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Novel Apical Barrier Strategy Using Recombinant Platelet-Derived Growth Factor And Beta Tricalcium Phosphate: Insights From A Case Series

Dr. Vasanth MN[1], Dr. Sruti Murali[2], Dr. Palak Borade[3], Dr. Priyanka Bhangale[4], Dr. Lakshmi V Pillai[5] and Dr. Sudharani[6]

[1]Senior Resident, King George's Medical University, Lucknow
[2]Oral Pathology Consultant, Vijaya Dental Care Multispeciality Dental & Implant Center
[3]PG Trainee - Final Year, Oral & Maxillofacial Pathology and Oral Microbiology, Government College of Dentistry, Indore
[4]Assistant Professor, Dr D Y Patil Dental College and Hospital Pimpri, Dr D Y Patil Vidyapeeth Pimpri Pune
[5]Assistant Professor, Malabar Dental College
[6]Senior Resident, Government Dental College, Kottayam
[1]vasanthmn760@gmail.com, [2]srutimurali@hotmail.com, [3]palakborade18@gmail.com, [4]priyanka.bhangale@dpu.edu.in, [5]naveen.lakshmi239@gmail.com and [6]sudhabajantri1995@gmail.com
[3]ORCID iD: 0009-0000-6839-2774 and [4]ORCID ID - 0000-0003-0382-0779

Apexification aims to induce apical closure in immature, non-vital teeth with open apices, facilitating periapical healing and root development. Traditional methods, while effective, can be time-consuming and unpredictable. This case series evaluates the use of recombinant human platelet-derived growth factor (rhPDGF) combined with beta tricalcium phosphate (β-TCP) as a novel apical barrier in apexification procedures. A 9-month follow-up was conducted to assess clinical outcomes and periapical healing. two patients presenting with immature non-vital teeth and open apices were treated using rhPDGF and β-TCP as an apical barrier and MTA was all so placed. After thorough debridement and disinfection of the root canal system, a mixture of rhPDGF and β-TCP was placed at the apical region to stimulate bone formation and induce apical closure followed by mta was placed. Radiographs were taken pre-operatively, immediately post-operatively, and at 9 months to evaluate apical barrier formation and periapical healing.All treated cases demonstrated favorable clinical and radiographic outcomes at the 9-month follow-up. Radiographs revealed substantial apical bone regeneration with clear evidence of apical closure. No patients exhibited signs of infection, pain, or complications during the follow-up period. The use of rhPDGF and β-TCP consistently promoted the formation of a functional apical barrier and periapical tissue healing, providing a biologically favorable environment for root-end closure.

Keywords: Apexification, Recombinant human platelet-derived growth factor, Beta tricalcium phosphate, Apical barrier, Periapical healing, Open apex.

INTRODUCTION

Apexification is a well-established endodontic procedure aimed at inducing apical closure in non-vital immature teeth with open apices. Traditional techniques often rely on calcium hydroxide to stimulate hard tissue formation over extended treatment periods, sometimes taking several months, which increases the risk of reinfection, tooth fracture, and patient non-compliance[1]. More recently, mineral trioxide aggregate (MTA) has gained popularity due to its ability to create a robust apical plug in a single visit[2]. However, MTA has certain limitations, including handling difficulties, extended setting times, and the potential for tooth discoloration[3]. To overcome these challenges, recent research has explored bioactive materials for enhancing apexification outcomes. One promising alternative is the combination of recombinant human platelet-derived growth factor (rhPDGF) and beta tricalcium phosphate (β-TCP) as an apical barrier material. This approach not only promotes periapical healing but also supports bone regeneration[4]. rhPDGF stimulates cellular proliferation, angiogenesis, and tissue regeneration (Rios et al., 2016), while β-TCP acts as an osteoconductive scaffold that facilitates new bone formation and gradually resorbs over time[5]. When used together, these materials create an optimal environment for accelerated apical barrier formation and tissue healing[6]. The technique outlined in this case series uses rhPDGF and β-TCP as an apical barrier, offering a more predictable and efficient alternative to traditional calcium hydroxide-based apexification. Compared to MTA, this combination has been shown to enhance bone regeneration and reduce treatment time, providing better long-term outcomes[7]. In this series, clinical and radiographic outcomes at a 9-month follow-up demonstrate significant bone regeneration and successful apical closure, supporting this technique as a superior option for apexification. This case series contributes to the growing body of evidence favoring the use of bioactive materials, such as rhPDGF and β-TCP, for endodontic procedures. These findings suggest that this approach may represent the future of regenerative endodontics, offering improved patient outcomes and more predictable results.

Case no 1: A 24-year-old patient presented with a non-vital, immature tooth no. 21 (upper left central incisor) due to trauma. The patient reported mild discomfort, and clinical examination revealed a necrotic pulp and an open apex. Radiographs showed a periapical radiolucency with incomplete root development. Apexification using recombinant human platelet-derived growth factor (rhPDGF) combined with beta tricalcium phosphate (β-TCP) as an apical barrier, followed by mineral trioxide aggregate (MTA) placement and obturation of the root canal system.

Anesthesia and Isolation:

- Local anesthesia was administered to ensure patient comfort.
- Tooth no. 21 was isolated using a rubber dam to prevent contamination during the procedure.

Access Cavity Preparation:

- A conventional endodontic access cavity was prepared using a high-speed handpiece and sterile diamond burs.

- The canal was thoroughly explored, and working length determination was performed using an apex locator and confirmed with a periapical radiograph.

Canal Debridement and Disinfection:

- The canal was cleaned using copious irrigation with 2.5% sodium hypochlorite (NaOCl) to disinfect the root canal system.
- Minimal mechanical instrumentation was done to prevent weakening of the thin dentinal walls of the immature root.
- Final irrigation was done with saline, followed by 17% EDTA to remove the smear layer, and then dried using paper points.

Placement of rhPDGF and β-TCP as Apical Barrier:

- A pre-prepared mixture of recombinant human platelet-derived growth factor (rhPDGF) and beta tricalcium phosphate (β-TCP) was carefully inserted into the apical third of the root canal using a sterile carrier instrument.
- The material was gently condensed at the apical area, ensuring that it formed a stable barrier of approximately 3–5 mm at the apex, providing a matrix for new tissue growth.
- A radiograph was taken to verify the proper placement of the apical barrier.

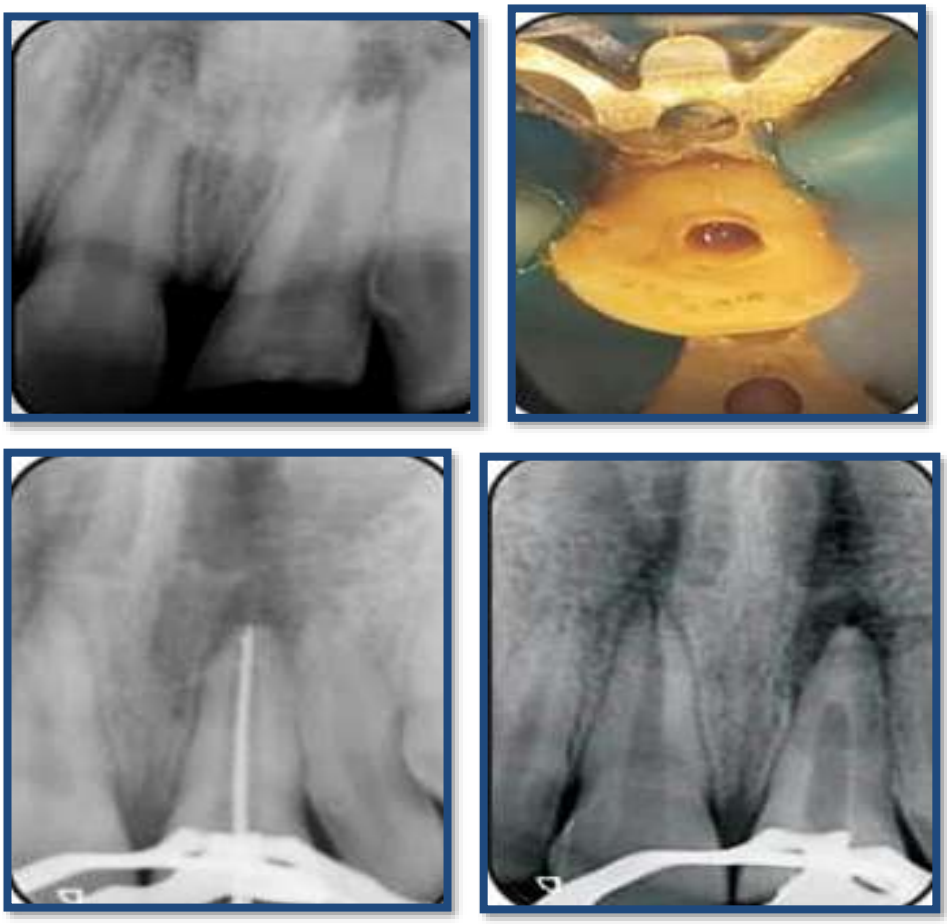
MTA Placement:

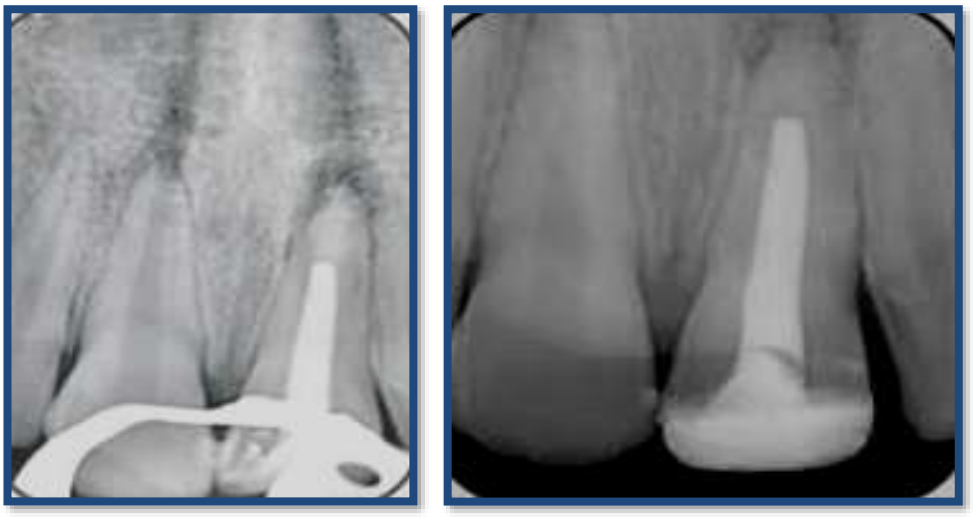
- Once the rhPDGF/β-TCP apical barrier was confirmed radiographically, mineral trioxide aggregate (MTA) was mixed according to manufacturer instructions and placed over the barrier.
- The MTA was condensed using hand pluggers to form a 3–4 mm layer over the apical barrier material.
- A moist cotton pellet was placed in the canal to allow the MTA to set, and the tooth was temporarily restored using a temporary filling material.

Follow-up:

- At the next appointment, after confirming the set of the MTA, the temporary restoration was removed.
- The canal was inspected, and radiographs confirmed the apical barrier and proper setting of the MTA.The remaining canal space was obturated using a warm vertical compaction technique with gutta-percha and a resin-based root canal sealer.A radiograph was taken to confirm the complete and proper obturation of the canal. The access cavity was sealed with a permanent composite restoration to ensure coronal seal and prevent bacterial re-entry.The patient was advised on post-operative care and scheduled for regular follow-up appointments At the 9-month follow-up, the patient reported no symptoms, and clinical examination revealed normal function of tooth no. 21, with no signs of discomfort or tenderness.Radiographic examination showed complete resolution of the periapical radiolucency, with evidence of significant periapical bone regeneration and apical closure.The rhPDGF and β-TCP combination promoted effective tissue regeneration, while the MTA provided a durable apical sealThe apexification procedure was successful, with

tooth no. 21 exhibiting a positive clinical and radiographic response. The use of rhPDGF and β-TCP as an apical barrier followed by MTA placement facilitated rapid and predictable apical closure, bone regeneration, and long-term stability of the treated tooth.This procedure emphasizes the integration of bioactive materials (rhPDGF and β-TCP) with MTA to enhance tissue regeneration and ensure successful outcomes in apexification.





1)Pre operative radiograph 2) access opening 3)working leanth

4) After placing growth factor, b-tcp and mta 5) after obturation 6) 9 months followup

- **RECONSTITUTION OF GROWTH FACTOR**
- Reconstitution of 10 microgram of powder growth factor with 100 Micro-leter of distilled water to make concentration of 0.1 microgram per ml by Centrifuge with 1000 rpm per minute. Solution was Stored in 17 diffrent micro pipets at -20 ° with 6 ml each andremaining 2 pipet with 5 ml (FIG-2).

1)centrifuge of growth factor 2)10 microgram rh-PDGF powder 3)storage in micropipets

Case no 2 : Patient History: A 24-year-old patient presented with non-vital, immature tooth no. 11 (upper right central incisor) and tooth no. 12 (upper right lateral incisor) due to previous trauma root canal treatment was already completed. Clinical examination revealed tender on percussion in both teeth, with tooth no. 11 having an open apex, and radiographs confirmed periapical radiolucency for tooth no. 11 and a mature, closed apex in tooth no. 12.

Treatment Plan:

- Apexification for tooth no. 11 using recombinant human platelet-derived growth factor (rhPDGF) and beta tricalcium phosphate (β-TCP) as an apical barrier, followed by mineral trioxide aggregate (MTA) placement and root canal obturation.
- Standard re- root canal treatment and obturation for tooth no. 12.

Step-by-Step Procedure:

Anesthesia and Isolation:
- Local anesthesia was administered for patient comfort.
- Teeth nos. 11 and 12 were isolated using a rubber dam to maintain a sterile environment.

Access Cavity Preparation:
- A conventional access cavity was prepared on tooth no. 11 using sterile diamond burs.old gutta percha is removed
- Working length determination was performed using an apex locator and confirmed radiographically.

Canal Debridement and Disinfection:
- The root canal system of tooth no. 11 was thoroughly irrigated with 2.5% sodium hypochlorite (NaOCl) to disinfect the canal.
- Minimal mechanical instrumentation was done to preserve the fragile dentinal walls of the immature tooth.
- Final irrigation with 17% EDTA was performed to remove the smear layer, followed by saline, and the canal was dried with sterile paper points.

Placement of rhPDGF and β-TCP as Apical Barrier:
- A mixture of recombinant human platelet-derived growth factor (rhPDGF) and beta tricalcium phosphate (β-TCP) was introduced into the apical third of the root canal using a sterile carrier.
- The mixture was condensed to form a 3–5 mm apical barrier, providing a matrix to promote bone and tissue regeneration.
- A radiograph was taken to confirm the accurate placement of the apical barrier.

MTA Placement:
- After confirming the proper placement of the apical barrier, mineral trioxide aggregate (MTA) was mixed and placed over the rhPDGF/β-TCP barrier.
- The MTA was condensed with hand pluggers to form a 3–4 mm layer over the barrier.
- A moist cotton pellet was placed inside the canal to allow the MTA to set, and the tooth was temporarily restored with a temporary filling material.

Follow-up (After 1 Week):
- One week later, the temporary filling was removed, and the set of the MTA was verified.
- Radiographs confirmed proper MTA placement.

Root Canal Obturation:

- The remaining root canal space was obturated using gutta-percha and a resin-based sealer via the warm vertical compaction technique.
- A final radiograph was taken to verify the obturation.
- Tooth no 12 is obturated using single cone technique.

Final Restoration:

- The access cavity of tooth no. 11 was sealed with a permanent composite restoration to ensure a tight coronal seal.

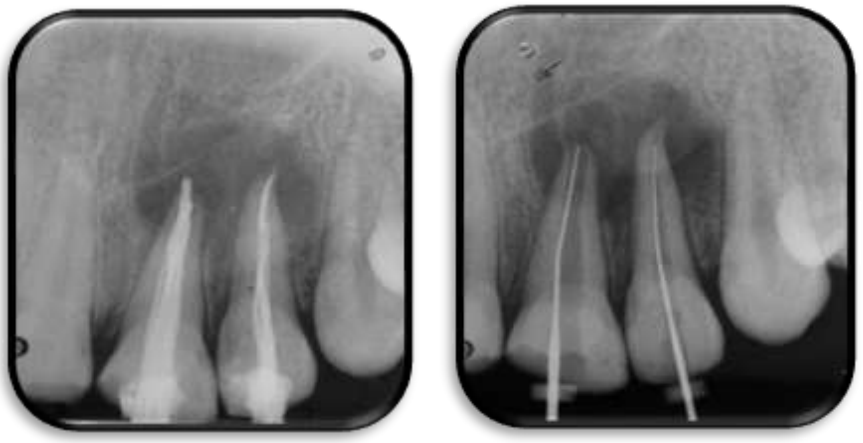
Follow-Up:

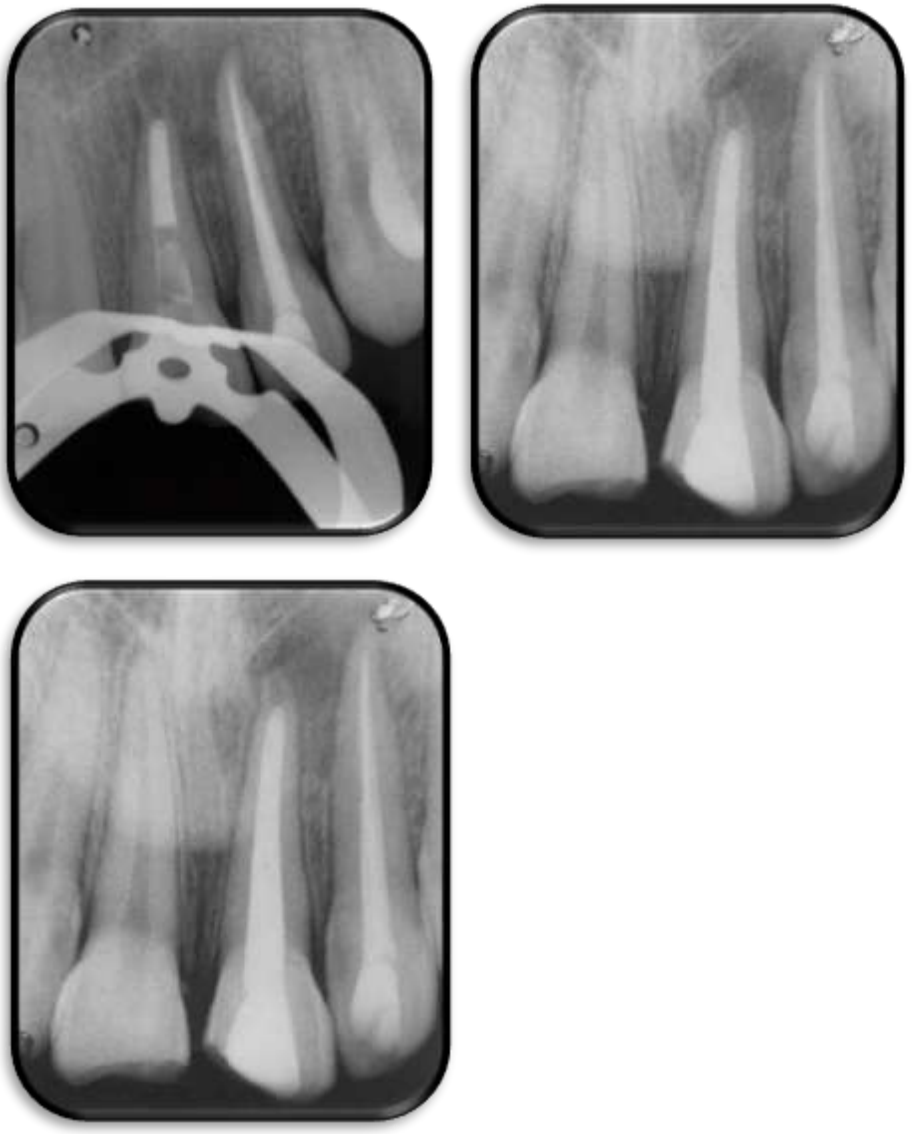
9-Month Follow-Up:

- At the 9-month follow-up, both teeth nos. 11 and 12 exhibited positive clinical outcomes, with no signs of discomfort or infection.
- Radiographically, tooth no. 11 showed significant periapical bone regeneration and complete apical closure, confirming the success of the rhPDGF/β-TCP and MTA apexification procedure.
- Tooth no. 12 showed normal healing and stable periapical tissues with no pathological findings.

OUTCOME:

The treatment of tooth no. 11 using rhPDGF and β-TCP for apexification, followed by MTA and successful obturation, resulted in complete apical closure and periapical bone healing. Tooth no. 12, which underwent standard root canal treatment, also showed excellent healing and restoration success. Both teeth were symptom-free and fully functional at the 9-month follow-up.This procedure outlines the dual approach for treating both tooth no. 11 with apexification and tooth no. 12 with standard root canal treatment.





1)Pre operative 2)working lenth 3) growth factor ,b-tcp and mta placement

4)after obturation 5) after 9 months followup

DISCUSSION

The cases presented demonstrate successful management of an immature tooth (tooth no. 11) with an open apex through apexification using recombinant human platelet-derived growth factor (rhPDGF) and beta tricalcium phosphate (β-TCP), followed by mineral trioxide aggregate (MTA), alongside a routine root canal treatment for a mature tooth (tooth no. 12). The combination of these materials has proven effective in promoting apical closure and

periapical healing, offering a promising alternative to traditional methods like calcium hydroxide apexification or MTA alone.

Apexification in Tooth No. 11: Apexification traditionally relies on calcium hydroxide to stimulate hard tissue formation at the root apex, but this approach requires multiple visits over a prolonged period, often taking several months to years to achieve full closure (Sheehy & Roberts, 2020). The long treatment duration increases the risk of reinfection and tooth fracture, making it less predictable in some cases (Sheehy & Roberts, 2020). MTA has become the gold standard for apical barrier formation due to its high sealing ability and biocompatibility (Torabinejad et al., 2011); however, even with MTA, achieving rapid and robust bone regeneration remains a challenge (Ravichandra et al., 2020).

In this case, the use of rhPDGF and β-TCP as the apical barrier provided several advantages. rhPDGF is known to enhance cellular proliferation, promote angiogenesis, and facilitate wound healing, which are critical processes for tissue regeneration in the periapical region (Rios et al., 2016). β-TCP, on the other hand, served as an osteoconductive scaffold, supporting the growth of new bone and gradually resorbing over time (Agarwal et al., 2021). Together, these materials create a bioactive environment conducive to faster bone formation and apical closure.

The clinical and radiographic results from the 9-month follow-up demonstrated significant bone regeneration and complete closure of the apex in tooth no. 11. The rhPDGF/β-TCP combination likely accelerated the healing process, as seen by the resolution of the periapical radiolucency, which corroborates findings from other studies on the regenerative potential of bioactive materials in endodontic procedures (Schmitt et al., 2021).

Role of MTA: Following the placement of the rhPDGF/β-TCP barrier, MTA was placed over the apical barrier. MTA is widely recognized for its excellent sealing properties, biocompatibility, and ability to set in the presence of moisture, making it an ideal material for use in apexification and regenerative procedures (Torabinejad & Parirokh, 2010). In this case, MTA provided a durable seal, ensuring that the regenerative process initiated by the rhPDGF/β-TCP was well-supported by a stable apical barrier.

The combination of rhPDGF, β-TCP, and MTA offers a robust and predictable treatment approach, addressing the limitations of conventional apexification techniques (Ravichandra et al., 2020). Recent literature supports the use of bioactive materials for enhanced healing and reduced treatment times in cases of immature teeth with open apices (Nevins et al., 2020). The positive outcomes in tooth no. 11 highlight the efficacy of this approach in clinical practice, demonstrating rapid periapical healing and root-end closure without the need for prolonged calcium hydroxide therapy.

Root Canal Treatment in Tooth No. 12: Tooth no. 12, with a closed apex, was treated with standard root canal therapy. The mature root allowed for conventional obturation with gutta-percha and sealer. Radiographic and clinical results at the 9-month follow-up showed normal healing of the periapical tissues, with no signs of reinfection or inflammation. The predictable nature of routine root canal therapy in mature teeth underscores its effectiveness when proper debridement, disinfection, and obturation techniques are followed (Ng et al., 2011).

The comparison between teeth nos. 11 and 12 demonstrates the need for different approaches in managing immature versus mature teeth. While tooth no. 12 followed a conventional treatment path, the innovative use of bioactive materials in tooth no. 11 was crucial in achieving successful apexification, highlighting the versatility of modern endodontic materials in diverse clinical scenarios.

CONCLUSION

The use of rhPDGF and β-TCP in apexification procedures represents a significant advancement in regenerative endodontics. This case series shows that bioactive materials can enhance tissue healing, reduce treatment time, and improve clinical outcomes, as evidenced by the complete apical closure and bone regeneration. These cases suggest that bioactive materials like rhPDGF and β-TCP should be considered for cases involving immature teeth with open apices, providing a predictable and efficient alternative to traditional techniques.

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