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Bio-obturation: A Novel Approach in Root Canal Treatment Using Endodontic Biomaterials

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Bio-obturation is an innovative approach in root canal therapy that effectively addresses complex clinical challenges using bioactive endodontic materials. This report highlights 14 diverse cases where bio-obturation was employed to manage complications such as internal and external resorption, root perforations, draining sinus tracts, mechanical obstructions, and trauma-related injuries. The outcomes demonstrate notable healing and resolution of various tooth related pathologies in failed primary root canal treatments. Root perforations and canal blockages were successfully sealed, restoring the integrity of the root canal system and ensuring continued tooth function and retention. Bio-obturation facilitated stabilization and regeneration of periradicular and supporting tissues in trauma cases, including avulsed teeth and inflammatory root resorption. Cases involving open apices, dens invaginatus, and complex root canal anatomy also showed favorable results. Overall, bio-obturation offers a transformative alternative to conventional root canal filling by promoting enhanced biological sealing and improved periradicular healing, thus increasing the probability of sustainable long-term clinical success. While calcium-enriched mixture cement served as the bioactive material in these cases, this approach may also be effectively implemented using other advanced calcium silicate-based biomaterials, broadening its applicability in challenging endodontic scenarios.

Keywords: Bio-obturation, Biomaterials; Calcium-Enriched Mixture; Calcium Silicate Cement; CEM Cement; Endodontics; Mineral Trioxide Aggregate; Root Resorption; Root Perforation; Regenerative Endodontics

Introduction

Ideal root canal filling materials must meet various criteria to ensure long-term healing and retention of the tooth. Properties should include biocompatibility, strong adhesion and sealing, dimensional stability, regenerative potential, and antibacterial activity. Additionally, they should possess radiopacity, resistance to moisture sensitivity, reinforce weakened root structure, exhibit sufficient flexibility and durability, along with cost-effectiveness [1, 2]. In recent years, endodontic treatments have evolved and advanced significantly. They have become more predictable due to a better understanding of microbiology, wound healing, anatomical complexities of the root canal system, disinfection protocols and the introduction of innovative biomaterials [3, 4].

A cornerstone of effective root canal treatment after disinfection is effective obturation, creating a hermetic seal to prevent leakage and bacterial recolonization of the root canal system. Conventional obturation techniques, such as cold lateral and warm vertical condensation, use gutta-percha along with various sealers [5]. These methods have been reliable due to their ability to contribute some mechanical support and provide an acceptable seal. However, they do have limitations. The single-cone technique, while simpler to perform, is particularly susceptible to failure due to the dissolution and degradation of traditional sealers, which may compromise long-term treatment outcomes [6].

Recent advancements in biomaterials have shifted the focus from bioinert to bioactive endodontic materials [7-10]. These biomaterials enhance sealing efficacy, biological compatibility, and regenerative capacity of the periodontium [1, 11]. Among these, calcium silicate-based cements (CSCs), such as mineral trioxide aggregate (MTA) (ProRoot® MTA, Dentsply, Tulsa Dental, Tulsa, OK, USA) and calcium-enriched mixture (CEM; BioniqueDent, Tehran, Iran), have emerged as crucial biomaterials in modern endodontics [12, 13]. These bioactive materials not only create a durable seal but also actively promote tissue healing and reformation of supporting structures. This is due to release bioactive ions that stimulate hydroxyapatite formation, fostering regenerative processes such as dentinogenesis, cementogenesis and hard tissue repair [14-17].

The choice of biomaterial is critical to the effectiveness of root canal treatment and the promotion of periapical tissue healing. Materials based on tricalcium silicate and its derivatives exhibit optimal properties that include biocompatibility, bioactivity, and high moisture tolerance, making them particularly effective for challenging cases [18]. However, the selection of these biomaterials must be guided by evidence-based research to ensure clinical efficacy.

Bio-obturation represents a transformative approach in endodontics, utilizing bioactive materials to address complex endodontic challenges [19]. Central to its effectiveness is the process of biomineralization, where bioactive materials interact with tissue fluids to deposit mineralized structures such as hydroxyapatite [20, 21]. This biologically integrated seal enhances the structural integrity of root canal system, increase the tooth's resistance to fracture and promotes the regeneration of periapical tissues [22]. Biomineralization also enhances the adaptability of these materials to seal complex root canal anatomies, including lateral canals, isthmuses, and apical deltas, providing a comprehensive solution for long-term healing [23].

This approach is especially beneficial in managing internal and external resorption, root perforations, canal obstructions, and trauma-related injuries, conditions where traditional methods and materials are often ineffective. By combining sealing properties, antibacterial activity, and regenerative potential, bio-obturation offers a biologically driven alternative for managing refractory/non-healing cases. This paper explores the clinical applications and outcomes of bio-obturation in 14 complex cases. It highlights the role of this obturation technique in the endodontic practice, where achieving healing and repair along with long-term favorable results in both immature and mature teeth are the primary goal. Through these case reports, a comprehensive overview is provided of its clinical applications, benefits, and its ability to address the limitations of traditional techniques.

Bio-obturation Technique

The bio-obturation technique for bioactive cements (*i.e.*, CSCs) requires precise preparation, accurate placement, and controlled compaction to achieve optimal sealing and acceptable density. Before initiating obturation, it is essential to thoroughly chemo-mechanically prepare and irrigate the canal with sodium hypochlorite (NaOCl) to remove bacteria/debris and disinfect the root canal system. However, the management of the smear layer is a debated topic in endodontics. Some clinicians choose to retain the smear layer, as it may serve as a coupling agent, potentially enhancing the bonding of bioceramic cements to the dentin without compromising its sealing ability. It has been shown that the removal of the smear layer is not critical to achieve adequate sealing and penetration of endodontic biomaterials into patent dentinal tubules [24].

In mature teeth, a master apical file (MAF) preparation size of a 35 or size 30 in significantly curved canals is recommended, this will facilitate effective obturation, ensuring adequate space for the insertion and proper adaptation of the cement within the canal system. Once the canal is properly prepared and dried, the cement should be mixed according to the manufacturer's instructions to achieve a homogeneous creamy consistency. The mixed cement is then inserted into the canal using a plastic instrument or carrier gun. An appropriate endodontic plugger is employed to advance the bulk of the biomaterial apically, ensuring uniform distribution and proper placement.

To achieve optimal apical compaction, a stainless-steel K-file, one or two sizes smaller than the MAF is engaged to compact the apical 3-5 mm of the CSC. Initially, the biomaterial should coat the canal walls and the radial lands of the compacting instrument. The file must be directed circumferentially with a clockwise turn pushing apically along the canal walls while applying light to moderate pressure to ensure thorough compaction. A quarter turn counterclockwise is recommended on retrieval, to avoid moving to much cement coronally. In cases where the apex is closed, firmer pressure can be applied to enhance the sealing. Intermittent use of sterile paper points can absorb excess moisture and improve the compaction of the biomaterial, preventing overhydration. Obturation density can be increased using ultrasonic activation of the MAF or small plugger.

Once apical compaction is achieved, additional cement should be incrementally added and compacted from the apical to coronal portions of the canal, utilizing progressively larger endodontic pluggers. Radiographic assessment should confirm uniform obturation with satisfactory density and distribution. If the obturation appears inadequate, re-compaction using smaller K-files can refine the filling to achieve the desired outcome.

In cases with large open apices, minimizing excessive extrusion of CEM into periapical tissues is desirable. Although minor extrusion does not typically impede healing, careful control of the biomaterial placement is important to avoid complications. Consistent with findings by Terauchi *et al.* [25],

Figure 1. *A*) Pre-treatment radiograph showing a single root with a single canal and an apical lesion; *B*) Post-treatment radiograph after non-surgical endodontic treatment with CEM cement bio-obturation; *C*) Radiograph taken 16 months later showing a normal PDL and resolution of the apical lesion

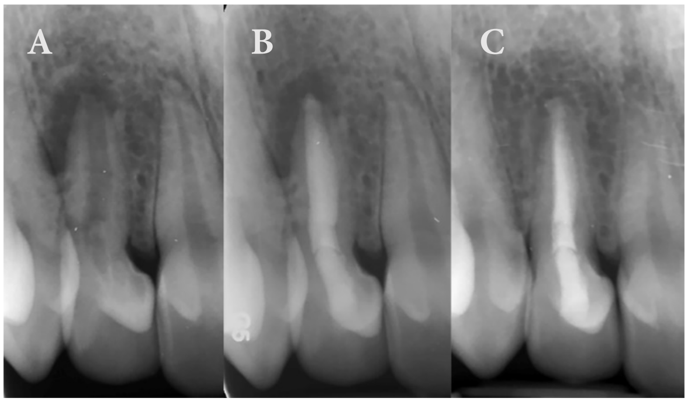

Figure 2. *A*) Pre-treatment radiog raph of tooth #12, showing dens evaginatus and a large periapical lesion; *B*) Immediate post-treatment radiograph following non-surgical retreatment and obturation with CEM cement; *C*) Radiograph taken at the 10-year follow-up, showing complete resolution of the periapical lesion and a normal PDL

flush and slightly overfilled obturation levels are associated with favorable healing outcomes, while underfilled cases significantly increase the likelihood of nonhealing and surgical intervention in retreatment cases. In some open apex cases, operators may prefer placement of apical barriers prior to obturation to avoid excessive extrusion of the cement [26].

Throughout the obturation process, clinicians should use their judgment to tailor techniques to the case-specific anatomy, including the presence of resorption and canal obstructions. Radiographic imaging after initial 3-4 mm apical plug placement is helpful to confirm dense compaction. Post-obturation radiographs help confirm adequate apical and coronal cement density, without voids or deficiencies. This is critical for long-term success and can reduce indications for retreatment or surgical intervention.

The subsequent case presentations illustrate various challenging scenarios where bio-obturation was employed to manage conditions that may have been difficult or ineffective at resolving pathosis using other conventional techniques.

General Procedure for All Cases

All cases followed a standardized treatment protocol. Patients, parents or guardians were informed of risks, benefits and outcomes and written consents were formalized. After performing clinical and radiographic evaluations, local anesthesia was administered, and the tooth was properly isolated. Chemomechanical preparation involved irrigation with 5.25% NaOCl, followed by thorough drying of the canal. Bio-obturation was conducted using CEM cement, following the manufacturer's instructions. The biomaterial was placed with a plastic instrument or carrier gun and compacted apically using appropriate pluggers. A radiographic assessment was then performed to confirm the adequacy of obturation density/adaptation.

Post-operative instructions were provided to the patients, who were scheduled for follow-up appointments at 1 week, 1 month, and annually thereafter. Healing was assessed both clinically and radiographically, with successful outcomes defined as the absence of symptoms, functional tooth retention, and the resolution of periapical pathology.

Primary Endodontic Treatment

***Case #1*:** A 31-year-old female patient presented with persistent pain in tooth #37, diagnosed with pulp necrosis and symptomatic apical periodontitis. Radiographic findings revealed a single root with a single canal and an apical lesion (Figure 1A). Accessory canals were noted and filled during bio-obturation (Figure 1B). At the first recall one week later, the patient was asymptomatic, and the tooth was functional. A second recall at 16 months showed the patient remained asymptomatic, with radiographs indicating a normal periodontal ligament (PDL) and no periapical pathology (Figure 1C).

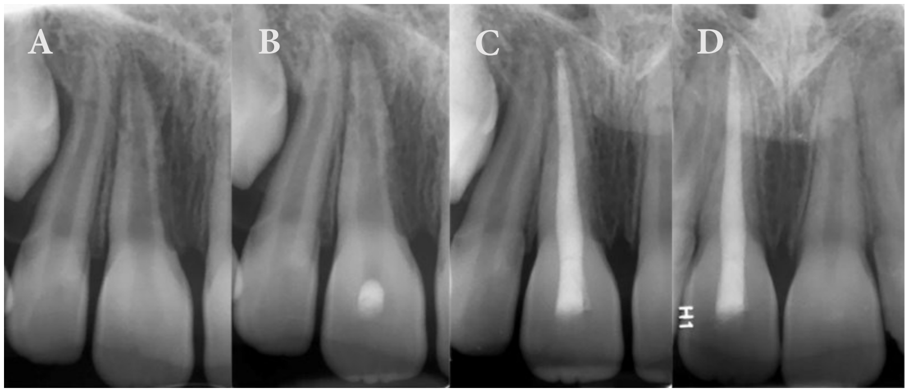

Figure 3. *A*) Pre-treatment radiograph of tooth #11, showing extensive external inflammatory root resorption and diffuse bone resorption; *B*) A radiograph after one month of calcium hydroxide placement shows its dissolution; *C*) Post-treatment radiograph showing bio-obturation with CEM cement; *D*) Radiograph at the one-year follow-up, demonstrating complete resolution of resorption and normalization of the PDL

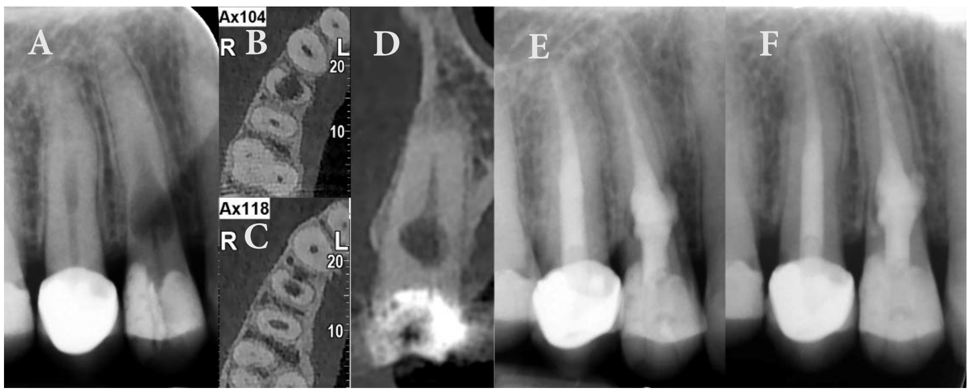

Figure 4. *A-D*) Pre-treatment periapical radiograph and CBCT images of tooth #14 showing extensive internal root resorption with perforation and bone resorption near the perforation site; *E*) Post-treatment radiograph after non-surgical endodontic retreatment with CEM cement bio-obturation; *F*) Follow-up radiograph taken 12 months later, showing resolution of the bone defect and cessation of resorption with PDL reformation

***Case #2*:** A 57-year-old female patient presented with a crown anomaly (dens invaginatus) in tooth #12. Clinical examination revealed localized tenderness and redness in the surrounding area. Radiographs identified a large periapical lesion (Figure 2A). The initial diagnosis was pulp necrosis with symptomatic apical periodontitis. Non-surgical endodontic retreatment included meticulous chemomechanical instrumentation and bio-obturation (Figure 2B). The treatment was uneventful, and no complications occurred. At the first recall, one-week post-treatment, the localized tenderness and redness had resolved, and the tooth was functional. At the long-term follow-up, 10 years later, the patient remained asymptomatic, with radiographs showing a normal PDL and complete healing of the periapical lesion (Figure 2C).

***Case #3*:** An 11-year-old boy presented with severe mobility in tooth #11, which had been avulsed one month prior and reinserted into the socket without additional care. Clinical examination revealed localized tenderness/redness. Radiographs showed extensive external inflammatory root resorption and diffuse bone resorption (Figure 3A). The initial diagnosis was pulp necrosis due to trauma, associated with symptomatic periapical periodontitis. Calcium hydroxide was placed as an intracanal medicament at the initial visit. One-month later, mobility and localized tenderness had partially resolved but radiographic findings remained unchanged from the initial session (Figure 3B). At this time, endodontic treatment employing bio-obturation was completed (Figure 3C). At the one-year follow-up, the patient was asymptomatic, and radiographs revealed normal PDL with resolution of resorptive and periapical changes (Figure 3D).

***Case #4*:** A 57-year-old female patient presented with localized discomfort during chewing on tooth #14. Radiographic and CBCT analysis confirmed extensive internal root resorption with perforation and adjacent bone resorption (Figures 4A-D). The treatment included bio-obturation to seal the perforation (Figure 4E). At the first recall, one-week post-treatment, the patient reported no discomfort, and the tooth remained functional. At the second recall, 12 months later, the patient remained asymptomatic, with radiographs showing a normal PDL and complete resolution of bone resorption (Figure 4F).

Figure 5. *A*) Pre-treatment radiograph showing an endodontically tooth with underfilling and an apical lesion; *B*) Post-treatment radiograph after retreatment with CEM cement obturation; *C-D*) Radiographs taken 31 and 60 months later showing a normal PDL and resolution of the apical lesion.

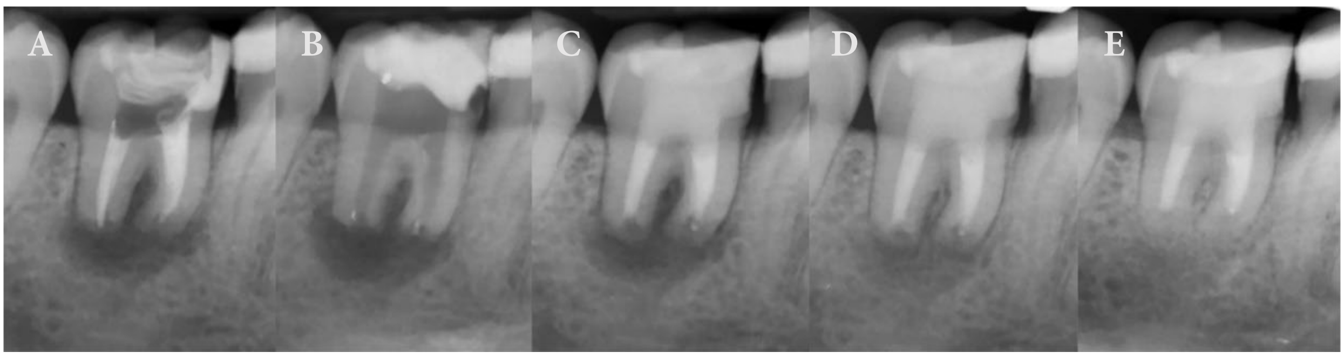

Figure 6. *A*) Pre-treatment radiograph showing severe external root resorption, open apices, and an apical lesion in tooth #47; *B*) complete removal of root canal filling materials; *C*) Post-treatment radiograph after non-surgical endodontic retreatment with CEM cement bio-obturation. Radiographs taken 12 months; *D*) and 29 months; *E*) later showing a normal PDL and complete resolution of the apical lesion

Non-Surgical Endodontic Retreatment

***Case #5*:** A 40-year-old male patient presented with symptomatic apical periodontitis in tooth #25, previously endodontically treated. Radiographic examination revealed a single root with underfilling and an apical lesion (Figure 5A). The root filling materials were removed, and the canal was re-instrumented, followed by bio-obturation (Figure 5B). At the first recall one week later, the patient was asymptomatic. Next recalls at 31 and 60 months showed the patient remained asymptomatic, with radiographs indicating a normal PDL and no periapical lesion (Figures 5C-D).

***Case #6*:** A 28-year-old female patient presented with symptomatic apical periodontitis in tooth #47, which had been previously endodontically treated. Radiographic findings revealed incomplete root canal obturation, advanced apical root resorption with open apices, and a large apical lesion (Figure 6A). The root filling materials were removed (Figure 6B), and the canal was re-instrumented, followed by bio-obturation (Figure 6C). At the first recall appointment, 10 days post-treatment, the patient was asymptomatic. The next recalls at 12 and 29 months showed the patient remained asymptomatic, with radiographs indicating a complete bone healing and a normal PDL (Figure 6D-E).

***Case #7*:** A 45-year-old male patient presented with symptomatic apical periodontitis in tooth #16. Radiographic examination revealed internal root resorption and apical lesions (Figure 7A). The existing root filling materials were removed, and the canals were refilled by bio-obturation (Figure 7B). At the first recall appointment, one day post-treatment, the patient was asymptomatic. At the second radiographic 67-month recall, the patient was asymptomatic, with normal PDL and supporting bone (Figure 7C).

Case #8: A 53-year-old female patient presented with a draining sinus tract and discomfort in the area of tooth #35, which was endodontically treated and served as the mesial abutment of a 3-unit PFM bridge. Radiographic examination revealed a chronic apical abscess using a gutta-percha tracking

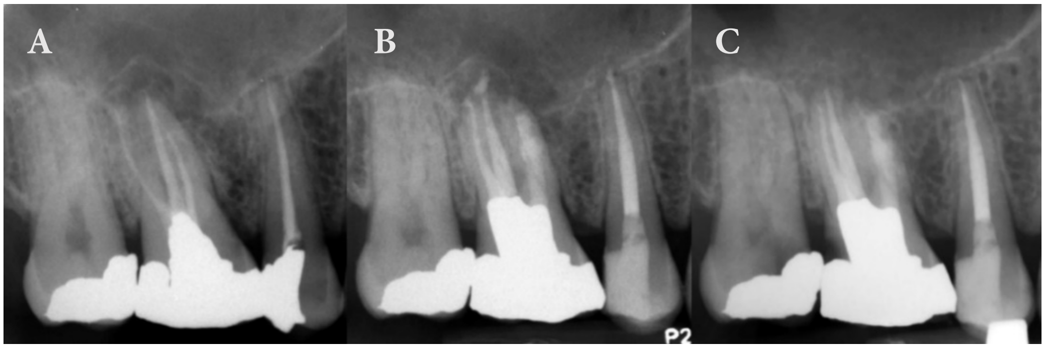

Figure 7. *A*) Pre-treatment radiograph showing internal root resorption and apical lesions in tooth #16; *B*) Post-treatment radiograph after endodontic retreatment with CEM cement bio-obturation, demonstrating dense filling/sealing of the canal, in particular, the mesiobuccal root; *C*) Radiograph taken 67 months later showing a normal PDL and complete resolution of the apical lesion

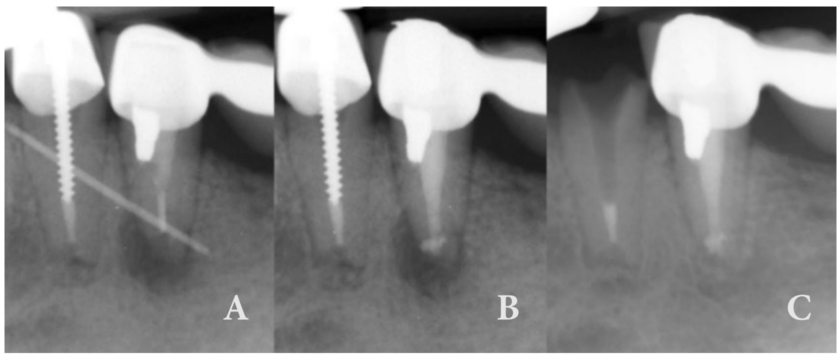

Figure 8. *A*) Pre-treatment radiograph showing chronic apical abscess with gutta-percha tracing, external root resorption, and a large apical lesion in tooth #35; *B*) Post-treatment radiograph after CEM cement bio-obturation; *C*) Radiograph taken 63 months later showing a normal PDL and resolution of the apical lesion

point and apical root resorption (Figure 8A). The canal was re-instrumented, followed by bio-obturation with minor CEM extrusion (Figure 8B). At the first recall, one-week post-treatment, the patient was asymptomatic, the draining sinus tract resolved and the tooth remained functional. Radiographic recall at 63 months showed a normal PDL and complete healing of the periapical pathology without symptoms (Figure 8C).

***Case #9*:** A 49-year-old male patient presented with an acute apical abscess involving teeth #46 and #47, both previously endodontically treated. Radiographic examination revealed apical root resorption in both teeth with lesions and open apices. (Figure 9A). Bio-obturation resulted in overfilling of the mesial root of tooth #47 without complications (Figure 9B). The teeth were restored with an amalgam build-up (it is important to note that amalgam, while used in this case, is not an ideal material for core buildup due to its stiffness, which significantly exceeds that of dentin and increases the risk of tooth fracture). At the first recall, one-week post-treatment, the abscess had resolved, and the patient reported no discomfort; both teeth were functional. At the second recall, 25 months later, the patient remained asymptomatic. Radiographs demonstrated a normal PDL and resolution of the apical lesions in both teeth (Figure 9C).

***Case #10*:** A 46-year-old female patient presented with tooth #44 for non-surgical endodontic retreatment after failure of the initial orthograde treatment. Radiographic findings revealed apical periodontitis, external root resorption, and a separated carbide bur blocking the root canal (Figure 10A). The retreatment was performed and involved removing the existing root filling material and the separated instrument, followed by bio-obturation (Figure 10B). At the first recall, one-week post-treatment, the patient was asymptomatic. At the second recall, 27 months later, the patient remained asymptomatic, and routine periapical radiograph as well as the CBCT images demonstrated a normal PDL with complete healing of the apical lesion (Figures 10C-D).

***Case #11*:** A 52-year-old female patient presented with a draining sinus tract associated with tooth #36, which had been previously endodontically treated. Radiographic examination using gutta-percha for tracing revealed a furcal lesion and root perforation in the distal root caused by post preparation and insertion (Figure 11A). The treatment procedure involved the removal of the root filling materials

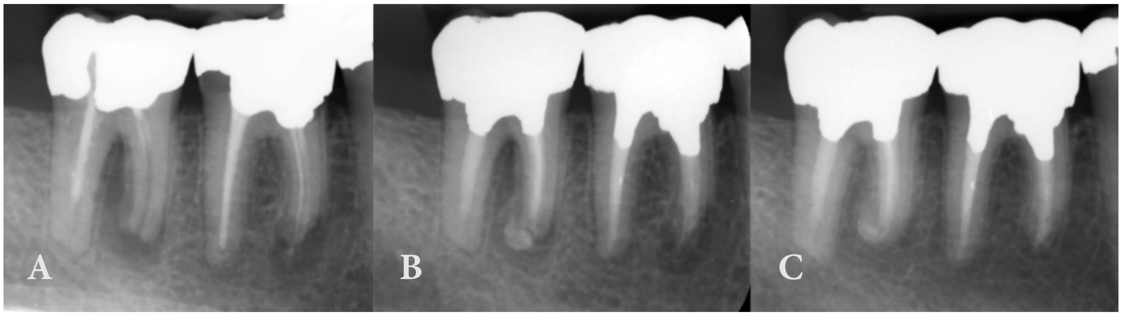

Figure 9. A) Pre-treatment radiographs of teeth #46 and #47 showing external root resorption, and apical lesions, with open apices in the mesial roots of both teeth; *B*) Post-treatment radiographs after CEM cement bio-obturation; *C*) Radiographs taken 25 months later showing normal PDL and resolution of the apical lesions

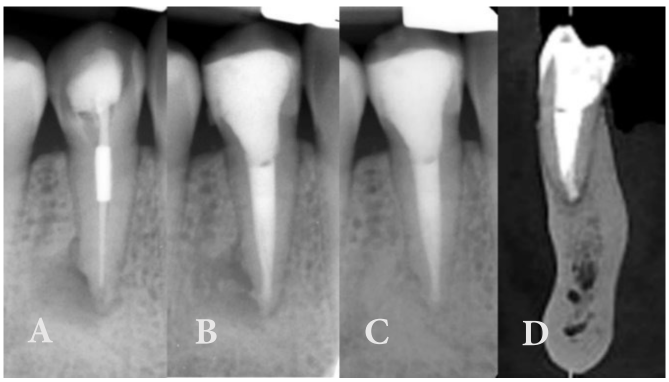

Figure 10. A) Pre-treatment radiograph of tooth #44 showing apical periodontitis, external root resorption, and a separated bur blocking the root canal; *B*) Post-treatment radiograph after non-surgical endodontic retreatment, illustrating removal of the fractured instrument and bio-obturation with CEM cement; *C & D*) Follow-up radiographs (periapical and CBCT) taken 27 months later, showing complete healing of the apical lesion and a normal PDL

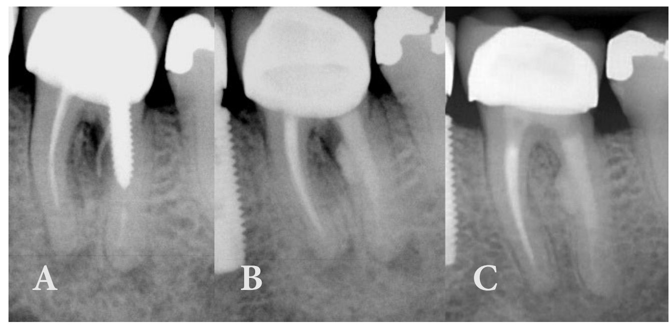

Figure 11. A) Pre-treatment radiograph of tooth #36 showing a furcation lesion and root perforation in the distal root caused by post perforation; *B*) Post-treatment radiograph after bio-obturation; *C*) Follow-up radiograph taken 27 months later, showing complete resolution of the furcal lesion with remineralization of the defect and normal PDL

and the prefabricated post, followed by bio-obturation (Figure 11B). At the first recall, one-week post-treatment, the sinus tract had closed, and the patient reported no discomfort. At the second recall, 27 months later, the patient remained asymptomatic, and radiographs showed a normal PDL with complete resolution of the furcal lesion (Figure 11C).

Surgical Endodontic Treatment

***Case #12*:** A 28-year-old female presented with severe pain, class II mobility, and symptomatic periapical periodontitis involving tooth #25. Radiographic examination revealed a large apical lesion, extensive external/apical root resorption, and overfill of the gutta-percha (Figure 12A). The treatment plan included intentional replantation with retrograde root canal preparation and bio-obturation. Under local anesthesia the tooth was carefully extracted, and minimal resection of the apical portion of the root was conducted. The root canal was prepared in reverse using Gates Glidden burs #3 and #4, up to the level of the core material. This was followed by enucleation of the apical lesion and removal of the extruded gutta-percha. Finally, the canal was obturated to be flush with the resection level using a bio-obturation technique, completing the procedure in 8 minutes (Figure 12B). At the 1-week recall, the patient reported resolution of pain. At the 12-month recall, the tooth was asymptomatic and functional. Radiographs showed a normal PDL space (Figure 12C).

Case #13: A 33-year-old female patient presented with severe pain and symptomatic periapical periodontitis in tooth #45. Radiographic examination revealed a large apical lesion with apical root resorption, presence of an untreated canal and perforation/overfill from the previous obturation (Figure 13A). The treatment included intentional replantation, root-end resection, bio-obturation and retrograde CEM filling (Figure 13B). At the first recall, 1-week post-treatment, the patient reported significant pain relief, and the clinical examination showed no complications. At the 24-month follow-up, the patient was asymptomatic and functional; the radiograph examination revealed a normal PDL (Figure 13C).

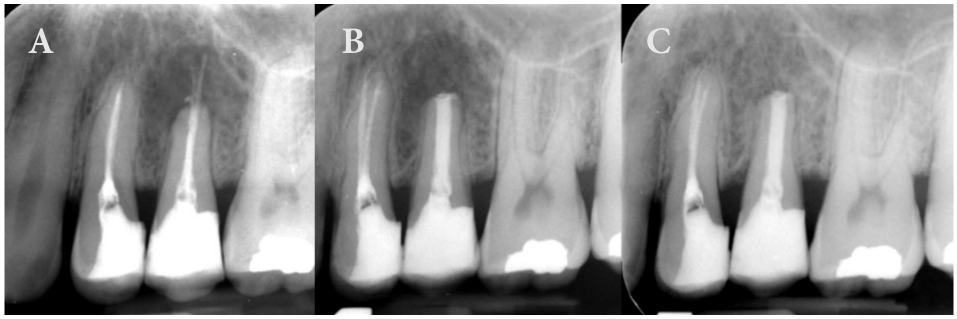

Figure 12. *A*) Pre-treatment radiograph showing a large apical lesion and extensive external root resorption; *B*) Post-replantation radiograph following retrograde root canal preparation and CEM bio-obturation; *C*) Radiograph at the 12-month follow-up demonstrating the complete resolution of the apical lesion and normalization of the PDL

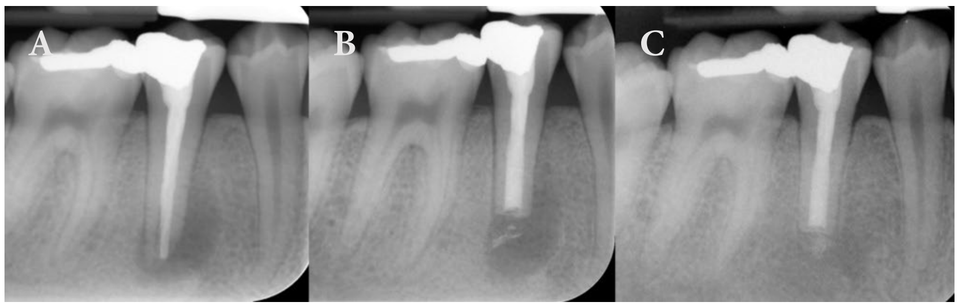

Figure 13. *A*) Pre-treatment radiograph showing a large apical lesion and an untreated main canal; *B*) Post-treatment radiograph showing the completed retrograde bio-obturation with CEM cement; *C*) Radiograph at the 24-month follow-up demonstrating normal PDL space and complete resolution of the apical pathosis

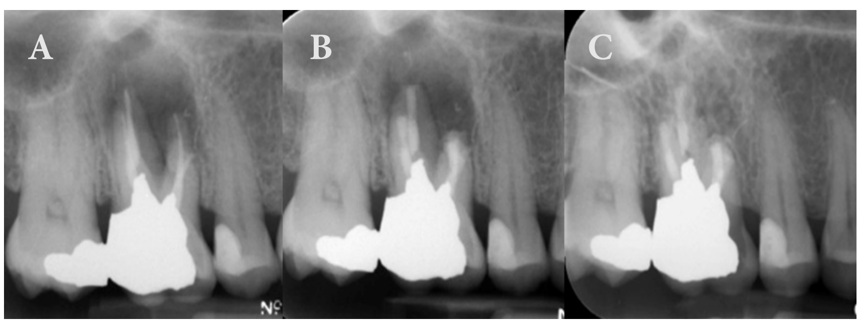

Figure 14. *A*) Pre-treatment radiograph showing a very large apical lesion in tooth #16; *B*) Post-treatment radiograph showing retrograde bio-obturation with CEM cement in all four canals; *C*) Radiograph at the 44-month follow-up demonstrating normal PDL and complete resolution of the apical lesion

Case #14: A 54-year-old male patient presented with mild localized pain and symptomatic periapical periodontitis in tooth #16. Radiographic examination revealed a large apical lesion suggesting involvement all three apices (Figure 14A). The treatment plan was intentional replantation and bio-obturation (Figure 14B). At the 1-week recall, the patient reported complete pain relief, and clinical findings were within normal limits with no complications. At the 44-month follow-up, the patient remained asymptomatic and functional, with radiograph showing a normal PDL space and complete resolution of the apical lesion (Figure 14C).

Discussion

Bio-obturation materials, also known as CSCs or bioceramics, exert their therapeutic effects by having bioactive physico-chemical properties that promote innate regenerative mechanisms, that are fundamental to their success in complex endodontic cases [13, 27]. One of the most notable characteristics of CSCs is their bioactive sealing ability [21]. These biomaterials chemically interact with dentin upon application, releasing calcium and hydroxyl ions [12, 28]. This interaction forms an interfacial layer resembling hydroxyapatite, as Sarkar *et al.*

described in 2005 [23], which tightly fuses to the dentin with no measurable gap. This process significantly enhances the seal (i.e., bio-seal) and strengthens the integration between the biomaterial and the dentin. Moreover, the bioactive properties of CSCs facilitate the repair of periapical tissues by promoting the regeneration of damaged structures such as cementum, the periodontal ligament, and bone. When in contact with periradicular tissues, CSCs undergo a bioactive reaction, forming a hydroxyapatite-like bio-cap over the material and the surrounding dentin [21]. This process enhances their sealing ability, biocompatibility, and potential for cementogenesis, contributing to the long-term success of endodontic treatments. These combined effects ensure the long-term effectiveness of endodontic treatment. By facilitating a durable and biologically integrated seal, CSC-based bio-obturation materials represent a transformative approach in modern endodontics [21, 23].

Bio-obturation materials exhibit superior flowability when using a higher water-to-powder ratio, thus increasing cement adaptation in cases with complex root canal morphology [29]. The biomaterials effectively fill irregularities such as lateral canals, isthmuses, apical deltas, and resorptive defects. These are often challenging to obturate using traditional materials. The enhanced flowability, combined with the hygroscopic or setting-induced linear expansion of the biomaterial, allows for optimal adaptation to the canal walls, reducing voids and ensuring a bacterial tight seal [30, 31]. Such properties are critical for achieving consistent and predictable outcomes, particularly in challenging cases where traditional obturation techniques may be inadequate.

The ability of bio-obturation materials to maintain an alkaline environment within the root canal system and dentinal tubules where microorganisms can persist, further enhances their effectiveness [32, 33]. As the biomaterial releases hydroxyl ions over time, the alkaline environment not only neutralizes bacterial pathogens but also inhibits the growth of any residual microorganisms. This antibacterial effect is crucial for preventing reinfection and allows for healing and the regeneration of supporting tissues [34, 35]. Additionally, studies using scanning electron microscopy have shown that materials like OrthoMTA (BioMTA, Seoul, Korea) and other CSCs, can foster intratubular mineralization, leading to the gradual entombment of bacteria within dentinal tubules over time [36]. This process effectively seals the root canal system, neutralizes microorganisms and further minimizes the risk of reinfection. The combined effects of sustained alkalinity and bacterial entombment create a biologically favorable environment that not only supports tissue regeneration, but decreases the probability of reinfection.

In addition to these sealing and antibacterial properties, bio-obturation materials actively stimulate hard tissue reformation [13, 37]. These biomaterials promote the proliferation of dental pulp stem cells and other progenitor cells, facilitating the regeneration of mineralized tissues such as dentin, cementum and hard tissue barriers in vital pulp therapy, endodontic surgery, apexification/apexogenesis and resorption/perforation repair. [38, 39]. This regenerative capacity makes bio-obturation an ideal strategy for challenging cases such as open apices, resorption, and trauma-related injuries. By stimulating tissue repair and promoting the formation of hard tissue, bio-obturation can restore the structural integrity of the radicular component of the tooth, contributing to its continued function.

Various techniques have been employed for root canal obturation using CSCs, each with unique advantages and limitations [40]. The Lawaty technique utilizes hand files in a step-back method to incrementally carry and compact CSCs, offering superior mass and radiopacity but requiring more time. The Auger technique involves engine-driven NiTi rotary files in reverse mode for compaction, sometimes combined with gutta-percha points of matching taper for efficient CSC delivery and condensation. The Plugger technique, on the other hand, uses NiTi pluggers for incremental CSC transfer and condensation. In practice, a combination of these techniques can optimize outcomes. In the cases presented, we employed a hybrid method combining hand files for precise placement and appropriate pluggers for effective condensation and acceptable CEM density.

Recent studies have examined the role of chelation in enhancing the intratubular penetration of CSCs. Interestingly, it has been shown that MTA can penetrate dentinal tubules with or without smear layer removal and regardless of the chelating agent used [24]. The findings indicate that MTA intratubular mineralization can extend from the root canal wall to the cementum in roots with patent and non-infected tubules, achieving penetration levels of up to 90%. However, despite the potential advantages of employing chelation when using conventional obturation techniques, the results of the case review, demonstrated satisfactory outcomes and obturation quality without this additional method.

We employed CEM cement for the management of all 14 cases, as it was readily available and a cost-effective alternative to MTA. This biomaterial combines antibacterial action, biocompatibility, and superior sealing with regenerative potential [22, 41-43]. Its bioactive ion release from indigenous sources (calcium, phosphorus, and hydroxyl) establishes an alkaline pH, promotes hydroxyapatite formation in both bio-seal and bio-cap features, and stimulates hard tissue formation, including dentinogenesis, cementogenesis, and osteogenesis [37, 41]. Unlike MTA, CEM cement offers a faster setting time, easier handling, and minimal tooth discoloration. These attributes, coupled with its ability to induce biomineralization, make it an ideal biomaterial for pulp capping, pulpotomies, perforation repair, and regenerative endodontics in both primary and permanent teeth, as well as in mature and immature teeth, particularly in complex cases [11, 41, 44-46].

The unique mechanisms of action of bio-obturation materials, including bioactive sealing, enhanced adaptability, antibacterial properties, and regenerative capabilities, may position these bio-cements as a transformative option in endodontic treatment. These biomaterials offer a comprehensive approach to root canal therapy, addressing both the biological and structural needs of the tooth, which is particularly valuable in managing complex cases where traditional techniques and materials may not promote adequate healing of the periodontium. Careful consideration of the specific clinical scenario, combined with the most current scientific and clinical data, is essential in ensuring the successful application of bio-obturation in endodontic practice.

Conclusion

Bio-obturation with bioactive materials (e.g., CEM cement) improves root canal therapy through enhanced biological sealing and periradicular healing. Demonstrated in 14 cases, it effectively manages root resorption, perforations, and trauma injuries, achieving functional tooth retention and pathology resolution. This biologically driven approach offers a reliable alternative to conventional methods, ensuring long-term clinical success.

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Conflict of interest

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Authors' contributions

SA is the sole author and is solely responsible for all aspects of the study, including conception, data collection, analysis, and manuscript preparation.

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