# Bioceramic cement as a reparative material in apexification of immature permanent tooth: a case report

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## ABSTRACT

**Introduction**: Bioceramic cement is the latest material of choice that can be used in apexification, resorption case, perforation repair, and known as high-quality sealing material in regenerative endodontics. The treatment of apexification in immature teeth poses a considerable challenge due to the wide root canal, the absence of apical constriction, and thin dentin walls, thus requiring specialized techniques and materials for managing teeth with an open apex. The objective of this case report is to delineate the treatment of apexification in teeth with open apices using the latest bioceramic material (Bio-C® Repair). **Case report**: An 11-year-old female patient with chief complaints of swollen gums covering the cervical third of the crown after her front tooth was broken due to a fall two years ago. Radiographic examination showed a wide root canal with an open apex and radiolucency in the apical area. The apexification procedure with an apical plug was performed with Bio-C® Repair, followed by anatomical fiber post and direct composite restoration for the final restoration. In the 2-month and 4-month control, the periapical lesion showed signs of healing on radiographs. Bioceramic materials act as an artificial barrier in open apex management and provide various advantages, such as shortening treatment time, strengthening dentin structure, and possessing bioactive properties that can induce healing. The orthograde placement of bioceramic material is challenging in terms of length control. Using bioactive materials can reduce the risk of adverse impacts from material extrusion. **Conclusion**: A new bioceramic material (Bio-C® Repair) is recommended for the apexification procedure because it can overcome the limitations of MTA (e.g., tooth discoloration, handling difficulties, prolonged setting time, and the release of heavy metals.

## Keywords

open apices, immature permanent tooth, apexification, bioceramic, apical barrier technique

# *Semen biokeramik sebagai material apeksifikasi gigi permanen imatur: laporan kasus*

## *ABSTRAK*

***Pendahuluan**: Material biokeramik merupakan material pilihan yang digunakan untuk menangani prosedur apeksifikasi, resorpsi, perforasi, dan sebagai material regeneratif endodontik. Perawatan apeksifikasi pada gigi yang belum matang menimbulkan tantangan besar karena saluran akar yang lebar, tidak adanya konstriksi apikal, dan dinding dentin yang tipis, sehingga memerlukan teknik dan material khusus untuk merawat gigi dengan apeks terbuka. Tujuan laporan kasus ini adalah untuk menjelaskan perawatan apeksifikasi pada gigi dengan apeks terbuka menggunakan material biokeramik terbaru (Bio-C® Repair). **Laporan kasus**: Pasien perempuan 11 tahun datang dengan keluhan pembengkakan pada gusi yang menutupi sepertiga servikal mahkota gigi, setelah gigi tersebut patah karena terjatuh dua tahun yang lalu. Pemeriksaan radiografis menunjukkan saluran akar yang lebar dengan apeks terbuka serta radiolusensi pada area apikal. Prosedur apeksifikasi dilakukan dengan pembuatan penutupan apikal (apical plug) menggunakan material biokeramik Bio-C® Repair, yang diikuti pemasangan pasak fiber anatomis dan tumpatan resin komposit sebagai restorasi akhirnya. Pada kontrol 4 bulan, lesi periapikal menunjukkan tanda kesembuhan secara radiograf. Material biokeramik berperan sebagai penutupan apikal artifisial pada manajemen apeks terbuka dan memberikan berbagai keuntungan seperti mempersingkat waktu perawatan, menguatkan struktur dentin, dan memiliki sifat bioaktif sehingga dapat menginduksi penyembuhan. Penempatan material biokeramik pada ujung apeks secara orthograde merupakan prosedur yang cukup sulit terutama saat mengontrol panjang kerja. Penggunaan material bioaktif dapat menurunkan risiko dampak negatif dari ekstrusi material. **Simpulan**: Material biokeramik baru seperti Bio-C® Repair menjadi rekomendasi untuk tatalaksana prosedur apeksifikasi karena dapat mengatasi berbagai keterbatasan MTA seperti diskolorasi gigi, kesulitan handling, waktu pengerasan yang lama, dan pelepasan kandungan metal berat yang toksik.*

## *Kata kunci*

*apeks terbuka, gigi permanen imatur, apeksifikasi, biokeramik, teknik penutupan apikal*

## INTRODUCTION

Traumatic injuries during childhood can interfere with root development leading to the formation of teeth with open apices. Root development takes 2-3 years from eruption until apical closure occurs.[1] If there is interference during this period, the formation of the root will stop, and a tooth with an open apex will form.[2,3] The treatment of a tooth with an open apex is quite challenging because it has the characteristics of a wide root canal, no apical constriction, and a thin dentin wall that requires special techniques to treat teeth with an open apex.[4,5]

Apexogenesis, apexification, and regenerative endodontic therapy (RET) are three types of treatment that can be performed, depending on the vitality of the injured immature tooth.[6] Apexogenesis is a vital pulp treatment procedure performed to continue the physiological growth of the root while maintaining its vitality. Apexification is a method to induce closure of exposed root ends in immature teeth with pulpal necrosis using bioactive materials. Regenerative endodontic therapy is a biological procedure to replace damaged pulp tissue with viable tissue which restores the normal function of the dentin-pulp complex.[2,7]

For many years, calcium hydroxide paste or $Ca(OH)_2$ was used as an apexification treatment material by inducing root tip closure with calcification followed by root canal filling.[3] Then, in 1993 mineral trioxide aggregate (MTA) was introduced as the first bioactive material used in endodontics, one of which is the alternative material for apexification treatment. This material is used to create artificial apical closures or so-called apical plugs, due to its sealing properties, stability, and biocompatibility MTA is superior to $Ca(OH)_2$ paste.[5,8,9] This material is an effective alternative for apexification treatment and allows for shorter apexification treatments.[2]

Mineral trioxide aggregate (ProRoot MTA®, Tulsa Dentsply), still has various limitations such as tooth discoloration, difficulty in manipulation and insertion, long setting time, and release of heavy metal substances such as arsenic (As) which have toxic properties in tissues.[10] Therefore, bioceramic or calcium silicate-based materials have been modified over time.[11] Changes in the composition, particle size and dosage forms of calcium silicate-based bioceramic cement can improve physical and mechanical properties that can provide benefits during clinical applications.[12]

After the presence of MTA, Biodentine (Septodont, Saint Maur-des-Fosses, France) was found with faster setting time than MTA and eliminated the potential for tooth discoloration. In addition, a new calcium silicate-based cement was also found, which was modified in a ready-to-use dosage form with a consistency that is easy to apply, does not cause discoloration, and does not have toxic ingredients for tissues such as BIO-C ® Repair (Angelus, Londrina, Brazil). However, case reports regarding apexification treatment using this material are still rarely reported.[13] Therefore, the aim of this case report is to describe in detail the procedure for apexification in teeth with open apices, utilizing the most recent bio-ceramic material (Bio-C® Repair).

## CASE REPORT

An 11-year-old female patient reported a chief complaint on her gum and fractured upper front right tooth. The patient have a history of trauma two years back and admitted that the teeth first began to appear at the age of 8 years. The patient only feels pain shortly after the injury, after that no longer feels pain, but still uncomfortable biting and worried about the swelling in her gums that continues to grow.

Intraoral clinical examination revealed the maxillary right central incisor tooth had a diagonal fracture of the crown with exposed pulp in the mesio-incisal section (Ellis fracture class III) and labioversion malposition (Figure 1). The gum was swelling with a sinus tract and stalk in its apical part then extended to the cervical third of the crown of the tooth with a diameter of ± 8 mm (Figure 1). No abnormalities found extraorally.

**Figure 1**. Pre-operative clinical photograph

The tooth 11 was tender to percussion and palpation. Thermal test gave a negative response. Radiographic examination revealed an open apex 2 mm wide accompanied by a radiolucent image at the apical tooth with a diameter of 5.5 mm (Figure 2).

**Figure 2.** Preoperative radiograph

Following rubber dam placement, an access opening was done. Then the working length was determined radiographically 2 mm short of the radiographic apex (Figure 3). Cleaning of the root canal begins with the removal of the necrotic pulp tissue with an extirpation needle (VDW® sterile barbed broaches), brownish-white pulp tissue was obtained (Figure 4).

**Figure 3.** Working length determination

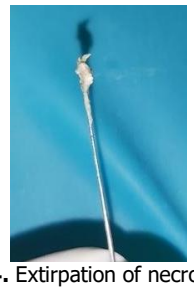

**Figure 4.** Extirpation of necrotic tissue

The root canal was irrigated with saline carefully to help remove necrotic tissues and pus from the root canal, then intracanal suction was used to dry the canal. After that, the root canal preparation was carried out carefully using a file #80 (K-File, Maillefer Dentsply) with a circumferential filing motion according to working length followed by re-irrigation using 1.25% NaOCl 20 mL (Onemed dental) and 17% EDTA 20mL (Onemed dental) with saline (NaCl) in between. Then the root canal is medicated with intracanal $Ca(OH)_2$ (UltraCal™, UltraDent) and temporary seal with Cavit™.

On the second visit, subjective and objective examinations were carried out again. The patient feels that the swelling has started to decrease but in the last 2 days a throbbing feeling has appeared in the tooth. Clinical examination showed that the swelling had decreased, but was still quite large with a diameter of ± 4 mm (Figure 5). Objective examination percussion and palpation are still tender.

**Figure 5.** Clinical photograph on second visit

Following rubber dam placement, remove the temporary restoration and the remaining $Ca(OH)_2$ medication. Then the root canal was irrigated carefully with a manual syringe technique using the side vented 30G needle with 1.25% NaOCl (20 mL, 5 minutes), 17% EDTA (20 mL, 5 minutes), and 0.12% Chlorhexidine (10 mL, 3 minutes), with saline in between. After that, the root canal is dried and medicament is applied intracanal $Ca(OH)_2$ and temporarily filled with Cavit™.

On the third visit, the patient felt no complaints and the swelling was minimal with a diameter of ± 1 mm (Figure 6). Percussion and palpation are still tender even though they are not as painful as before. Then the work area was isolated with a rubber dam to perform the apical plug procedure using BIO-C® Repair (Batch number: 60180). This material is placed in the root canal, then pushed in an apical direction using the base of the paper point ISO #80 (Absorbent point, Maillefer, Dentsply) to obtain a tactile sensation while forming a 4 mm apical plug at the tip of the open apex.

**Figure 6.** Clinical photograph on third visit

Radiograph evaluation was taken, then the result was an apical plug formed 4 mm apically. However, BIO-C® Repair material was extruded 1 mm from the open apex of tooth 11. The root canal was placed with moist cotton pellets that are temporarily filled at once, to wait for the material to harden. On the following visit BIO-C® Repair material hardened and the root canal was obturated using thermoplastic gutta-percha using the backfill method (Elements™ free) (Figure 7).

**Figure 7.** Radiograph of an apical plug & root canal obturation

Two months after the apexification procedure, the patient had no complaints, the swelling was gone, there was only a small protrusion on the gingiva region 11 (Figure 8), and no tenderness on percussion and palpation. In the radiograph, there is an increase in the density of the alveolar bone at the apical of tooth 11 (Figure 8). In this moment patients are categorized as having progress in healing so that they are continued with permanent restorations using anatomical fiber posts & composite resin (Figure 9).

**Figure 8.** Clinical photograph (left) and Radiograft (right) 2 months after apexification

**Figure 9.** Anatomical fiber post & Radiograph definitive restoration

After four-month apexification procedure, there is no complaint from the patient and signs recovery in radiographs are also getting better (Figure 10)

**Figure 10.** Clinical photograph & radiograph 4 months after apexification

## DISCUSSION

Treatment for immature teeth with open apex has challenges, such as thin wall thickness making it easy to fracture, and no apical stop making it prone to material extrusion during treatment, so procedures such as apexification must be carried out carefully with the suitable material. Based on the anamnesis, it is known that the patient experienced a delayed eruption on tooth 11 which just started to erupt at the age of about 8 years, then the patient experienced trauma to that tooth at the age of 9 when the root growth reached one third of the apical resulting an open apex with a blunderbuss appearance and an apical foramen diameter of ± 2 mm. Even so, the root length and the dentin thickness of the tooth are quite enough because the root formation is almost done thereby improving the prognosis of treatment apexification. However, the patient left the pulp exposed for 2 years so that chronic lesions develop in the periapical area, cause considerable swelling, and increase the difficulty level of treatment.

In this case report, calcium silicate-based bioceramic cement was used as an apical plug material, namely BIO-C® Repair (Angelus, Londrina, Brazil), issued a permit by the US FDA in 2018. This material was chosen because this bioceramic material has modifications in its composition, particle size, and preparations that correct the deficiencies of previous MTA materials such as ProRoot MTA and MTA Angelus. Bismuth-oxide composition which functions as a radio-opacity material is replaced with zirconium oxide to prevent tooth discoloration, this material is also similar to the radio-opacity agent used in Biodentine™. This is an important characteristic in the treatment of apexification because the majority of the case occurs in the front teeth, which require esthetic properties.[14,15]

Furthermore, this calcium silicate-based material also has a smaller particle size which has the effect of a faster hardening time because it increases the surface area. When compared with ProRoot MTA which has a particle size (of 5-19 µm), its initial setting time is 40 minutes, and 4 hours for the final setting time.[16,17] While BIO-C® Repair with a particle size of 2 µm has an initial settings time of 15 minutes and a final setting time of 2 hours.[14] Even so, Biodentine™ still has the fastest setting time, that is 6 minutes for the initial setting time and 10-12 minutes for the final setting time due to the content of calcium chloride accelerator in the liquid.[18] However, the procedure for making an apical plug on the large open apex diameter requires sufficient work time so that if the setting time is long enough, then we do not need to rush and can ensure that the material condenses properly.

In addition to setting time, smaller and homogeneous particle sizes can also increase particle distribution during the hydration process so that the resulting consistency is more unified, unlike wet sand. The consistency possessed by BIO-C® Repair is putty, which is a semi-solid mass in a ready-to-use package and it facilitates easier insertion and condensation of material for the orthograde formation of the apical plug during the apexification procedure.[14] This consistency can also result from the manipulation of other modified MTA products, such as MTA Flow ™ (Ultradent by replacing the liquid with a gel form so that it can produce various kinds of consistency according to the indications.[19]

In this case, there was an extrusion of 1 mm of BIO-C® Repair when forming the apical plug. Based on long-term evaluation (36-54 months) in the literature, it is stated that extrusion of MTA on tissue does not interfere with healing. Besides that, the properties of BIO-C® Repair, which do not contain toxic metal content in its composition, make this material safer when in contact with periapical tissue.[11,20] Even so, the extrusion of bioceramic material into tissues should still be avoided so as not to give rise to the possibility of unpredictable effects from foreign material, especially if the position of the teeth is adjacent to important anatomical structures such as maxillary sinuses and nerve fibers. However, apical barrier material can be used to control the condensation, such as collagen plug and autogenous platelet-rich-fibrin (PRF) membrane. If the extruded MTA causes complaints such as pain, paresthesia, or other uncomfortable complaints related to the extruded tooth material, then treatment such as surgery must be carried out.[21] In some cases, clinical and radiographic observation of MTA extrusion can be carried out 1-6 years after treatment, depending on how much material is extruded and the degree of healing of the lesions that occur.[22]

Orthograde condensation of bioceramic material to form apical plug in this case was carried out manually with a big-size paper point, unfortunately this technique makes the bioceramic cement stick to the root canal walls and is difficult to clean, thereby weakening the bond of the resin cement to the dentine of the root canal walls. Therefore, the procedure for placing the apical plug material can be improved by using a special tool such as the Micro Apical Placement (MAP) System to place material directly into the apical plug area. This technique can also reduce microleakage on the apical plug compared to manual condensation.[23]

Evaluation of recovery after apexification treatment is generally carried out within 1, 3, and 6 months, and every year up to 4-5 years after the apexification procedure or until subjectively, clinically, and radiographically shows complete healing.[22] These complete healing criteria can be seen radiographically by observing the size of the periapical lesion and the formation of normal periapical tissues such as the lamina dura, periodontal tissue, and cementum. In this case, the patient still needed further control to assess the healing of the lesion until normal apical anatomy was formed and evaluate the response of BIO-C® Repair extrusion to the tissue.

## CONCLUSION

Apexification treatment has several challenges such as the risk of fracture of the thin root canal wall, the extrusion of the material used during treatment, the patient's cooperation in undergoing treatment, and the long evaluation time. By carrying out proper treatment management and selecting the right material, the treatment of an open apex with a periapical lesion and large swelling gum as in this case can also provide good healing results in a short time. Currently there are many types of bioceramic materials on the market, an understanding of the composition and properties of these bioceramic materials is necessary for case selection. BIO-C® Repair can be recommended as one of the effective materials for the management of apical plug apexification because it gives ease of use, no discoloration, and no release of toxic materials such as arsenic.

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