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*Case Report*

# Regenerative endodontic therapy assisted by a concentrated growth factor scaffold for bilateral symmetrical dens evaginatus fractures in permanent teeth: a case report

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**Abstract:** Objective: To evaluate the therapeutic efficacy and long-term outcomes of regenerative endodontic therapy (RET) assisted by a concentrated growth factor (CGF) scaffold in the management of chronic apical periodontitis associated with pulp necrosis of immature permanent teeth caused by bilateral apical fractures. Methods: A 10-year-old girl presented with bilateral mandibular second premolars (teeth #35 and #45) complicated with chronic periapical periodontitis secondary to apical fractures. At the first visit, infection control was achieved through debridement and root canal preparation, after which a calcium hydroxide dressing was placed. At the second visit, tooth #35 underwent RET using an induced blood clot as a scaffold, with the canal sealed by mineral trioxide aggregate (MTA). Tooth #45 received RET using CGF gel prepared from autologous venous blood as a scaffold, and the canal orifice was sealed with the bioceramic material iRoot BP Plus. Both teeth were restored with resin. Postoperative follow-ups were conducted at 2, 6, 12, and 24 months, as well as at 3-5 years. Results: Both teeth demonstrated resolution of periapical radiolucency, progressive periapical healing, and continued root development. Complete root canal calcification was observed in tooth #35 within 3-5 years. In tooth 45, calcification and apical development within the root canal were observed at 6 months, with fusion occurring after 1 year, and complete canal closure by 4-5 years. Throughout the follow-up period, both teeth remained asymptomatic and functional. Conclusion: RET assisted by a CGF scaffold effectively controlled infection, promoted root wall thickening, and facilitated continued root development, offering advantages over conventional apexification and apical barrier techniques. This case highlights the potential clinical value of CGF as a bioactive scaffold in managing pulp necrosis of immature permanent teeth associated with apical deformities.

**Keywords:** Regenerative endodontic treatment, bilateral symmetrical dens evaginatus fracture, immature permanent teeth, concentrated growth factor, independent apical development

## Introduction

Dens evaginatus (DE) is a developmental dental anomaly with a relatively high prevalence in Asian populations, reported at approximately 1.2% [1, 2]. It is characterized by an accessory tubercle on the occlusal surface of the affected tooth. This tubercle is susceptible to attrition or fracture, which may lead to dentin exposure or pulp infection, resulting in pulpitis, periapical disease, or abscess formation [3, 4]. Traditional approaches such as apexification and apical barrier techniques can achieve apical closure through hard tissue deposition; however, they do not support continued root development. Consequently, these methods often leave thin, fragile canal walls, predisposing teeth to root fractures and compromising long-term prognosis [5, 6].

Regenerative endodontic therapy (RET) is an innovative approach that utilizes endogenous stem cells and biological scaffolds to promote apical development, root wall thickening, and apical closure. RET has demonstrated higher clinical success and survival rates compared to conventional apexification [7, 8]. Concentrated growth factor (CGF), a novel platelet-derived

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**Table 1.** Comparison of clinical and radiographic parameters of the two teeth at baseline

| Tooth | Periapical radiolucency diameter (mm) | Lesion location | Apex development (Nolla stage) | Root canal morphology | Root length (mm) | Adjacent tooth toot length (mm) | Difference in length from adjacent tooth (mm) |
|---|---|---|---|---|---|---|---|
| #35 | 2.5 | Periapical | Open (Stage 9) | Not enlarged | 17.2 | 18.5 | -1.3 |
| #45 | 3.8 | Apical and distal (more extensive) | Open (Stage 8) | Markedly enlarged | 15.6 | 18.7 | -3.1 |

scaffold, provides a dense fibrin matrix with sustained release of multiple growth factors. Previous studies have shown that CGF can continuously release bioactive molecules such as transforming growth factor-β1 (TGF-β1), platelet-derived growth factor-AB (PDGF-AB), insulin-like growth factor-1 (IGF-1), and vascular endothelial growth factor (VEGF), thereby facilitating stem cell adhesion, proliferation, and differentiation [9]. Compared with platelet-rich plasma (PRP), CGF exhibits superior release kinetics and greater stability, making it a promising alternative to overcome the limitation of blood clot scaffolds in pulp regeneration, particularly in cases with large open apices [10].

Although RET has been studied in immature teeth, clinical reports specifically addressing bilaterally symmetrical cases of dens evaginatus (DE) remain limited. This case report presents a 10-year-old girl with bilateral symmetrical DE fractures of the mandibular second premolars, complicated by chronic apical periodontitis. For the first time, RET was performed using a CGF scaffold in combination with bioactive materials. Clinical and radiographic evaluations were conducted over a five-year follow-up period to systematically evaluate periapical healing and root development. This case provides evidence-based support and technical insight for the conservative management of similar developmental anomalies.

## Case

A 10-year-old female elementary school student presented on May 12, 2018, with the chief complaint of "pain in the left lower posterior tooth for one week". History of present illness: One week earlier, spontaneous and occlusal pain developed in the left lower posterior tooth after biting a hard object. The pain was mild, without severe intensity, nocturnal exacerbation, or fever. The patient also reported previous transient episodes of spontaneous pain that resolved without medical intervention. Medical history: The patient was generally healthy, with no history of drug allergies, systemic diseases, or hereditary disorders.

Clinical examination: Extraoral examination revealed facial symmetry, a maximal interincisal opening of approximately three finger breadths, no deviation on opening, and no palpable lymphadenopathy. Intraoral examination showed a mixed dentition with good oral hygiene and no obvious carious lesions. Tooth #35 was fully erupted, exhibiting a characteristic "target-shaped" fracture on the occlusal surface. The tooth was percussion-sensitive and displayed Grade I mobility. The surrounding mucosa appeared normal, without erythema, swelling, or sinus tract formation. Tenderness was elicited on apical palpation. The contralateral tooth #45 also exhibited a similar target-shaped fracture but was percussion-negative, showed no mobility, and had normal gingival tissue. Radiographic findings and treatment plan: Panoramic radiography revealed widening of the periodontal ligament space around tooth #35, with a periapical radiolucency measuring approximately 2.5 mm in diameter. The apex remained open (Nolla stage 9), and the root length was about 17.2 mm, slightly shorter than that of the adjacent tooth (approximately 18.5 mm). For tooth #45, a larger periapical radiolucency was observed at the apical and distal root regions, measuring approximately 3.8 mm in diameter. The root canal appeared markedly wide, the apex was open (Nolla stage 8), and the root length was 15.6 mm, significantly shorter than that of the adjacent tooth (approximately 18.7 mm). Baseline comparison indicated that tooth #35 was relatively more mature, with root length closer to that of its adjacent tooth and a smaller lesion, whereas tooth #45 exhibited less root development and a larger periapical lesion. Detailed measurements are presented in **Table 1** and **Figure 1**. The final diagnosis was bilateral DE fractures of teeth #35 and #45, complicated by chronic apical periodontitis. The treatment plan prioritized RET with pulp revascularization. If unsuccessful, apexification or apical barrier tech-

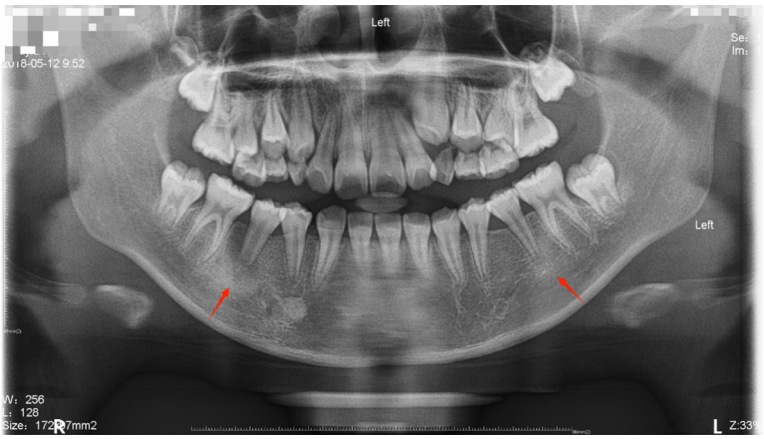


**Figure 1.** Panoramic radiograph.

niques would be considered, with extraction reserved as a last resort. Alternatively, apexification or apical barrier procedures could be performed initially, with extraction considered if outcomes proved unfavorable. Treatment procedures and outcomes: With parental consent, tooth #35 was treated first. At the initial visit, under rubber dam isolation and local anesthesia with 4% articaine, conventional access cavity preparation and pulp exposure were performed. The canal was gently irrigated with 20 mL of 1.5% sodium hypochlorite, followed by 17% EDTA and saline, up to 1 mm short of the apex. After removal of the infected tissue, the canal was dried with paper points and medicated with calcium hydroxide. At the second visit (two weeks later), under rubber dam isolation and local anesthesia with 3% mepivacaine, the calcium hydroxide was removed. The canal was irrigated, dried, and mechanically stimulated with a file to stimulate apical bleeding. The canal was filled with blood up to 1-2 mm below the enamel-dentinal junction and let to allow clot formation. Mineral trioxide aggregate (MTA) was then mixed and placed as an apical barrier, followed by root canal obturation and composite resin restoration. Two months later, the patient requested treatment for tooth #45, which was confirmed to meet the same indications. The initial visit followed the same protocol of irrigation, canal preparation, and intracanal medication. At the second visit, after thorough irrigation, venous blood was collected and centrifuged to prepare the CGF gel. The gel was cut into small fragments and placed into the root canal up to 1-2 mm below the enamel-dentinal junction. Bioceramic material (iRoot BP Plus) was placed above the scaffold to seal the canal orifice, followed by permanent resin restoration. Postoperative periapical radiographs were obtained, and the procedure was completed uneventfully (**Figure 2**). Follow-up findings: Both teeth (#35 and #45) demonstrated favorable healing and progressive root development. For tooth #35, complete resolution of the periapical radiolucency was observed at 2 months, with apical constriction evident at 6 months. By 1 year, calcification appeared in the apical third of the canal, which continued to progress at 2 years. Complete canal closure was achieved between 3 and 5 years (**Figure 3**). For tooth #45, periapical rediolucency had subsided and calcification began in the middle third of the canal at 6 months, accompanied by independent apical development. At 1 year, the calcified region expanded, and the independently developed apical segment fused with the main root. Between 2 and 3 years, progressive calcification was observed, and the root length reached parity with adjacent teeth. By 4-5 years, complete canal calcification was achieved (**Figure 4**).

## Discussion

DE is a developmental dental anomaly characterized by an occlusal tubercle containing pulp tissue. This structure is fragile and prone to fracture under occlusal forces, resulting in pulp exposure and subsequent infection. Although pulp exposure may remain asymptomatic for extended periods, it often progresses to apical periodontitis or cyst formation. Traditional treatments for immature permanent teeth with pulp necrosis have relied on apexification using calcium hydroxide or apical barrier techniques with MTA. These approaches aim to induce hard tissue barrier formation at the apex. In a study involving 115 immature necrotic permanent teeth (71 due to trauma and 44 associated with DE), calcium hydroxide apexification achieved a success rate of 74.8% and a periapical healing rate of 69.6%. However, this approach requires prolonged treatment with

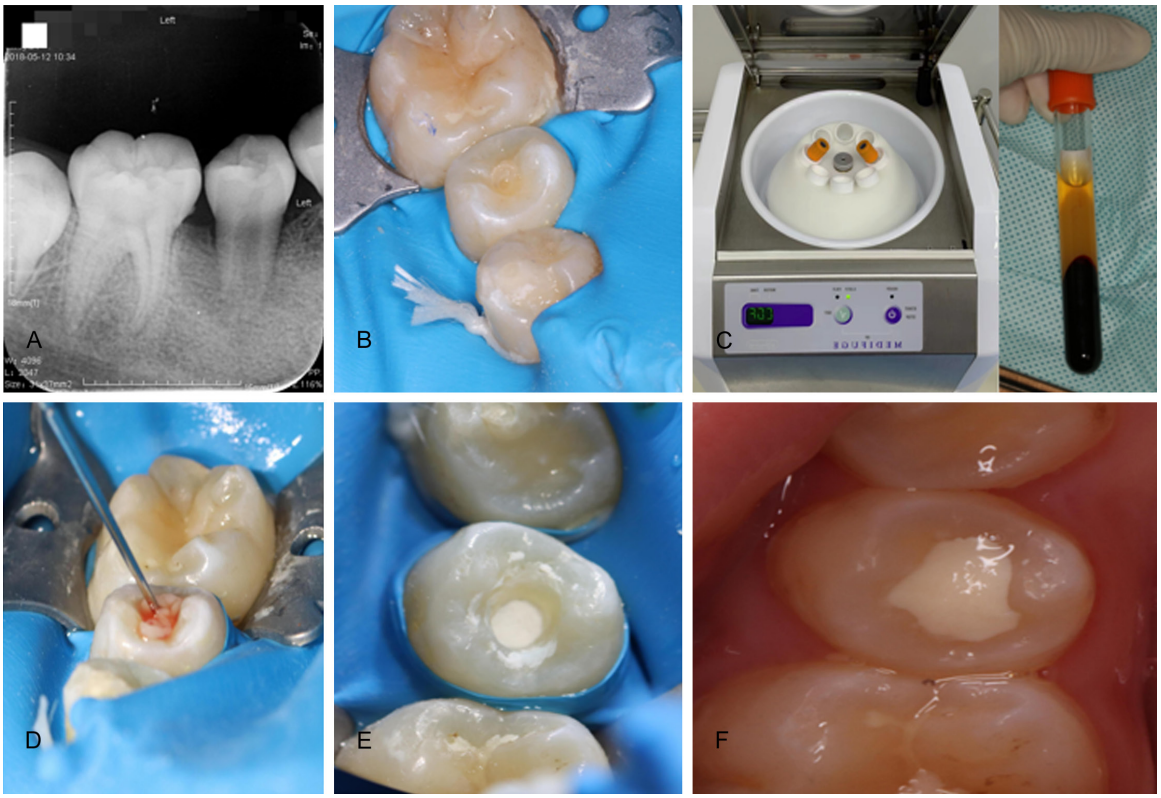


**Figure 2.** Clinical procedure of regenerative endodontic therapy. A. Preoperative image of the affected tooth; B. Access cavity preparation under local anesthesia with rubber dam isolation; C. Centrifugation of autologous blood to prepare CGF gel; D. Placement of CGF scaffold into the root canal; E. Placement of iRoot BP Plus; F. Temporary restoration of the access cavity. Note: CGF, concentrated growth factor.

multiple follow-up visits. Moreover, long-term calcium hydroxide application can weaken dentin, significantly increasing the risk of root fracture. It may also result in porous or irregular apical barriers, thereby compromising the long-term sealing efficacy [11]. Yoshpe et al. reported that MTA apexification significantly enhances root fracture resistance, with clinical success rates comparable to those achieved with calcium hydroxide. However, MTA does not facilitate continued root development, leaving unresolved concerns such as thin dentinal walls and shortened roots. Moreover, there remains a risk of material extrusion, particularly in cases without a natural apical barrier, which underscores the importance of meticulous hemostasis management [12].

RET, which leverages stem cells and biological scaffolds to promote root development and apical closure, is regarded as a more favorable treatment option. Pereira et al. found that RET achieves a complete healing rate of approximately 95%, significantly higher than the 86% reported with traditional apexification [8]. In addition, RET promotes dentinal wall thickening and root canal widening, thereby enhancing root strength. In cases of DE, RET has demonstrated superior root development compared with calcium hydroxide apexification, including greater increases in root surface area and more complete apical constriction [13].

A critical step in RET is establishing a scaffold within the root canal to support tissue regeneration. Inducing apical bleeding to form a blood clot is commonly employed as a natural scaffold; however, in some cases, adequate bleeding cannot be achieved, resulting in poor-quality clot formation. To overcome this limitation, autologous platelet concentrates such as platelet-rich plasma (PRP), platelet-rich fibrin (PRF), and concentrated growth factor (CGF) have been introduced as alternative scaffolds, providing greater stability and a reservoir of growth factors. PRF can release growth factors

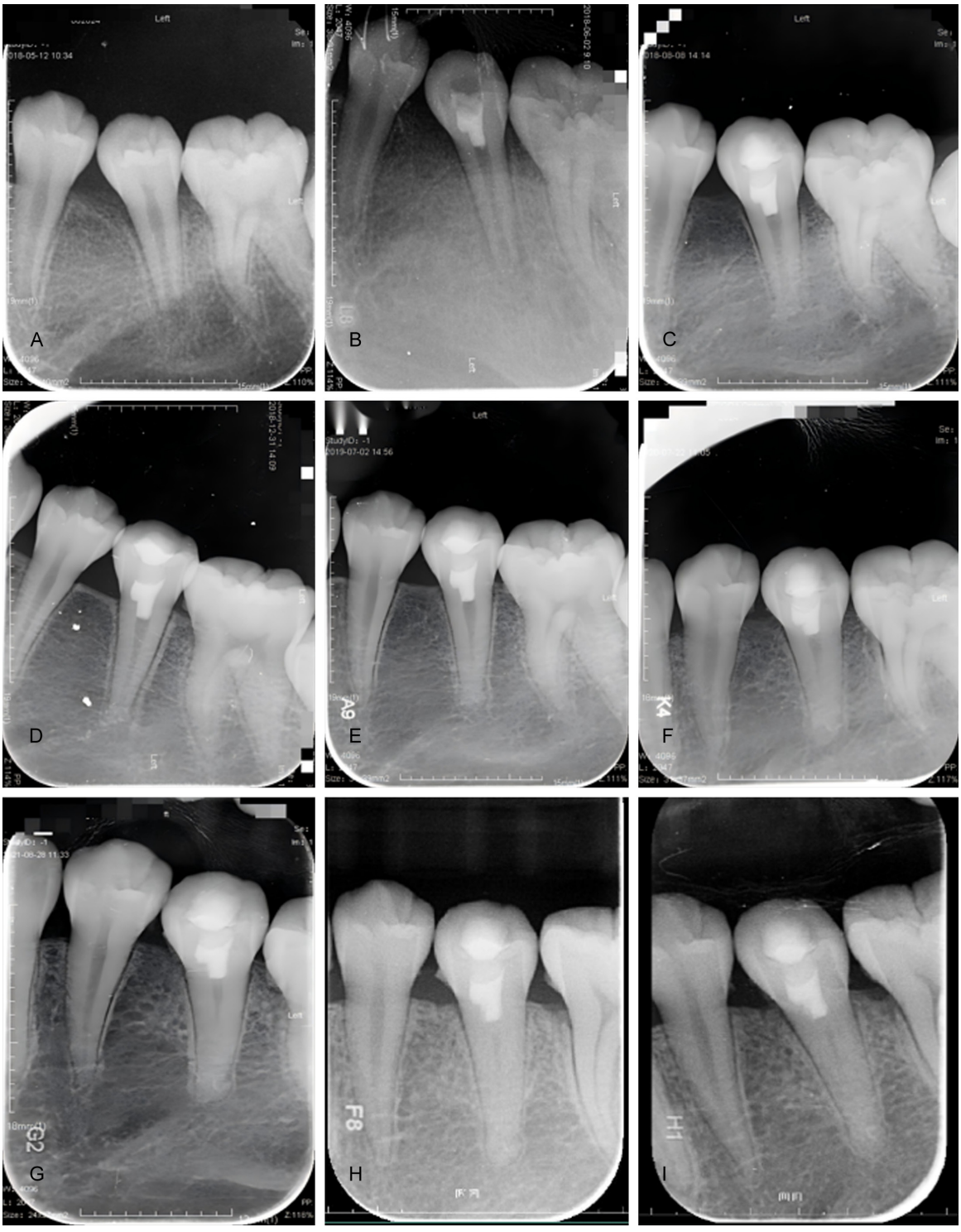


**Figure 3.** Radiographic follow-up of tooth #35. A. Preoperative image. B. Immediate postoperative: Periapical radiolucency at the apex remains. C. Two months postoperatively: Periapical radiolucency resolved. D. Six months postoperatively: Apical constriction observed, root canal narrowed. E. One year postoperatively: The apical one-third of the root canal shows calcification. F. Two years postoperatively: Continued calcification, with the apical half of the root canal increasingly obliterated. G. Three years postoperatively: Progressive root canal calcification. H. Four years postoperatively: Complete canal calcification, root length approaching that of the adjacent teeth. I. Five years postoperatively: Full canal calcification, root length comparable to adjacent teeth.

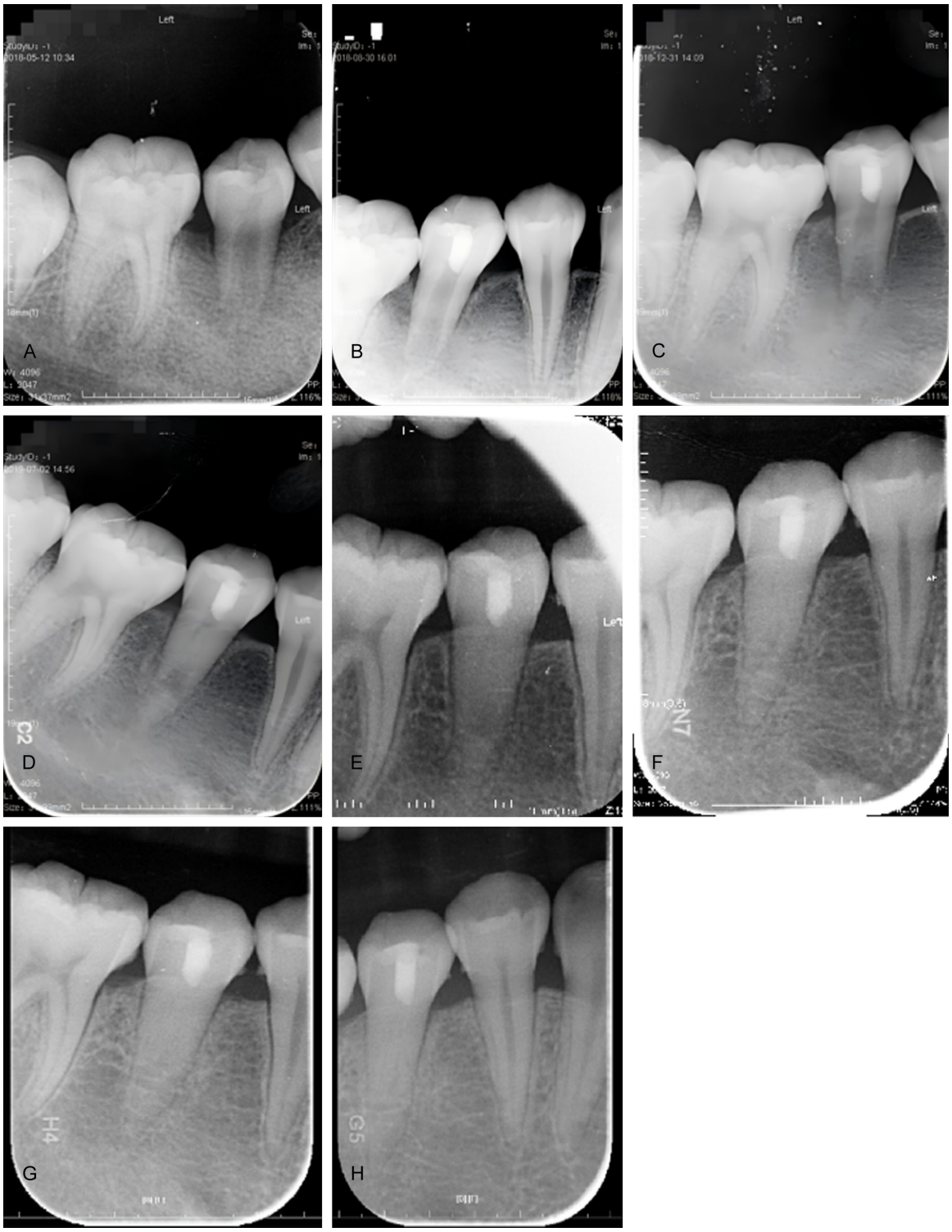


**Figure 4.** Radiographic follow-up of tooth #45. A. Preoperative image. B. Immediate postoperative: The shadow at the root tip has not completely disappeared. C. Six months postoperatively: Periapical radiolucency resolved; apical segment and main root developed independently, with calcification observed in the middle section of the main root canal. D. One year postoperatively: Increased calcification in the root; root canal image becomes blurred, and the independently developed apical segment fuses with the main root. E. Two years postoperatively: Progressive root canal calcification; the previously independent apical segment is now continuous with the main root. F. Three years postoperatively: Continued canal calcification; root length comparable to adjacent teeth. G. Four years postoperatively: Complete root canal calcification. H. Five years postoperatively: Persistent complete root canal calcification.

continuously over approximately 7 to 14 days, while CGF, produced through variable-speed centrifugation, generates a dense fibrin matrix without the need for additives. CGF is enriched with platelets and leukocytes and contains high levels of bioactive factors such as PDGF, TGF-β1, IGF-1, VEGF, and bFGF, which promote cell proliferation, differentiation, and angiogenesis. Clinical studies using CGF as a scaffold in place of blood clots for pulp regeneration in immature permanent teeth have demonstrated favorable outcomes in pulp regeneration, periapical healing, and root development. Moreover, compared with PRF, CGF may provide superior support for continued root maturation and periapical tissue repair [14].

After debridement and disinfection, a blood clot (tooth #35) and CGF gel (tooth #45) were used as scaffolds for the two symmetrical teeth at the subsequent visit. Approximately 3-4 mm of MTA for tooth #35 or iRoot BP Plus for tooth #45 was then placed over the scaffold to seal the root canal. Following diagnosis and treatment, the two teeth were compared to evaluate the therapeutic effect. During follow-up, the calcification pattern of tooth #45 differed from that of tooth #35. Specifically, calcification in tooth #45 initially appeared in the middle third of the canal, accompanied by the development and eventual fusion of an independent apical segment. This phenomenon may be attributable to the unique biological properties of CGF. Compared with blood clots, CGF has a denser fibrin network and can continuously release multiple growth factors, including TGF-β1, PDGF-AB, IGF-1, and VEGF, thereby providing a more stable microenvironment for the adhesion, proliferation, and differentiation of apical papilla stem cells. The enhanced scaffold stability and sustained signaling likely contributed to a tissue regeneration pattern distinct from that observed with blood clots, explaining the observed middle-canal calcification and independent apical development in tooth #45.

During the five-year follow-up, both treated teeth demonstrated favorable healing and continued root development. Clinical symptoms resolved within several months postoperatively, accompanied by the disappearance of periapical radiolucency. Radiographic assessment at 6-12 months revealed apical constriction and the formation of new hard tissue. Progressive root elongation and canal wall thickening were subsequently observed, with complete apical closure and canal obliteration by calcified tissue achieved between 3 and 5 years. Root canal calcification following RET reflects the deposition of bone-like or dentin-like tissue. Unlike conventional apexification, RET enables treated teeth to attain normal root length with thickened canal walls. Previous reports using CGF scaffolds have similarly reported apical closure and canal wall thickening within one year, corroborating the regenerative outcomes observed in this case [15].

In summary, this case demonstrates that both conventional blood clot and CGF scaffold-assisted regenerative RET can be effectively applied for the management of pulp necrosis in immature permanent teeth caused by DE, with both approaches yielding favorable therapeutic effects. This treatment not only controls infection but also promotes continued root development and apical closure, supporting long-term tooth preservation. Compared to traditional apexification, RET harnesses the intrinsic regenerative potential of the tooth, avoiding the sequelae of short roots and thin canal walls. The use of autologous scaffolds such as CGF further optimizes the intracanal regenerative environment, enhances treatment predictability, and provides an alternative for teeth with limited apical bleeding. For clinical cases of pulp necrosis due to DE, RET should be considered the first-line approach, with apexification or extraction reserved as secondary options if RET is unsuccessful. Further studies are warranted to validate the long-term efficacy of RET and to refine protocols for regenerative treatment in such cases.

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## Disclosure of conflict of interest

None.

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