooth necrosis in relation to tooth 21. Percussion and palpation revealed negative results and tooth was asymptomatic (Fig. 4A). Delay in root growth and maturation with respect to tooth 21 and adjoining periapical radiolucency was identified in the radiographic examination (Fig. 4B). The radiographic picture of lack of root maturation and periapical radiolucency could probably refer to the previous history of dental trauma. Endodontic treatment of tooth 21 was planned, and access to the root canal was obtained during the first appointment using a high speed bur and subsequently irrigation with 2.5% sodium hypochlorite and saline in order to remove the necrotic pulp tissue. A complete dry canal was visualised without any traces of moisture or pus. Working length was determined manually (Fig. 4C) and paper points were used to assure a dry root canal. Considering the particular broad, thin and fragile root canal, Biodentine was determined to be the choice of obturating material. In the same appointment, the root canal was completely obturated with Biodentine up to the dentine-enamel junction and in the following appointment, finished with composite resin. Although a clear visual apexification, extrusion of Biodentine beyond the root canal space was noted in the immediate post-operative radiograph (Fig. 4D).

The first follow-up appointment was 3 months later, followed by control at six months interval up to 24 months follow-up. The tooth remained asymptomatic and the patient reported no subjective complaints during the entire follow-up period. Slow resorption of the extruded Biodentine, uneventful healing and a complete healthy periapex were substantiated with periapical radiographs taken at 3, 6, 12 (Fig. 4E) and 24 (Fig. 4F) months follow-up.

Discussion

Preservation of tooth integrity and strength is important for the long-term survival of endodontically treated teeth [Baba et al., 2009]. Root canal irrigants, mechanical root canal preparation techniques, medicaments of

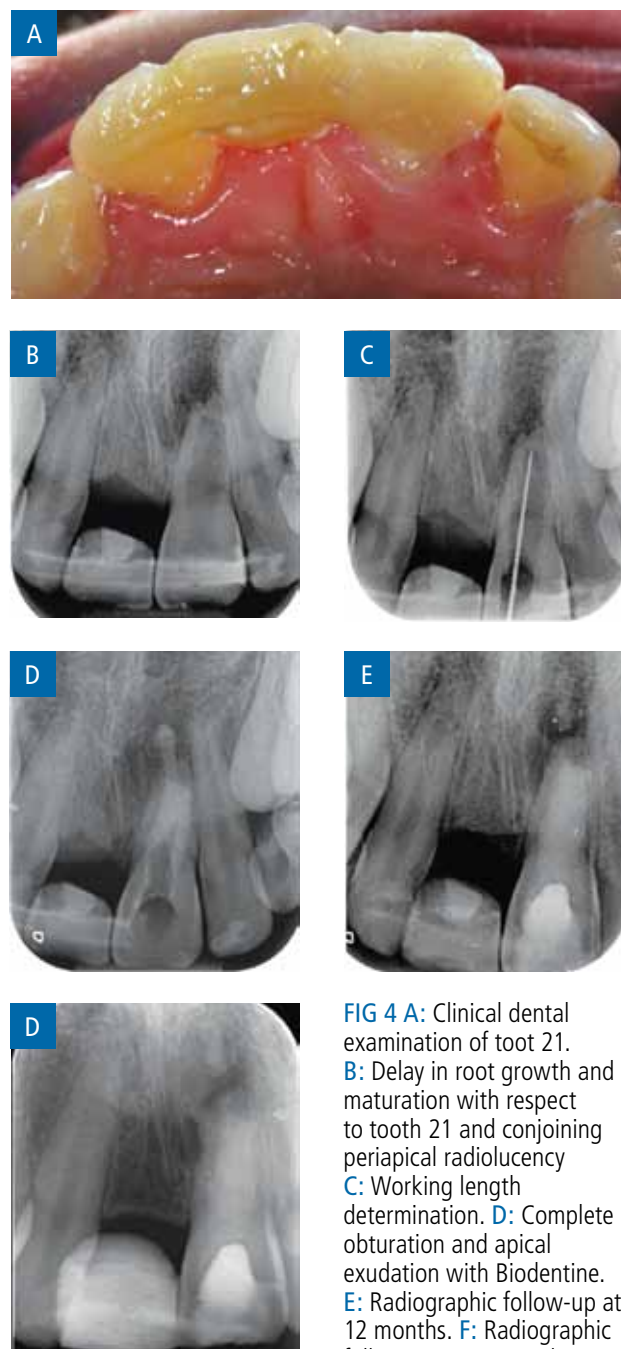


FIG 4 A: Clinical dental examination of tooth 21. **B:** Delay in root growth and maturation with respect to tooth 21 and adjoining periapical radiolucency **C:** Working length determination. **D:** Complete obturation and apical exudation with Biodentine. **E:** Radiographic follow-up at 12 months. **F:** Radiographic follow-up at 24 months.

root canal filling materials and their influence on the mechanical properties of the dentine itself play an important role in determining the prognosis of fracture-related endodontically treated immature teeth [Moazami et al., 2014]. The weakening of the dentin by 23-43.9% following root canal filling with calcium hydroxide has been attributed to long term usage of this material to induce an apical barrier in immature teeth [Rosenberg et al., 2007]. However, for a long time, calcium hydroxide has also been used as a pre-obturation endodontic medication to disinfect the root canal [White et al., 2002]. Till date there is no conclusive data that calcium hydroxide exposure for one month or less had a negative effect on

the mechanical properties of radicular dentine [Yassen and Platt, 2013]. In the present cases, calcium hydroxide was used as a disinfectant for no longer than two weeks, thereby, assuring no weakening of the root dentine.

Calcium silicate-based cements adhere to root dentine, forming a crystalline bond in a biochemical process termed biomineralisation [Reyes-Carmona et al., 2010]. The biomineralisation ability of Biodentine initiates calcium and silicate uptake by the dentine, which in turn would cause chemical and structural modification of dentine, that may result in higher acid resistance and physical strength [Han and Okiji, 2011]. Hence, the use of Biodentine in the present cases as an obturation material may eventually improve the resistance of the endodontically treated immature teeth against fracture. From an earlier *in vitro* study, it could be concluded that mineral trioxide aggregate significantly strengthened immature root canals [Cauwels et al., 2010]. Moreover, Biodentine exhibits greater compressive strength in comparison to other tricalcium silicate cements, which is attributed to the low water/cement ratio made possible by the water soluble polymer in the liquid. The physical properties of Biodentine such as flexural strength, elastic modulus and Vickers hardness are similar to dentine [Grech et al., 2013a, Grech et al., 2013b].

Progressive discolouration of the tooth crown is a potential aesthetic complication after endodontic treatment of immature anterior teeth. Discoloration is either a result of materials ingressing into dentinal tubules or by material remnants in the pulp chamber, which get darker over time and is transmitted through the hard tissues [Lenherr et al., 2012]. In the present report, no discolouration was observed in any of the three cases after using Biodentine. This is consistent with the literature as Biodentine exhibited colour stability independent of oxygen and light irradiation unlike other tricalcium silicate cements such as mineral trioxide aggregate [Valles et al., 2013].

Conclusion

Copious irrigation of the root canal, minimal mechanical preparation, use of calcium hydroxide as a disinfectant and complete obturation of these immature teeth with a bioactive cement with superior mechanical properties, such as Biodentine, were the prominent reasons for the success of these cases. In addition to the clinical and radiographic success, the aesthetically satisfying outcome provides compelling motivation for using Biodentine in the endodontic treatment of aesthetically sensitive areas such as immature anterior teeth.

Why this paper is important to paediatric dentists.

- Trauma of immature permanent teeth with open apex is a frequent occurrence and always poses a clinical challenge. This study reports a new treatment protocol for three such cases with 24-month follow-up.

- This study emphasises the possible alternative endodontic therapy that could provide equally satisfying clinical results in cases where revascularisation/regenerative endodontic treatment is not a viable option.
- This study reports three cases treated with new generation bioactive tricalcium silicate cement (Biodentine) developed for better mechanical, biological and aesthetic characteristics.

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