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Comparative evaluation between calcium hydroxide with mineral trioxide aggregate and regenerative endodontics in inducing root apex closure during apexification

[1]Dhwani R Bhandari, BDS, Rajarshi Dental Care & Implant Center, India

[2]Vidya Shankar Patil, BDS, MPH Drexel University, Pennsylvania, United States.

[3]Harshvardhan Jain, BDS, One Dental Place, India

[4]Amar Shaw, MDS, Public Health Dentistry, Goregaon Dental Centre, India

Corresponding Author: Dhwani R Bhandari, BDS, Rajarshi Dental Care & Implant Center, India.

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Abstract

To assess better effectiveness between regenerative endodontic procedures (REP) and apexification procedures (AP) with mineral trioxide aggregate (MTA) and calcium hydroxide for inducing root end apex closure.Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines were followed. Electronic databases were searched for studies evaluating effectiveness of REP and AP in terms of survival rate, success rate, increase in root length, root width and decrease in apical diameter. Nine studies were included in review. It was found that REP significantly improved apical root end closure. AP are equally effective in forming calcific barrier, however it was concluded that regeneration procedures are comparably superior to apexification procedures with greater outcomes. Clinicians should consider employing the REP in cases when root development is severely deficient and where tooth's prognosis is hopeless even with an apexification procedure.

Keywords: Apexification, Necrotic Pulp, Regenerative Endodontics, Revascularization, Root Canals

Introduction

The main aetiology for infected immature permanent teeth is traumatic dental injury, particularly intrusions, avulsions and combined injuries.[1] Moderate-to-severe trauma can lead to pulp necrosis and apical periodontitis as well as root resorption and/or arrested root development possibly due to damage to Hertwig's epithelial root sheath, known to be essential for root formation and maturation. [1-3]

Treatment of infected immature permanent teeth is a challenge for endodontists. The presence of thin dentinal root walls makes teeth more susceptible to fractures. In addition, chemical–mechanical preparation, working length determination and obturations are difficult to

accomplish due to the presence of open apices. [4,5] In such cases, the conventional treatment is apexification with periodic changes in calcium hydroxide-based intra canal medications or placement of an apical plug with mineral trioxide aggregate (MTA).[6] Both treatments aim to form an apical calcific barrier.[6] Although these procedures result in the resolution of the infection and the remission of signs and symptoms, they do not allow continued root development, and the teeth persist with thin and fragile dentinal walls.[7]

Long-term application of intracanal calcium hydroxide ($Ca[OH]_2$) was historically the treatment of choice for necrotic teeth with open apices.[8] However, this treatment option requires patients to attend multiple clinic visits over an extended period of time, with treatments regularly extending over 6 months.[8,9] Also, the long-term use of $Ca(OH)_2$ may change the physical properties of dentin and ultimately reduces the root strength.[10] An alternative to apexification with $Ca(OH)_2$ is placement of an apical barrier using a material such as mineral trioxide aggregate (MTA).[7,8] Treatment with MTA apexification produces comparably favourable outcomes to long-term $Ca(OH)_2$ treatment regarding the resolution of symptoms and periapical pathology.[9-12] Despite the advantage of fewer visits, MTA apexification does not appear to improve root strength or produce thickening or lengthening of root canal walls.[11] Regenerative endodontic treatment (RET) provides a new treatment modality. In the 1960s, Dr. Nygaard-Ostby [7] first introduced the concept of tissue regeneration in the root canal. In 2004, Dr. Banchs and Trope [8] introduced a modified endodontic treatment protocol that included minimal instrumentation, extensive irrigation, and intracanal antibiotic injection, followed by induction of blood and healing in the canal.[8]

In contrast, RET or Regenerative Endodontic Surgery (REPS) is a biological procedure designed to replace damaged structures such as roots and dentin, as well as cells in the pulp-dentin complex. The main purpose of REPS is to stimulate mesenchymal stem cells such as bone/dental progenitor stem cells, dental pulp tissue in the root canal and to create a suitable environment for the continuation of the tooth root. [12]

Methodology

Protocol development

Review was performed in according to PRISMA guidelines [13] with the following focused research question "Is there any difference in the effectiveness of regenerative endodontics (C) and apexification procedures (I) in patients with necrotic permanent tooth (P) with regards to (O) survival rate, success rate, increase in root length, root width and decrease in apical diameter"?

Eligibility Criteria: studies were selected based on following criteria's:

Inclusion Criteria

1. Articles in English language and having sufficient data on effectiveness of REP and AP and reporting outcome in terms of survival rate, success rate, increase in root length, root width and decrease in apical diameter.
2. Studies published between January 2000 till April 2023 and as free available full text articles and from open access journals.
3. Comparative studies and clinical studies were taken into consideration.

Exclusion criteria

1. Articles in other than English language.
2. Reviews, abstracts, letter to the editor, editorials, animal studies and in vitro studies will be excluded.
3. Articles not from open access journals

Data extraction

The descriptive study details were extractedwith the following headings: author(s), country of study, year of study, sample size, reason for pulp necrosis, irrigation material used, intracanal medicament used, follow up duration, intervention and comparator group.

Search Strategy

An electronic search was performed from January 2000 till April 2023 for the studies published within the last 23 years using the following databases: PubMed, google scholar and EBSCOhost.

Appropriate key words and Medical Subject Heading (MeSH) terms were selected and combined with Boolean operators like AND using the following keywords and their combinations: “root canals” (MeSH) AND “regenerative endodontics” (MeSH); “apexification procedure” (MeSH) AND “calcium hydroxide” (MeSH); “mineral trioxide aggregate” (MeSH) AND “necrotic pulp” (MeSH) AND apical periodontitis (MeSH); “pulp regeneration” (MeSH) AND “endodontic infections” (MeSH) AND “irrigants” AND “periapical disease” AND “randomized controlled trials” (MeSH); AND “comparative study”.

Study Characteristics

A summary of qualitative study characteristics all included studies is shown in **Table 1.** Data was evaluated from nine studies [13-21] from a total of 671 teeth with pulp necrosis having undergone the endodontic treatment. Trauma and caries were the common reason for pulp necrosis with presence of periapical pathology. All the included studies had randomized controlled trial (RCT) study design. EDTA and NaOCL were the most commonly usedirrigants with placement of triple antibiotic paste (TAP) and calcium hydroxide as intracanal medicament. All the included studies had regenerative endodontic procedure (REP) compared against the apexification procedure with MTA and $Ca(OH)_2$ with a mean follow up duration of 15 months for inducing incomplete root formation and proper apical closure.

Table 1: Showing descriptive characteristics of included studies.

Author, years of study	Study type	Sample size	Pulp necrosis reason	Irrigation method	Intracanal medicament	Follow up (months)	Intervention	Comparator group
Alobaid et al. 2014[13]	RCT	31	Trauma	17% EDTA	TAP	15-22	REP	AP
Awies et al. 2017[14]	RCT	22	Trauma/Caries	5.25% NaOCL	TAP	12	REP	AP
Chen et al. 2015[15]	RCT	38	Trauma/Caries	2.5% NaOCL	-	12	REP	AP
Felippe et al. 2006[16]	RCT	20	Caries	1.5% NaOCL	$Ca(OH)_2$	5	REP	AP
Jeeruphan et al. 2012[17]	RCT	61	Trauma/Caries	5.25% NaOCL	TAP	24	REP	AP
Lin et al. 2017[18]	RCT	103	Trauma	1.5% NaOCL, 17% EDTA	TAP	12	REP	AP
Pereira et al.	RCT	44	Trauma	1.5%	TAP	12-30	REP	AP

2020[19]				NaOCL, 17% EDTA, saline and CHX				
Silujjal et al 2016[20]	RCT	43	Trauma/Caries	1.5% NaOCL, 17% EDTA	$Ca(OH)_2$ / TAP	12-96	REP	AP
Xuan et al. 2018[21]	RCT	30	Trauma	-	-	12	REP	AP

AP- apexification procedure; CHX- chlorhexidine; EDTA- ethylene dioxide tri-aggregate; REP- regenerative endodontics procedure; Tap- triple antibiotic paste.

Discussion

Apexification is the traditional method in treating permanent, non-vital teeth. This approach has been performed using calcium hydroxide $Ca(OH)_2$ after root canal antibiotics, is recommended.[5] $Ca(OH)_2$ is convenient, easy to use, inexpensive, and widely used in medicine.[10] Disadvantages of long-term $Ca(OH)_2$ therapy include unpredictability of formation of an apical seal and difficulty in following up with patients.[6]

The method of using $Ca(OH)_2$ to achieve apexification is gradually being replaced by mineral trioxide aggregate (MTA) as a one-step technology.[11,12] The advantages of using an apical plug include less equipment to complete the treatment appointment, more predictable apical barrier formation, and a reduced need for a patient follow-up. [11]

This review was conducted to provide a comparative analysis between regenerative endodontics and apexification procedures with mineral trioxide aggregate and calcium hydroxide for inducing incomplete root formation and proper apical closure. Both the interventions are aimed at saving immature necrotic teeth.

However, the results of this review are consistent with the systematic review and review by Panda et al. 2022 [22] to compare clinical outcomes using endodontic therapy (RET) and apexification in the treatment of young, immature teeth. Clinical outcomes such as dentin wall thickness (DWT), root length increase (RL), apical closure (AC), viability response (VR) and success rate (SR) were evaluated. The survival rate was found to be similar in both interventions; However, if root development is poor, dentin is insufficient, and the prognosis of the tooth is hopeless even with apical treatment, RET should be preferred.

Systematic review [23] evaluated the clinical` and functional outcomes of immature teeth treated with endodontic revascularization or apexification after at least three months of follow up to determine which was most effective. The authors concluded that although endodontic revascularization surgery can make roots longer and wider, trials are needed to measure the "true increase" in root growth using the standard model because some electronic interventions may exaggerate the gain. It is also concluded that appropriate root canal antibiotics should be considered to improve SCAP survival while reducing microbial infection and infection risk. According to their meta-analysis, the results did not favour one treatment over the other.

Another review [24] evaluated the clinical and radiographic outcomes of non-vital permanent teeth

treated with RET, and the authors found positive tooth survival and periapical pathology after RET. However, results regarding better outcomes such as continued root growth are unclear. This study also follows up on the results of our review.

Conclusion

Clinicians should consider REP in cases with root growth defects, inadequate dentin, and where the dental outcome is hopeless. REP improved apical closure. MTA and $Ca(OH)_2$ have similar effects in creating a calcification barrier, but it can be concluded that reconstructive surgery is better than apexification surgery and has better results.

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