

REVASCULARIZATION THE BIOLOGICAL APPROACH - AN OVERVIEW

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ABSTRACT

Regenerative endodontic procedures (REPs) have become a biologically based approach for treating immature teeth with necrotic pulp and open apices. They provide an alternative to traditional apexification techniques. Some goals of pulp revascularization include restoring blood flow and continuing root development. This method has become a prominent alternative, with various treatment protocols available in the scientific literature. The field of regenerating tissues, rather than replacing them with artificial materials, is gaining attention in health sciences. This article reviews the current approach to pulp revascularization and outlines its methods, highlighting the potential for pulp regeneration to become a routine dental procedure in pediatric dentistry.

Key words: Regenerative endodontics, revascularization, vital pulp therapy, immature teeth, root regeneration

INTRODUCTION

Treating immature teeth with open apices is a complex and evolving challenge in pediatric dentistry and endodontics. Traditional methods, like apexification with calcium hydroxide or mineral trioxide aggregate (MTA), have been commonly used to encourage root development and closure.^{1,2}

However, these techniques often fail to restore the vitality of the dental pulp and do not promote continued root maturation.³ Many regenerative endodontic treatments (REPs) face challenges, and redoing these cases can be difficult. Given the high failure rate, we need a reliable method for regeneration. A novel concept of revascularization of immature nonvital, infected teeth was recently introduced. The concept of revascularization was introduced by Ostby in 1961 and in 1966, Rule and Winter documented root development and apical barrier formation in cases of pulpal necrosis in children.⁴

The goal is to create and deliver new tissues to replace the necrotic pulp. The development of normal, sterile granulation tissue within the root canal is thought to aid in revascularization and stimulation of cementoblasts or the undifferentiated mesenchymal cells at the periapex, leading to deposition of a calcific material at the apex as well as on the lateral dentinal walls. In 2001, Iwaya et al and in 2004 Banchs and Trope demonstrated the advantages of this treatment modality, which resulted in a radiographically apparent normal maturation of the

entire root versus an outcome of only a calcific barrier formation at the apex after conventional calcium hydroxide induced apexification.⁵

The ideal treatment for achieving further root development and thickening of dentinal walls in an immature tooth with apical periodontitis is revascularization. This allows a nonvital tooth to regain vitality and supports the repair and regeneration of the pulp-dentin complex. The term "revascularization" refers to restoring blood vessels in the pulp chamber after injuries.

Revascularization is the procedure to reestablish the vitality in a nonvital tooth to allow repair and regeneration of tissues. The rationale of revascularization is that if a sterile tissue matrix is provided in which new cells can grow, pulp vitality can be re-established.⁴

Regenerative endodontic treatment for nonvital infected teeth can occur in two ways: (1) using tissue engineering technology, which focuses on actively regenerating the dentin-pulp complex to implant or regenerate the pulp; and (2) pulp revascularization, which involves forming new tissue from existing tissue in the teeth to continue root development.⁶

To facilitate revascularization, it is crucial to eliminate infection and effectively remove the microbial environment. This presents a significant challenge for achieving long-term success in regenerative therapy.

The choice of intracanal medication for these procedures remains a topic of debate. Since 2018, the AAE has recommended using triple and double antibiotic pastes in low concentrations or calcium hydroxide. Different compositions of these antibiotic pastes have been widely cited in literature.^{7,8} Calcium hydroxide has been used in various pulp revascularization methods, including in combinations with two percent chlorhexidine gel.⁹

Research into regenerating the pulp-dentin complex has been ongoing for a long time. Current studies in regenerative endodontics utilize improved materials, tools, and medications, applying principles from trauma research and tissue engineering. This allows for effective disinfection of an infected pulp, the artificial placement of a scaffold, and proper sealing of the access cavity to prevent further infection.

CASE SELECTION¹⁰

- Young patients- high healing potential, high vascularity.
- Tooth with immature apex and necrotic pulp secondary to trauma, pulp exposure, caries.
- Apex open > 1.5 mm allow in growth of tissues.
- Pulp space not needed for post and core restoration.
- Compliant patient.

PROCEDURE

The standard revascularization protocol suggests that an immature tooth diagnosed with apical periodontitis should be accessed. Irrigation with 2.5% sodium hypochlorite is done for more than 20 minutes to achieve disinfection. This is followed by the use of the "3 mix-MP" triple antibiotic paste, which consists of equal amounts of ciprofloxacin, metronidazole, and minocycline (concentration = 20 mg/ml) in propylene glycol or macrogol ointment as a carrier. This paste is applied to the root canal and the access cavity is sealed.

After about three weeks, if there are no symptoms, mechanical irritation of the apex is performed using a sterile K-file to encourage bleeding into the root canal up to the cemento-enamel junction. A blood clot is formed at this level, followed by a double seal of mineral trioxide aggregate in the cervical area and a bonded resin restoration to prevent bacterial entry from above.¹¹

Criteria for pulp revascularization success

According to the AAE, the success of regenerative endodontic procedures like pulp revascularization is reached when the following goals are met: primary goal - the elimination of symptoms and evidence of bone healing; secondary goal - increased root wall thickness and/or increased root length (desirable, but perhaps not essential); and tertiary goal - a positive response to vitality tests, indicating a more organized vital pulp tissue.⁷

MECHANISM OF REVASCULARIZATION

Various possible mechanisms have been documented for the origin and nature of the newly formed tissues.

- It is possible that a few vital pulp cells remaining at the apical end of the root canal may proliferate into the newly formed matrix and differentiate into odontoblasts. The newly formed odontoblasts can lay down tubular dentin at the apical end, causing apexogenesis, as well as on lateral aspects of dentinal walls to lay down dentin causing elongation and strengthening of the root.¹²
- Stem cells from the apical papilla (SCAP) or bone marrow may also contribute to root development. The apical papilla is a specific stem cell tissue with greater potential to regenerate pulp tissue and support root development.¹³
- Another potential mechanism involves stem cells in the periodontal ligament, which can grow into the canal and deposit hard tissue (cementum, bone) onto the inner surface of root dentin.¹¹
- Multipotent dental pulp stem cells, abundant in immature teeth, may also play a role in continued root development. Additionally, the blood clot itself, rich in growth factors, can significantly aid in regeneration. These factors include platelet-derived growth factor, vascular endothelial growth factor (VEGF), platelet-derived epithelial growth factor, and tissue growth factor. They promote the differentiation, growth, and maturity of fibroblasts, odontoblasts, cementoblasts, and more from immature, undifferentiated cells in the new tissue matrix.¹⁴

Adjuncts to blood clot^{15,16}

- Platelet-rich fibrin (PRF), a second-generation platelet concentrate, was first developed by Choukroun et al. (2001). It is a non-thrombinized autologous fibrin mesh that serves as a reservoir of growth factors and allows continuous release of growth factors over a period of 7-14 days. Platelet rich plasma (PRP), a first generation platelet concentrate acts as a reservoir of growth factors. In contrast, PRP exhibits sudden release of growth factors in approximately 7-14 h. After that, the release of growth factors from PRP dramatically diminishes. Studies have shown that Supplementations with PRP can potentially improve the desired biological outcome of this regenerative technique

ADVANTAGES¹⁷

- This procedure can often be completed in a single visit once infection is controlled, eliminating the need for multiple appointments as seen with calcium hydroxide apexification.
- It is also cost-effective.
- The key advantage is restoring tooth vitality and promoting continued root development, strengthening the root through the deposition of new dentin and hard tissue.

Case reports indicate progressive thickening of dentinal walls, ongoing root development, and positive responses to thermal pulp testing.

LIMITATIONS¹⁸

1. Some complications can include discoloration of the crown, development of resistant bacterial strains, and allergic reactions to intracanal treatments.
2. There is also a risk of necrosis in the pulp and apical papilla.
3. Additional complications related to systemic health conditions and immune issues can hinder achieving adequate root maturation when a periradicular infection is present.
4. A lack of long-term follow-up studies suggests that the revascularization procedure remains a supplement.

CONCLUSION

Although pulp revascularization is a newer therapy among regenerative endodontic procedures, it appears effective for immature teeth, as it facilitates root

formation through a straightforward method and improves the prognosis for treated teeth. In promoting root elongation and thickening, revascularization endodontic therapy demonstrates superior effectiveness without significantly increasing treatment failure. Revascularization of the pulp of immature permanent teeth with apical periodontitis is a clinical possibility; a treated tooth might even respond normally to electric pulp test after about a year. This treatment modality should be preferred to the traditional apexification. However, further studies are needed to assess its long-term effectiveness and explore new approaches.

Conflict of interest

None.

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