

Introduction

Apexogenesis and apexification are treatment options that are commonly used for the treatment of immature permanent teeth defined as having an open apex. Apexogenesis is defined by the American Academy of Endodontics as a “vital pulp therapy procedure performed to encourage continued development and formation of the root end.” With vital pulp therapy, including pulp caps and pulpotomies, we are able to leave vital pulpal tissue in order to promote root development and allow apical closure to occur.

Irreversible pulpitis or necrotic pulps effecting immature teeth present a unique circumstance as vital pulp therapy is no longer an option to treat these teeth. Currently, apexification using calcium hydroxide or MTA is often used to solve the problem of an open apex, with an MTA plug having a high success rate of >90% according to the literature⁶. However, neither applying an MTA plug nor using calcium hydroxide fixes the issue of the immature roots having thin dentinal walls and being more prone to fracture than a fully mature tooth.² Regenerative endodontics aims primarily to resolve tooth pain and symptoms, secondarily attempts to treat the problem of thin roots, and lastly in limited cases, revitalization of the tooth is noted.

Regenerative Endodontics (aka Revascularization/Revitalization) Procedure

- 1) Case selection – immature apex and a necrotic pulp
- 2) Informed consent: may take multiple appointments, possible staining of crown due to antibiotics used, lack of response from individual
- 3) Alternative treatments: MTA apexification, no treatment, extraction
- 4) First appointment:
 - a. anesthetize, rubber dam, access.
 - b. Irrigate with **1.5%** NaOCl
 - c. Irrigate with EDTA
 - d. Dry canal with paper points
 - e. Place either calcium hydroxide or triple antibiotic paste (ciprofloxacin, metronidazole, minocycline) below CEJ
 - i. **Results:** Antibiotics significantly reduced stem cells of the apical papilla (SCAP) survival in a concentration-dependent fashion. Calcium hydroxide however was conducive with SCAP survival at all concentrations.⁸
 - f. Temporize
- 5) Second appointment (1-4 weeks after)
 - a. Assess response to initial treatment
 - b. Anesthetize without using a vasoconstrictor, dental dam isolation
 - c. Rinse with 17% EDTA and dry with paper points
 - d. Over instrument to create bleeding into the canal by extending ~2mm past the apical foramen
 - e. Place resorbable matrix such as CollaPlug over the blood clot, and cap with white MTA.
 - f. Place 3-4 mm of restorative material
- 6) Follow ups every 6, 12, and 24 months and then yearly recommended.

American Association of Endodontists. “Regenerative Endodontics.” *Endodontics Colleagues for Excellence*, 2013. doi:<https://www.aae.org/specialty/wp-content/uploads/sites/2/2017/06/ecfespring2013.pdf>.

Possible Procedures Following Pulpal Exposure

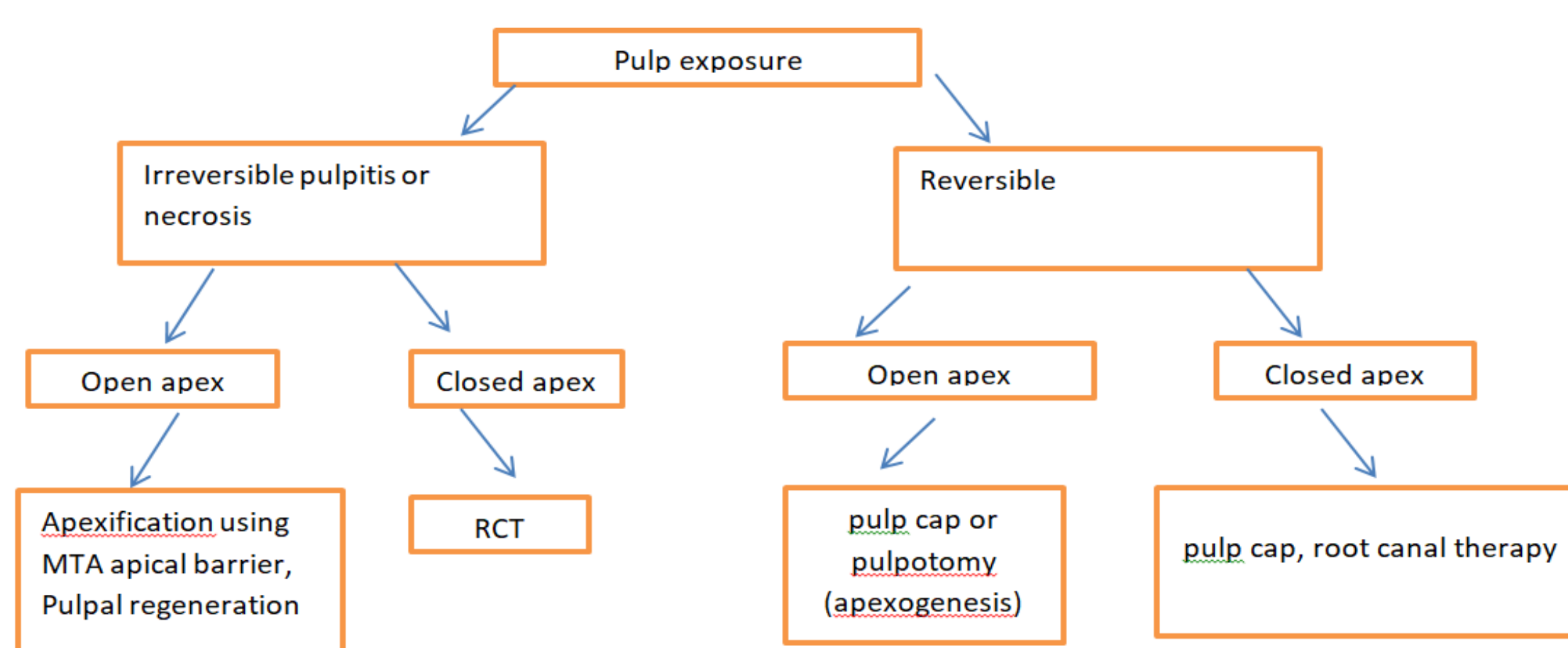


Figure 1. General flow chart of possible procedures following a pulpal exposure.

Regeneration?

The regeneration process is thought to work via stem cells from the apical papilla. For true regeneration we need: stem cells, a scaffold, and growth factors. The stem cells thought to participate in this process are the SCAPs. Scaffolds are needed to provide structure for the cells in order for cellular organization, differentiation, and vascularization. Current regenerative endodontic procedures primarily use a blood clot to provide the scaffold as well as utilizing growth factors found in platelets and dentin.¹

The formation of calcified tissue in a necrotic tooth (after the odontoblasts have died) is often thought of as regeneration of the dentin. However, histologically the hard tissue formed lacks certain tubular features that are characteristic of actual dentin, therefore the process currently is more of a reparative process from the formation of a calcified scar tissue than a true regenerative one.⁷

Apexification Procedure

Apexification is defined in the glossary of endodontic terms by the American Association of Endodontists as “a method to induce a calcified barrier in a root with an open apex or the continued apical development of an incompletely formed root in teeth with necrotic pulps”

- Calcium hydroxide – multiple appointments are needed for the reapplication of calcium hydroxide. The disadvantage is the time it takes for the formation of a calcified barrier (3-24 months)¹
- MTA “Immediate apexification” – pack a 3-5 mm MTA apical barrier and then obturate canal – can be done in a single visit

Both MTA and calcium hydroxide have similar clinical success rates. MTA may have a higher overall success rate due to better patient compliance as we minimize the amount of appointments needed.³

Indications and Clinical Significance

With regenerative procedures, we see a greater increase in the percentage of root width (28.2%) compared with that of just MTA apexification (0%) and calcium hydroxide apexification (1.5%) techniques⁴, allowing the immature teeth to have thicker dentinal walls and therefore be less prone to fracture in the future.

Due to the benefits of regeneration, such as allowing necrotic teeth with open apices to continue radiographic root development, the healing of apical periodontitis, and in certain cases a return of vitality responses, all demonstrate the usability of such a procedure.² Even with this, some authors believe that teeth with complete or near complete root formation may be more suited for conventional endodontic therapy or apexification as much is not known about the biology of regenerative endodontics.⁵

Clinically, regenerative endodontics can be considered as a first treatment option for immature teeth that are necrotic, as the use of such procedure does not prevent the possibility of using apexification procedures in the future if the regeneration attempt is unsuccessful.²

References

1. American Association of Endodontists. “Regenerative Endodontics.” *Endodontics Colleagues for Excellence*, 2013. doi:<https://www.aae.org/specialty/wp-content/uploads/sites/2/2017/06/ecfespring2013.pdf>.
2. Diogenes, Anibal, et al. “Regenerative Endodontics.” *JADA*, 23 March 2016, [jda.ada.org/article/S0002-8177\(16\)00058-1/fulltext](http://jada.ada.org/article/S0002-8177(16)00058-1/fulltext). <https://doi.org/10.1016/j.adaj.2016.01.009>
3. Lin, Jia-Cheng, et al. “Comparison of Mineral Trioxide Aggregate and Calcium Hydroxide for Apexification of Immature Permanent Teeth: A Systematic Review and Meta-Analysis.” *Journal of the Formosan Medical Association*, Elsevier, 22 Feb. 2016, www.sciencedirect.com/science/article/pii/S0929664616000516#:~:text=Ultrasonic%20filling%20plus%20MTA%20had,elongation%20of%20apical%20root%20length.
4. Jeeruphan, Thanawan, et al. “Mahidol Study 1: Comparison of Radiographic and Survival Outcomes of Immature Teeth Treated with Either Regenerative Endodontics or Apexification Methods: A Retrospective Study.” *Journal of Endodontics*, vol. 38, no. 10, 17 Aug. 2012, pp. 1330–1336., doi:<https://doi.org/10.1016/j.joen.2012.06.028>. [https://www.jendodon.com/article/S0099-2399\(12\)00610-3/abstract](https://www.jendodon.com/article/S0099-2399(12)00610-3/abstract)
5. Kim SG, Malek M, Sigurdsson A, Lin LM, Kahler B. Regenerative endodontics: a comprehensive review. *Int Endod J*. 2018 Dec;51(12):1367-1388. doi: 10.1111/iej.12954. Epub 2018 Jun 11. PMID: 29777616. <https://pubmed.ncbi.nlm.nih.gov/29777616/>
6. “Regenerative Endodontic Therapy: A Treatment with Substantial Benefits.” *American Association of Endodontists*, 4 Nov. 2017, www.aae.org/specialty/communique/regenerative-endodontic-therapy-a-treatment-with-substantial-benefits/.
7. Ricucci D, Loghin S, Lin LM, Spångberg LS, Tay FR. Is hard tissue formation in the dental pulp after the death of the primary odontoblasts a regenerative or a reparative process? *J Dent*. 2014 Sep;42(9):1156-70. doi: 10.1016/j.jdent.2014.06.012. Epub 2014 Jul 5. PMID: 25008021. <https://pubmed.ncbi.nlm.nih.gov/25008021/>
8. Ruparel NB, Teixeira FB, Ferraz CC, Diogenes A. Direct effect of intracanal medicaments on survival of stem cells of the apical papilla. *J Endod*. 2012 Oct;38(10):1372-5. doi: 10.1016/j.joen.2012.06.018. Epub 2012 Aug 16. PMID: 22980180.