

Regenerating Roots: Harnessing SCAPs for Apexo Genesis in a Curiously Exposed Immature Premolar. A Case Report

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ARTICLE INFO

Received: 📅 February 04, 2026

Published: 📅 February 20, 2026

Citation: Irfana khursheed and Waseem K Burza. Regenerating Roots: Harnessing SCAPs for Apexo Genesis in a Curiously Exposed Immature Premolar. A Case Report. Biomed J Sci & Tech Res 64(5)-2026. BJSTR.MS.ID.010104.

ABSTRACT

Introduction: The management of immature permanent teeth with deep caries and pulpal involvement requires a biologically based strategy to preserve pulp vitality and allow continued root development (apexogenesis). The apical papilla, harboring a unique population of stem cells (SCAPs), is fundamental to this process. Vital pulp therapy (VPT) with tricalcium silicate-based cements like Mineral Trioxide Aggregate (MTA) promotes healing and dentin bridge formation by creating a conducive environment for stem cell activity.

Case Report: A 12-year-old girl presented with a carious exposure on her maxillary left second premolar. The tooth was vital, with symptoms indicative of irreversible pulpitis and an open apex. A partial pulpotomy was performed using MTA to preserve the radicular pulp and the apical papilla. At the 18-month follow-up, the tooth was asymptomatic. Radiographic examination confirmed continued root development, apical closure, and significant thickening of the root walls.

Conclusion: This case underscores the critical importance of preserving the vital pulp and apical papilla in immature teeth. MTA pulpotomy is a highly effective treatment that leverages the innate regenerative potential of SCAPs to achieve apexogenesis, ensuring the tooth's long-term structural integrity and health.

Keywords: Apexogenesis; Vital Pulp Therapy; Stem Cells from Apical Papilla (SCAPs); Mineral Trioxide Aggregate (MTA); Pulpotomy; Open Apex

Introduction

The management of the immature permanent tooth is a primary objective in pediatric endodontics, with the goal of facilitating the completion of root formation to achieve structural strength and a natural apical constriction. This process, known as apexogenesis, is entirely dependent on the survival of a healthy pulp and the integrity of the Hertwig's epithelial root sheath (HERS) and the apical papilla [1]. Deep carious lesions can lead to pulpal exposure and inflammation. While a diagnosis of irreversible pulpitis in a mature tooth often necessitates root canal treatment, this approach in an immature tooth halts root development, resulting in a structurally compromised tooth with a diminished long-term prognosis. Vital Pulp Therapy (VPT), specifically pulpotomy, offers a biologically conservative alternative. It involves the removal of the inflamed coronal pulp while preserving the healthy radicular pulp tissue, aiming to maintain vitality and

allow for continued root maturation [2]. The biological rationale for this approach is powerfully supported by the discovery of Stem Cells from the Apical Papilla (SCAPs) [3].

The apical papilla is not merely connective tissue but a specialized niche at the apex of developing roots, recently characterized through detailed "immunoMapping" which reveals specific stem cell markers and the presence of migration-associated structures like podosomes [4]. These SCAPs are highly proliferative, possess multilineage differentiation potential, and are responsible for root dentin formation [3,5]. The success of a pulpotomy hinges on the ability of the remaining radicular pulp and, crucially, the SCAPs within the apical papilla to respond to a biocompatible material. Tricalcium silicate-based cements like Mineral Trioxide Aggregate (MTA) create an optimal environment for healing by sealing the pulp stump, exhibiting antimicrobial properties, and releasing bioactive molecules that stim-

ulate the differentiation of stem cells into odontoblast-like cells, facilitating dentin bridge formation and continued root maturation [6,7]. This case report describes the successful apexogenesis of an immature maxillary premolar with a carious pulp exposure using a partial pulpotomy with MTA, leveraging the inherent regenerative potential of the pulp and the SCAP-rich apical papilla.

Case History

A 12-year-old girl was referred to the Department of Endodontics at the Medical City, Qassim University, with a chief complaint of pain in her upper left back tooth, especially with cold drinks. Clinical examination of the maxillary left second premolar (tooth #25) revealed a deep carious lesion.

Diagnostic Tests Were Performed

1. **Cold Vitality Test:** The tooth elicited a sharp, lingering pain upon application of Endo-Ice.

2. **Electric Pulp Test (EPT):** The tooth produced an exaggerated response at lower thresholds compared to adjacent teeth.
3. **Percussion:** The tooth was non-tender to percussion.
4. **Palpation:** No tenderness or swelling was detected in the associated buccal mucosa.
5. **Periodontal Probing:** Probing depths were within normal limits (<3mm).

A preoperative periapical radiograph (Figure 1) revealed an immature root with an open apex and divergent, thin dentinal walls. A diagnosis of Symptomatic Irreversible Pulpitis with Normal Periapical Tissues was established for tooth #25. After discussing the treatment options, including non-surgical root canal treatment (which would halt root development) and vital pulp therapy (to promote continued root maturation), informed consent was obtained from the patient's parent for a partial pulpotomy.



Figure 1: Preoperative periapical radiograph of tooth #25 showing an open apex, thin divergent dentinal walls, and a deep carious lesion approximating the pulp.

Treatment Procedure

Appointment: Under local anesthesia (2% Lidocaine with 1:80,000 epinephrine) and strict rubber dam isolation, the access cavity was prepared. All caries were removed, revealing a pulpal exposure. The inflamed coronal pulp tissue was excavated to a depth of approximately 2-3 mm using a high-speed diamond bur with copious water spray, followed by a sterile spoon excavator. Hemostasis was achieved by applying gentle pressure with sterile cotton pellets moistened with 2.5% NaOCl for 5 minutes.

Pulpotomy and MTA Placement: Once hemostasis was confirmed, white ProRoot MTA (Dentsply Sirona) was mixed according to the manufacturer's instructions and placed directly over the pulpal wound in a 2-3 mm layer (Figure 2). A moist cotton pellet was placed over the MTA, and the cavity was sealed with a temporary restorative material (Cavit).

Final Restoration: The patient was recalled after one week. She was asymptomatic, and the temporary restoration was removed. The MTA was confirmed to be set. The coronal access was then permanently restored with a glass-ionomer base and composite resin.



Figure 2: MTA placement.

Results

The patient was recalled for clinical and radiographic evaluation at 3, 6, 12, and 18 months.

Clinical Findings: At all follow-ups, the tooth was completely asymptomatic. It responded normally to cold testing (a quick, non-painful response) and was non-tender to percussion and palpation.

- Radiographic Findings: (Figures 3A-4B).
- The 6-month follow-up radiograph showed initial signs of a dentin bridge under the MTA and continued root development.

- The 12-month radiograph demonstrated evident thickening of the root walls and further apical closure.
- The 18-month radiograph confirmed the completion of root formation, with a fully formed apex, significant thickening of the root dentinal walls, and a well-defined dentin bridge. The periodontal ligament space appeared normal.

The treatment was deemed successful based on the resolution of symptoms, positive vitality response, and radiographic evidence of continued root development and apical closure.

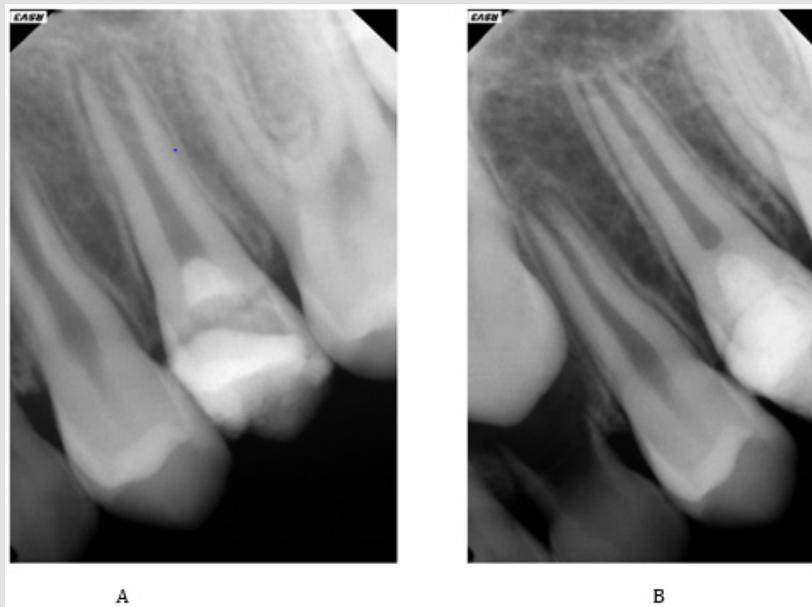


Figure 3:

- A. 3 Month Follow Up.
- B. 6-month follow-up radiograph showed initial signs of a dentin bridge under the MTA (arrow), and continued root development.

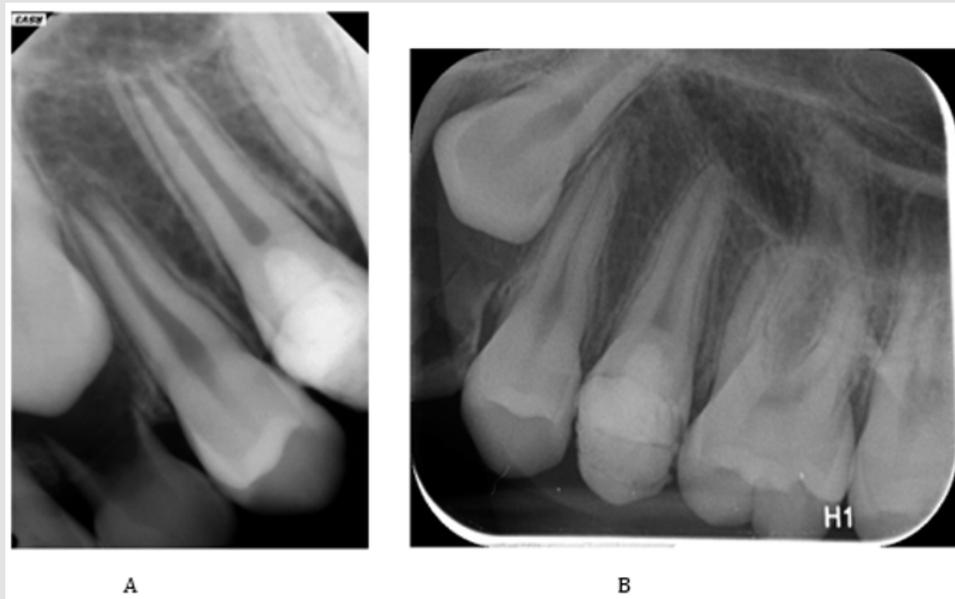


Figure 4:

- A. Twelve-month follow-up radiograph showing a dentin bridge formation (arrow), significant thickening of the root walls, and progressive apical closure.
- B. Eighteen-month follow-up radiograph demonstrating complete apical closure, further thickening of the root dentin, and a well-defined dentin bridge under the MTA.

Discussion

This case exemplifies the successful application of vital pulp therapy to achieve apexogenesis by harnessing the biological potential of the pulp-dentin complex and the apical papilla. The diagnosis of symptomatic irreversible pulpitis indicated significant inflammation confined to the coronal pulp. By performing a partial pulpotomy, the inflamed tissue was removed, while the healthy, vital radicular pulp and, most importantly, the SCAP-rich apical papilla were preserved. The role of the apical papilla as a “hidden treasure” is central to this success. Recent research has provided profound insights into its structure and function. Mavinga, et al. [4] provided a detailed Immu-Map of the apical papilla, characterizing stem cell niches that express specific markers like CD49f and SSEA4, which are associated with stemness maintenance [4]. Their work also highlighted the presence of podosome-like structures in the native tissue, suggesting an inherent capacity for cell migration and tissue remodeling that is crucial for root development [4].

Furthermore, studies have shown that SCAPs exhibit a remarkable ability to survive and maintain their proliferative advantage under physioxic (low oxygen) conditions similar to their native environment, which may explain their resilience following clinical procedures [4,6]. The choice of MTA as the capping material is supported by a robust body of evidence. Its bioactivity is well-established; upon hydration, MTA releases calcium ions and creates an alkaline environment that promotes cell recruitment, proliferation, and differ-

entiation [6]. More recent investigations into the mechanisms of MTA suggest it can influence the release of growth factors from the dentin matrix, such as TGF- β 1, further amplifying the regenerative signaling cascade [7]. This bioactive scaffold directly interacts with the underlying pulp tissue, stimulating the SCAPs and resident pulp cells to lay down a dentin bridge and continue the apposition of radicular dentin.

The findings from Palma, et al. [5] further reinforce the biological basis of our approach. Their long-term (5-year) follow-up of regenerative cases demonstrated that the apical papilla can survive and develop even in the presence of previous endodontic infection, highlighting the robustness of these stem cells [5,9]. In our vital case, by intervening before necrosis occurred, we created an even more favorable environment for the SCAPs to fulfill their physiologic role in root maturation. The continued root development and apical closure observed over 18 months are direct radiographic evidence of the vitality and functionality of the preserved pulp and apical papilla complex.

Conclusion

This case report confirms that in immature permanent teeth with vital pulps, a biologically grounded approach focused on preserving the pulp and the SCAP-rich apical papilla is the treatment of choice. A partial pulpotomy with MTA is a highly effective and predictable procedure that maintains pulp vitality and leverages the innate regenerative potential of stem cells to facilitate continued root development (apexogenesis). By understanding and utilizing the advanced biology

of the apical papilla, clinicians can ensure the long-term health, function, and structural integrity of the tooth, truly harnessing the “hidden treasure” within.

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ISSN: 2574-1241

DOI: 10.26717/BJSTR.2026.64.010104

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