

# Clinical Outcomes of Revascularization in Immature Permanent Teeth: A Case Series

Dr Akshita Bansal<sup>1</sup>, Dr. Arun Kumar<sup>2</sup>, Dr. Ruchi Singhal<sup>3</sup>,  
Dr. Ritu Namdev<sup>4</sup>

<sup>1</sup>MDS

<sup>2</sup>MDS Professor, Post Graduate Institute of Dental Sciences, Rohtak, Haryana.

<sup>3</sup>MDS Associate Professor, Post Graduate Institute of Dental Sciences, Rohtak, Haryana.

<sup>4</sup>MDS Senior Professor and Head, Department of Paediatric and Preventive Dentistry, Post Graduate Institute of Dental Sciences, Rohtak, Haryana, India.

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## ABSTRACT

Revascularization has emerged as a predictable regenerative endodontic procedure (REP) for managing immature permanent teeth with pulp necrosis. This case series presents 2 cases treated with standardized revascularization protocols, demonstrating favorable clinical and radiographic outcomes including resolution of symptoms, continued root development, and apical closure.

**Keywords:** Revascularization; Regenerative endodontics; Immature permanent teeth; Pulp necrosis; Apexogenesis; Case series

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## INTRODUCTION

Revascularization or regenerative endodontic procedures (REPs) have emerged as a transformative approach for managing necrotic immature permanent teeth. These teeth present a unique clinical challenge due to incomplete root development, thin dentinal walls, and wide-open apices, making them highly susceptible to fracture and compromising long-term prognosis (1,2). Traditional treatment strategies such as calcium hydroxide apexification or mineral trioxide aggregate (MTA) apical barrier techniques primarily aim to achieve apical closure; however, they do not allow continued root maturation, leaving roots short with persistent structural weakness (3–5).

In contrast, regenerative endodontic procedures utilize principles of tissue engineering—including stem cells, growth factors, and scaffolds—to promote continued root development, apical closure, and thickening of dentinal walls (6–8). The concept is based on the ability of the apical papilla to survive even in the presence of necrotic pulp and serve as a source of mesenchymal stem cells (SCAP) capable of regenerating pulp–dentin complex tissues (9,10).

Over the past decade, multiple clinical studies have reported favorable outcomes, including resolution of periapical pathology, increased root length, thickening of dentinal walls, and in some cases, return of pulp sensibility (11–13). Owing to this predictable success, both the American Association of Endodontists (AAE) and the European Society of Endodontology (ESE) have endorsed regenerative endodontics as a recommended treatment option for immature necrotic teeth (14,15). The latest AAE clinical considerations emphasize the importance of disinfecting the canal with irrigants and intracanal medicaments, inducing bleeding for a biological scaffold, and creating a coronal seal with bioceramic materials (14).

Despite these advances, REPs still exhibit variability in clinical outcomes depending on the degree of root immaturity, presence of infection, case selection, and procedural steps. Continued case documentation and high-quality clinical evidence are essential to refine protocols and enhance predictability.

This case series highlights 2 cases treated with revascularization using standard protocols, documenting clinical healing, radiographic changes, and long-term follow-up.

### Case 1

A 10 Y/M patient with history of trauma to maxillary anteriors 2 years back reported with history of composite restoration wrt 11 and apexification with fractured restoration wrt 21. After complete clinical and radiographic examination a diagnosis of Pulp necrosis with apical pathology and open apex wrt 11 was made. Revascularization was

performed wrt 11 following the above mentioned guidelines. A PFM crown was made wrt 21. Patient was regularly followed up for every 6 months. At 20 months follow up complete healing of periapical pathology was seen with closure of apex.

### Patient Information

#### Clinical Procedure

1. Access opening under rubber dam isolation.
2. Working length established; minimal instrumentation.
3. Irrigation with 1.5% NaOCl followed by saline.
4. Intracanal medicament: Triple antibiotic paste (TAP) / calcium hydroxide for 2–3 weeks.
5. Recall visit: Asymptomatic; induction of bleeding using sterile K-file.
6. Placement of collagen matrix and MTA over the clot.
7. Permanent restoration with composite.

#### Follow-up

Regular follow-up was done. Patient was asymptomatic and composite restoration was done. At 16 months follow-up complete closure of root apex and increased dentinal

#### Outcome

- Progressive healing noted at 3, 6, and 12 months.
- Significant root lengthening.
- Thickening of dentinal walls.
- Complete periapical healing on radiographs.

Pre-operative



### Case 2

#### Patient Information

- **Age:** 10 Y/M reported with history of trauma to maxillary anteriors 3 years back. Patient gave history of recurrent pain and swelling wrt 11 and 21. On radiographic examination, open apex and blunderbuss canals were found. A diagnosis of Necrotic pulp with chronic apical abscess and immature roots were made.

#### Clinical Procedure

(Same steps — irrigation, medicament, bleeding induction, MTA, restoration.)

#### Outcome

- Clinical healing after 1 month.
- Radiographic signs of continued root formation and closure of apex was found at the end of 14 months.

Pre-operative



## DISCUSSION

Revascularization or regenerative endodontic procedures (REPs) have transformed the management of immature necrotic permanent teeth by enabling continued root development, increased dentinal wall thickness, and apical closure—outcomes not achievable with traditional apexification techniques. The results observed in this case series are consistent with previously published literature, demonstrating the predictable nature of REPs when performed under standardized protocols.

The biological foundation of revascularization is based on the triad of stem cells, scaffolds, and growth factors. The apical papilla contains mesenchymal stem cells (SCAP) capable of differentiating and contributing to root maturation even after pulp necrosis (16). Minimal or no instrumentation preserves these cells and allows regeneration. Proper disinfection is critical; low-concentration sodium hypochlorite helps maintain stem cell viability (17), whereas intracanal medicaments like calcium hydroxide or triple antibiotic paste effectively reduce bacterial load (18-19).

Outcomes reported in the current cases—resolution of periapical pathology, root elongation, and dentinal wall thickening—align with findings from large case series and systematic reviews. Andreasen et al. (20-22) demonstrated that immature teeth have a high capacity for continued root development following trauma, and regenerative endodontics enhances this healing potential. Similarly, Tsilingaridis et al. (2012) and Wang et al. (2020) reported favorable outcomes in immature intruded teeth, emphasizing the role of biological healing.

Recent systematic reviews (23-24) support the success of regenerative approaches over traditional methods, noting improved fracture resistance of the root due to dentinal wall thickening. The American Association of Endodontists and International Association of Dental Traumatology (IADT 2020) recommend revascularization as a first-line treatment for necrotic immature teeth, especially in cases involving trauma.

Factors influencing success include absence of reinfection, adequate bleeding induction to create a natural scaffold, and the use of biocompatible materials such as MTA. Bleeding induction introduces stem cells and growth factors into the canal space (25). The cases in this series demonstrated predictable maturogenesis, highlighting proper case selection and adherence to biological principles.

Despite favorable outcomes, limitations remain. Radiographic outcomes do not fully confirm true pulp regeneration; histologic studies have shown tissue resembling periodontal ligament rather than pulp tissue. Additionally, inter-case

variability may arise from differences in patient age, etiology, or clinician technique. Long-term follow-up is essential to evaluate root maturation, potential canal calcification, or late resorptive complications.

Overall, the findings from this case series reinforce the growing evidence that revascularization is a reliable, biologically based treatment modality for immature necrotic teeth and should be considered a preferred approach when conditions are ideal.

## CONCLUSION

Revascularization offers a reliable treatment modality for immature necrotic permanent teeth, supporting periapical healing and continued root development. This case series highlights its predictable outcomes when performed following standardized regenerative protocols.

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