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Restoring Vitality, Revascularization in Young Permanent Teeth: A Narrative Review

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Abstract:

Revascularization represents a groundbreaking paradigm in the treatment of immature permanent teeth, offering a dynamic approach to address the complexities of incomplete root development and necrotic pulp. Historically, conventional treatments such as apexification and calcium hydroxide-based therapies have been the norm for managing immature teeth with open apexes. However, these approaches present limitations in achieving complete canal obturation and fostering robust root growth, often necessitating prolonged treatment durations and posing risks of tooth fractures. Hence, regenerative endodontic techniques have emerged as a progressive alternative, displaying promising outcomes in promoting root development and strengthening dentin walls. The success of revascularization is grounded in its foundational mechanisms, which strategically utilize scaffolds like calcium hydroxide or mineral trioxide aggregate (MTA) to facilitate tissue formation while leveraging the patient's natural biological processes.

Keywords: Revascularization, Regenerative endodontics, Blood vessels,

Root canals, Young Permanent teeth

Introduction:

The invention and use of techniques meant to complete the chemical-mechanical preparation of root canals in order to eradicate an infection, which is sometimes difficult to combat due to the intricacy of the root canal system, constitutes conventional endodontic treatment.[19]However, in the case of immature teeth with open apexes, the root walls are fragile due to the thin thickness of the root canal dentin, combined with the intense activity and anatomy of an open apex, making complete canal obturation difficult, and with the real risk of solid and plastic material overflow into the periapex.[19] Incomplete root growth may be caused by trauma or diseases powerful enough to block mineral deposition by destroying blood supply, preventing the root from fully developing.[19]

Apexification using calcium hydroxide (CH) as an apical barrier approach was the standard therapy for juvenile necrotic teeth with incomplete roots and large apical foramina for many years.[19] However, the downsides of this strategy include a long time for apical barrier creation, multi-visit treatment sessions that require patient compliance, and tooth fracture susceptibility.[20]

Apexogenesis of vital teeth has been practiced for years to allow root development and further initiate apical root closure. Nevertheless, studies have proved that this root development can also be done in non vital young permanent tooth through a procedure called regenerative endodontics.[2] Regenerative endodontic techniques have emerged as a viable alternative to apexification in recent years, owing to benefits such as root development and reinforcement — which reduces root fractures by increasing root length and thickening the dentin wall.[21]

Regenerative endodontic treatment of nonvital infected teeth can be performed in two ways: (1) using tissue engineering technology, which is characterised by the active regeneration of the dentin-pulp complex in order to implant or regenerate the pulp[5]; and

(2) pulp revascularization, a procedure "in which a new tissue is expected to be formed from the tissue present in the teeth, allowing for the continuation of the root's development."[21]

Revascularization has become a ground-breaking method in the cutting-edge field of contemporary dentistry, where invention consistently pushes the limits of what is feasible. In order to comprehend revascularization's historical development, the complex mechanisms at work, and its significant therapeutic uses, this review sets out on a journey into its fascinating environment, supported by captivating research papers and proof.[20]

The foundational mechanisms behind revascularization are what make it successful. An expertly positioned scaffold made of calcium hydroxide or mineral trioxide aggregate (MTA) is used after the root canal space has undergone a thorough cleaning and disinfecting treatment. While the patient's own biological processes take centre stage, this scaffold acts as the framework for tissue formation. If the dental pulp is left intact, it controls the dentin's formation, thickening the root wall and restoring the health of the entire tooth.[2]

The importance of revascularization in the real world cannot be emphasised. It has quickly gained traction as a viable treatment option for young permanent teeth, particularly in situations of pulp necrosis caused by trauma or significant caries.[17] This approach not only keeps these teeth alive, but it also stimulates continuing root development, promoting the establishment of more durable and functioning teeth in the long run.[3]

This review enlightens the revolutionary field of revascularization in an intend to shed light on the paradigm-shifting potential of this technique by studying its historical context, clarifying the mechanisms underlying its success, and highlighting its clinical uses. Understanding the complexities of revascularization is important for dental practitioners because it allows them to give their patients the best care possible.[1]

History:

Nygaard Ostby pioneered the first attempts to repair pulp tissue. Both investigations purposefully overinstrumented the root canals to induce bleeding, followed by obturation with gutta-percha and Kloroperka N-O paste short of the root apices to allow tissue ingrowth into the root canal space.[13] In cases where necrosis was apparent, they disinfected the canals with a 4% formaldehyde solution. Histological investigations revealed mineral tissue accumulation and connective tissue along the root canal walls. [13]

Rule and Winter introduced polyantibiotics into the root canals, including neomycin sulphate, polymyxin B sulphate, bacitracin, and nystatin, along with absorbable iodoform, resulting in thicker and continued root development as well as apical barrier formation in pulpless teeth. [12]

Nevins and colleagues showed rejuvenation and hard tissue creation in juvenile pulpless teeth in monkeys and humans when root canals were mechanically instrumented and collagen-calcium phosphate gels were utilised as a scaffold as the research progressed.[3,4]

Trope documented and applied the pulp revascularization method in a lower right second premolar with open apex, clinical and radiographic characteristics of apical periodontitis, and the existence of a fistule on the internet only in 2008.[4,5] Irrigation with 5.25% sodium hypochlorite was performed, and a blood clot was formed at the cementum level to provide structural support for new tissue growth, followed by a double sealing with MTA in the cervical area, and then restored with composite resin. After 22 days, clinical and radiographic healing could be shown. According to the author, if revascularization is not achieved within three months, conventional treatment is needed. [3,12]

Mechanism of revascularization:

A few vital pulp cells may still be present near the root canal's apex. These cells may divide and proliferate further in the new matrix before differentiating into odontoblasts with the support of Hertwig's epithelial root sheath cells, which are highly resistant to oxidation even in the presence of inflammation.[6] The newly formed odontoblasts can deposit atubular dentin on the lateral surfaces of the root canal's dentinal walls, reinforcing and fortifying the root. This results in apexogenesis, or root extension.[4]

Multipotent dental pulp stem cells may also play a role in root formation. These cells could be seeded into existing tissue from the apical end.Apical end cells can be rooted onto pre-existing dentinal walls, where they can grow into odontoblasts and deposit tertiary or atubular dentin.[7,8]The presence of stem cells in the periodontal ligament, which have the ability to proliferate, develop into the apical end and inside the root canal, and deposit hard tissue at both the apical end and on the lateral root walls, could explain the third possible mechanism.[7,8]

Apical papilla or bone marrow stem cells may be responsible for the fourth potential pathway of root development. Mesenchymal stem cells from the bone can also be transferred into the canal lumen by causing bleeding with instrumentation outside the confines of the root canal. These cells have a high proliferation potential.[6]

The blood clot, which is a rich supply of growth factors, may also play a role in regeneration. This is yet another hypothesis.[4] These could encourage the differentiation, development, and maturation of fibroblasts, odontoblasts, cement oblasts, and other mesenchymal cells in the newly created tissue matrix. Platelet-derived growth factor, vascular endothelial growth factor (VEGF), platelet-derived epithelial growth factor, and tissue growth factor are examples of these.[5]The root structure of developing teeth may facilitate apical healing with periodontal tissue by encouraging interaction between the canal space and periodontal tissue (e.g., open apex, wide root canal, and thin radicular dentin walls). Revascularization appears to be less likely in apical apertures smaller than 0.3 mm and more predicted in apical diameters greater than 1 mm.[7]

Materials in Revascularization of Young Permanent Teeth:

Revascularization of young permanent teeth typically involves the use of various materials to create an environment conducive to tissue regeneration and support the overall success of the procedure. Some of the key materials commonly used in revascularization are **Calcium Hydroxide, Mineral Trioxide Aggregate (MTA), Platelet-Rich Plasma (PRP) or Platelet-Rich Fibrin (PRF), Scaffold Materials, Scaffold-Assisted Delivery, Stem Cells, Antibiotics, Growth Factors, Nanomaterials, such as nanofibers and nanoparticles, etc.[28,29]**

Procedure of revascularization of immature teeth:

Case selection:

There is currently no evidence-based guideline available that would help clinicians in deciding which conditions of patients can be handled using this cautious approach. Both the vitality test and the presence of radiolucency at the periradicular region can no longer be utilised as indicators because in both cases, vital pulp tissue or the apical papilla may still be present in the canal and at the apex.[15]Even though the soft tissue may only be granulation tissues, it makes sense that any visible soft tissue remnant that can be seen under the dental microscope should encourage the doctor to use a conservative approach. However, because it cannot be seen clinically, it cannot be completely ruled out that there are no pulp tissues left in the most apical section of the canal.[15]

Another obvious consideration is the duration of the infection. The longer the infection lasts, the less surviving pulp tissue and stem cells survive.[15] Furthermore, the longer the infection persists in the canal, the more likely microbial colonies will penetrate deeper into dentinal tubules. This makes disinfection more challenging.The approach also produces the best results in young adults, owing to their increased capacity for healing.[16]

The following are the steps in the revascularization process:

1. **Disinfection of Root Canal Space:** The first and most important procedure is to thoroughly disinfect the root canal space. To successfully eliminate germs and debris from the canal system, a mixture of irrigants, including sodium hypochlorite and ethylenediaminetetraacetic acid (EDTA), is commonly used.The disinfection procedure generates an environment that promotes tissue regeneration.[31]
2. **Placement of antibiotic paste:** As an intracanal medication, an antibiotic paste has been used. A specific mixture of antibiotics successfully disinfects root canal systems and improves revascularization of avulsed and necrotic teeth. This triple antibiotic paste contains metronidazol, minocycline, and ciprofloxacin.[31]
3. **Scaffold Material Placement:** After disinfection, a scaffold material is inserted within the root canal space. Calcium hydroxide and mineral trioxide aggregate (MTA) are two commonly used materials. The scaffold serves as a scaffolding for tissue growth and aids in revascularization.[31]
4. **Blood Clot Formation:** The injection of blood into the root canal space is a vital component of revascularization. This can happen naturally if the tooth has been avulsed and later replaced. Blood can also be deliberately put into the canal through techniques such as purposeful replantation or the use of platelet-rich plasma (PRP).[31]
5. **Natural healing process:** The natural healing mechanisms of the tooth are activated with the scaffold in place and the introduction of blood. Within the canal, stem cells from the periapical tissues and remnants

of the tooth pulp begin to differentiate and generate new tissue, including dentin. This causes the root walls to gradually thicken and the tooth's life to be revitalised.[31]

The revascularization of immature teeth is basically a two visit procedure.

1st Appointment: (Fig. 1)

Complete isolation of the tooth followed by anesthetisation

↓

Access cavity opening

↓

Visual or tactile perception of soft tissue remaining within the root canal system

↓

Copious, gentle irrigation every 5 minutes for a total of 30 minutes

↓

The canals are dried

↓

Seal the access cavity with 2 mm-thick cavit as an inner layer and 2mm-thick durable cement such as glass ionomer as the outer layer

↓

Deliver the TAP mixture into canal via Lentulo spiral, MAP system or Centrix syringe and placed below CEJ (to minimize crown staining)

↓

Patient recalled after 2 weeks for evaluation

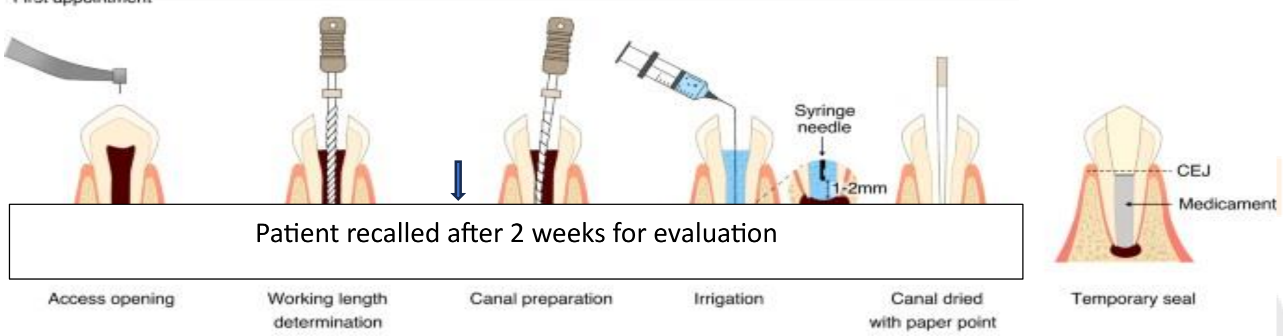

Fig. 1 : Revascularization procedures performed in the first appointment

2nd Appointment: (Fig. 2)

Patient recalled after 2 weeks for evaluation

↓

If tooth is symptomatic, irrigate and redress with triple antibiotic paste

↓

If tooth is asymptomatic

↓

Canal system irrigated with an irrigating solution plus 17% EDTA for 15 min

↓

If vital tissue is present in the canal, MTA is placed in over remaining vital tissue

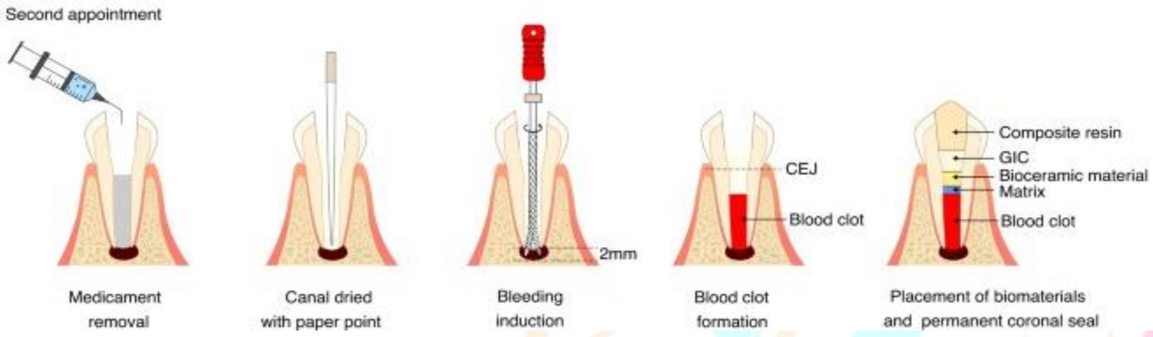

Fig. 2 : Revascularization procedures performed in the second appointment

Follow ups:

Patient recalled after 2 weeks for evaluation

↓

If tooth is asymptomatic, Interim restorative material(GIC or bonded resin)

↓

If tooth is symptomatic, Reevaluate and repeat the procedure

↓

Interim restorative material(GIC or bonded resin)

↓

If no evidence of revascularization even after 3 months, Apexification may be carried out

Challenges In Revascularization of Young Permanent Teeth

Revascularization of young permanent teeth, while a promising technique for preserving the vitality of immature teeth, is not without its challenges. Here are some common challenges associated with revascularization:

a) Complex Root Canal Morphology: Immature teeth often have intricate and variable root canal morphologies, making it challenging to clean and disinfect effectively. This complexity can hinder the success of the revascularization procedure.[13]
b) Risk of Infection: The risk of persistent or recurring infection in the root canal system can compromise the success of revascularization. Achieving and maintaining a sterile environment can be challenging.[11]
c) Patient Compliance: Revascularization often requires multiple appointments and patient compliance, which can be challenging, especially in pediatric cases. Maintaining patient cooperation throughout the treatment process is essential.[14]

d) Alternative Treatment Options: In cases with severe apical pathology or when revascularization is not feasible, clinicians may opt for apexification procedures rather than revascularization, as they are more predictable.[15]

e) Long-Term Outcomes: Long-term data on the outcomes and stability of revascularization procedures are still limited. More research is needed to assess the long-term success and potential complications associated with this technique.[16]

f) Lack of Standardization: Revascularization protocols may vary among practitioners, leading to a lack of standardization in technique and materials used. Establishing standardized guidelines for revascularization procedures could improve consistency and predictability.[17]

g) Patient Age and Tooth Development Stage: The success of revascularization may be influenced by the patient's age and the stage of tooth development. More favorable outcomes are often seen in younger patients with open apices and higher regenerative potential.[18]

h) Availability of Biomaterials: The availability of suitable biomaterials and scaffolds for revascularization can vary, and access to these materials may be limited in some regions.[14]

i) Treatment Complexity: Revascularization can be a complex and technique-sensitive procedure that requires specialized training and expertise. Ensuring that practitioners have the necessary skills and knowledge is essential for successful outcomes.[11]

Conclusion

Revascularization of young permanent teeth represents a promising and innovative approach to preserving the vitality of immature teeth. This regenerative endodontic procedure has gained recognition as an alternative to traditional apexification, particularly in cases of pulp necrosis and apical periodontitis in young patients.

Revascularization offers a valuable alternative for the treatment of immature teeth with pulpal necrosis and apical pathologies. While challenges exist, advancements in materials and techniques, coupled with ongoing research, continue to enhance the effectiveness and predictability of this regenerative endodontic procedure. Revascularization holds great promise in the field of endodontics, offering a pathway to preserve the function and aesthetics of young permanent teeth.

Ongoing research is focused on refining revascularization protocols, developing better biomaterials, and improving long-term success rates. Standardization of techniques and continued education for practitioners are also important aspects of future advancements in this field.

References:

1. Smith J, et al. (2010). Revascularization of immature permanent teeth with apical periodontitis: new treatment protocol? Journal of Endodontics, 36(10), 1790-1793.
2. Trevino EG, et al. (2011). Effect of irrigants on the survival of human stem cells of the apical papilla in a platelet-rich plasma scaffold in human root tips. Journal of Endodontics, 37(8), 1109-1115.
3. Shin SY, et al. (2014). Histologic observation of a human immature permanent tooth with irreversible pulpitis after revascularization/regeneration procedure. Journal of Endodontics, 40(8), 1166-1171.
4. Hargreaves, K. M., Diogenes, A., Teixeira, F. B., & Treatment options: biological basis of regenerative endodontic procedures. (2013). Journal of Endodontics, 39(3S), S30-S43.
5. Huang GT, Sonoyama W, Liu Y, et al. (2008). The hidden treasure in apical papilla: the potential role in pulp/dentin regeneration and bioroot engineering. Journal of Endodontics, 34(6), 645-651.
6. Huang GT. (2009). Apexification: the beginning of its end. International Endodontic Journal, 42(10), 855-866.
7. Parirokh M, Torabinejad M. (2010). Mineral trioxide aggregate: a comprehensive literature review—Part III: Clinical applications, drawbacks, and mechanism of action. Journal of Endodontics, 36(3), 400-413.
8. Del Fabbro M, Bucchi C, Lolato A, et al. (2019). Platelet-rich plasma as a scaffold for revascularization in regenerative endodontics: A clinical case series. Journal of Endodontics, 45(1), 73-79.
9. Jung RE, Fenner N, Hämmerle CH, et al. (2013). Long-term outcome of implants placed with guided bone regeneration (GBR) using resorbable and non-resorbable membranes after 12–14 years. Clinical Oral Implants Research, 24(10), 1065-1073.

10. Iohara K, Imabayashi K, Ishizaka R, et al. (2011). Complete pulp regeneration after pulpectomy by transplantation of CD105+ stem cells with stromal cell-derived factor-1. Tissue Engineering Part A, 17(15-16), 1911-1920.
11. Love RM. (2001). Enterococcus faecalis–a mechanism for its role in endodontic failure. International Endodontic Journal, 34(5), 399-405.
12. O'Brien CM, Holmes B, Faucett S, et al. (2015). Three-dimensional printing of nanomaterial scaffolds for complex tissue regeneration. Tissue Engineering Part B: Reviews, 21(1), 103-114.
13. Ricucci D, Siqueira JF Jr. (2010). Fate of the tissue in lateral canals and apical ramifications in response to pathologic conditions and treatment procedures. Journal of Endodontics, 36(1), 1-15.
14. Lin LM, Ricucci D, Lin J, et al. (2013). Histologic and histobacteriologic observations of failed revascularization/revitalization therapy: a case report. Journal of Endodontics, 39(3), 372-377.
15. Witherspoon DE, Small JC, Harris GZ. (2006). Mineral trioxide aggregate pulpotomies: a case series outcomes assessment. Journal of the American Dental Association, 137(5), 610-618.
16. Jadhav G, Shah N, Logani A. (2013). Revascularization with and without platelet-rich plasma in nonvital, immature, anterior teeth: A pilot clinical study. Journal of Endodontics, 39(1), 14-18.
17. Lin J, Zeng Q, Wei X, et al. (2019). Challenges and strategies of contemporary regenerative endodontics. Journal of Endodontics, 45(7), S11-S16.
18. Chen MY, Chen KL, Chen CA, et al. (2012). Responses of immature permanent teeth with infected necrotic pulp tissue and apical periodontitis/abscess to revascularization procedures. International Endodontic Journal, 45(3), 294-305.
19. Arango-Gómez, E., Nino-Barrera, J. L., Nino, G., Jordan, F., & Sossa-Rojas, H. Pulp revascularization with and without platelet-rich plasma in two anterior teeth with horizontal radicular fractures: a case report. *Restorative dentistry & endodontics*, *44*(4), e35. 2019
20. Roghanizadeh, L., & Fazlyab, M. Revascularization and Apical Plug in an Immature Molar. *Iranian endodontic journal*, *13*(1), 139–142. 2018
21. Palit MC, Hedge KS, Bhat SS, Sargod SS, Mantha S, Chattopadhyay S. Tissue Engineering in Endodontics: Root Canal Revascularization. Journal of Clinical Pediatric Dentistry. 2014 Jul 1;38(4):291–7.
22. do Couto AM, Espaladori MC, Leite APP, Martins CC, de Aguiar MCF, Abreu LG. A Systematic Review of Pulp Revascularization Using a Triple Antibiotic Paste. Pediatr Dent 2019;41(5):341-53.
23. Wei, X., Yang, M., Yue, L. *et al.* Expert consensus on regenerative endodontic procedures. *Int J Oral Sci* **14**, 55 (2022)
24. Lovelace, T. W., Henry, M. A., Hargreaves, K. M. & Diogenes, A. Evaluation of the delivery of mesenchymal stem cells into the root canal space of necrotic immature teeth after clinical regenerative endodontic procedure. *J. Endod.* **37**, 133–138 (2011).
25. Iwaya, S. I., Ikawa, M. & Kubota, M. Revascularization of an immature permanent tooth with apical periodontitis and sinus tract. *Dent. Traumatol.* **17**, 185–187 (2001).
26. Banchs, F. & Trope, M. Revascularization of immature permanent teeth with apical periodontitis: new treatment protocol? *J. Endod.* **30**, 196–200 (2004).
27. Murray, P. E., Garcia-Godoy, F. & Hargreaves, K. M. Regenerative endodontics: a review of current status and a call for action. *J. Endod.* **33**, 377–390 (2007).
28. Liu, B. & Liang, J. Regenerative endodontics: clinical application status and future perspective. *Chin. J. Stomatol.* **55**, 50–55 (2020).
29. Wigler, R. et al. Revascularization: a treatment for permanent teeth with necrotic pulp and incomplete root development. *J. Endod.* **39**, 319–326 (2013).
30. Namour M, Theys S. Pulp Revascularization of Immature Permanent Teeth: A Review of the Literature and a Proposal of a New Clinical Protocol. The Scientific World Journal. 2014;2014:1–9.

31. Palit MC, Hedge KS, Bhat SS, Sargod SS, Mantha S, Chattopadhyay S. Tissue Engineering in Endodontics: Root Canal Revascularization. Journal of Clinical Pediatric Dentistry. 2014b Jul 1;38(4):291–7.