Review Article

Management of Open Apex: A Review

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Abstract

Endodontic management of immature permanent teeth is still a challenge for both clinicians and researchers. Previously our concers were only associated with achieving adequate levels of disinfection since "aggressive" instrumentation was contraindicated and hence there exists a much greater reliance on irrigants and medicaments. TOOTH with open apex has also presented difficulties during obturation basically in controlling length. Long-term apexification procedures with calcium hydroxide have proven to be successful in saving many of the immature infected teeth but due to perceived problems associated with long-term placement of calcium hydroxide, which make canal walls prone to cervical fracture. Regenerative endodontics has brought a revolutionizing tissue engineering concept in the field of endodontics for the treatment of immature permanent teeth. It's been considered as a "paradigm shift" in the treatment modalities, as it fosters continued root maturation. Hence, this article reviews about the current techniques available for the management of permanent teeth with open apex.

Keywords: Apexification, Apexogenesis, MTA, Revascularization.

Introduction

Once enamel and dentin formation has reached the future CEJ, Hertwig's epithelial root sheath (HERS) begins with root development which determines its shape, size, number and length, but exact function of these cells is less definite. Literature suggests that in permanent tooth, root closure occurs 3 years post eruption, but before that, if any destruction occurs at HERS it leaves an open apex at the root end with weak, thin walls following discontinuous periodontal ligament formation and once destructed in HERS occurs it causes cessation in normal root development with no further odontoblastic differentiation because HERS remains sensitive to trauma, but this does not mean that it's an end and no further deposition of hard tissue will occur in this region.[1]

What is open apex?

Open apex is an unusual wide apical foramen that arises due multiple reasons such as incomplete development, extensive apical resorption, caries leading to pulpal necrosis or trauma before complete root formation, root-end resection, or maybe due to over instrumentation. Classically, there are two types of open apices; Blunderbuss were walls are divergent and flaring (apex being funnel shaped) whereas in *Non-Blunderbuss* walls may be slightly convergent to almost parallel.[2]

Access this article online

Website: www.jrad.co.in

DOI: https://doi.org/10.53064/jrad.2022.13.1.116

Problems associated with immature apex

- Achieving adequate apical seal using conventional obturation techniques
- Higher chances of fracture before, during, or after treatment because of the weak and thin dentinal walls
- Frequent periapical lesions occurring with or without apical resorption
- Crown root ratio is generally compromised resulting in short root.[3]

Investigation and diagnosis

Treatment plan majorly depends upon stages of root development and pulpal conditions. However pulp preservative strategies, early diagnosis, and intervention promote an environment for continued dentine apposition and root formation.

- Electric and thermal tests have limited value because of varing responses of permanent teeth with immature apex. Cold tests are considered more reliable than EPTs in teeth with incomplete root formation, but in traumatic injuries electric and thermal pulp tests both may be unreliable, only generalized idea can be taken from these tests.

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Received: 12 Oct, 21; **Accepted:** 12 Dec, 2021; **Published:** 31 Dec, 2021

How to cite this article: Jain V, Gandhi S, Hora BS, Ranka A. Management of Open Apex: A Review. J Res Adv Dent 2022;13(1):50-54.

- Laser Doppler Flowmetry measures blood flow in traumatized teeth and may serve more accurate readings.
- The pulse oximeter another accurate means of monitoring vitality as it records oxygenation levels in pulpal flow.
- Radiographic examination requires high-quality periapical and bitewing radiographs. They reveal about periapical status, type of open apex, its extent in relation to root development stage. Additionally using Cone Beam Computed Tomography provide more accurate information regarding periapical pathosis and root formation as compared to conventional radiographic techniques.[4]

Treatment modalities

Vital tooth with open apex

- Apexogenesis

Non vital tooth with open apex

- Apexification
- Revascularisation
- Regeneration

Apexogenesis

Apexogenesis is a "vital pulp therapy procedure that encourages continued physiological development and root end formation." In this healthy pulp tissues are protected by bioactive materials and inflamed part of pulp tissues are removed.[5]

Goals of apexogenesis by webber

1. Sustaining a viable Hertwig's sheath, allows continued development of root length to achieve more favorable crown-root ratio.
2. Maintaining pulpal vitality, allows remaining odontoblasts to lay down dentine, thus producing a thicker root and reducing chance of root fracture.
3. Promoting root-end closure, promotes natural apical constriction for root canal filling.
4. Generating a dentinal bridge at the site of the pulpotomy. Although bridging is not essential for the success of the procedure, it only suggests that pulp's vitality is preserved.

The time required for achieving the goals of apexogenesis ranges between 1 and 2 years depending on the degree of tooth development at the time of procedure. To determine the vitality of the pulp and the extent of apical maturation, patients are recalled at 3-months interval. If the pulp found, has become irreversibly inflamed, necrotic or internal resorption is evident, then immediately extirpated the pulp and start with apexification therapy.[2]

Procedure

Administer local anesthesia and place rubber dam, then remove all carious tooth structure then open up the pulp chamber and remove coronal pulp tissue with excavator. Care should be taken not to damage the radicular pulp and rinse all the residual debris. Hemorrhage should be controlled using moist cotton pellet over the amputated pulp. $Ca(OH)_2$ mixture is placed over the pulp stumps, then temporary restoration. Follow-up radiographs are taken periodically to check the root development. Once root development is complete root canal treatment is done.[5]

Materials used for apexogenesis

Calcium hydroxide, MTA, Calcium enriched mixture, Biodentine, Lasers

Indication

- Traumatized or pulpally involved vital permanent tooth when the apex is incompletely formed
- No history of spontaneous pain, sensitivity on percussion, or hemorrhage
- When radiographic appearance is normal.

Contraindication

- Evidence that radicular pulp has undergone degenerative changes
- Purulent drainage and periapical radiolucency
- History of prolonged pain
- Necrotic debris in canal.[6]

Apexification

Apexification is defined as method of inducing apical closure by the formation of osteo-cementum or similar hard tissue or the continued development of incompletely formed tooth in which pulp is no longer vital.-American Association of Endodontics

Objective

To induce the closure of the root canal's apical third or initiate the formation of calcific barrier against which obturation could be done.

Why apexification needed?

- So that thin root canal walls which are prone to fracture can be strengthened
- Tooth with open apex have large apical diameter and smaller corona diameter makes debridement difficult
- Since no apical stop present, it makes obturation difficult
- Complete dryness within the canal cannot be achieved.[7]

Diagnosis of cases for apexification

The results of one test cannot give the appropriate diagnostic result, hence a combination of radiographic, symptomatic, and clinical tests are required to decide the treatment plan. If the tooth is diagnosed to have necrotic pulp, then apexification is the treatment of choice.[8]

Traditional apexification (calcium hydroxide apexification)

Apexification is a conventional method for treating permanent teeth with open apices using calcium hydroxide dressings. Their procedures include chemo-mechanical canal debridement to a point just short of the apex, followed by placement of biocompatible material.

Disadvantages

Long-term application of calcium hydroxide dressings makes root dentine brittle due to its hygroscopic and proteolytic action, thus increasing risk of root fracture.

Calcium hydroxide apexification requires frequent medicament changes and long treatment period.

Single VISIT Apexification (MTA apical barrier)

In 1999 MTA was proposed for use as an "apical plug" in apexification cases. Authors suggested that after 1 week of calcium hydroxide dressing, 3–4 mm of MTA is placed apically with pluggers and paper points. Over the ensuing years, the technique has evolved into a single visit treatment, also known as the apical barrier technique or MTA apical plug. The MTA apexification technique is considered more challenging than the calcium hydroxide technique.[9]

Procedure[6,9]

FIRST VISIT

Includes chemo-mechanical preparation, disinfecting the root canals and short-term dressing of canals with $Ca(OH)_2$ for at least a week.
week

SECOND VISIT

Access is reopened & $Ca(OH)_2$ paste is flushed out from the canals via 0.5% sodium hypochlorite and 17% EDTA

↓

Canals are fully dried and MTA is mixed to a correct consistency

↓

Then the thick paste of MTA is placed into the apical portion of the root canal with a Half Hollenbach instrument

↓

MTA is then condensed (to the correct working length with large paper points or loose fitting pluggers) such that 3–4 mm apical plug is created and is confirmed using radiograph

↓

Over MTA a moist cotton pellet is placed and tooth is temporarily restored with cavit for minimum 3–4 hours

↓

In the next appointment, canals are filled with thermoplasticized GP and cement following final closure with composite restoration.

Advantages

- MTA allows short span treatment time. (2–3 appointments)
- Better patient compliance
- Good biocompatibility (extruded MTA does not produce an adverse host response or affect periapical healing)
- Sets well in moist environment with excellent sealing ability.

Limitations

- It does not allow continued root development or improvement in crown root ratio
- It does not strengthen or reinforce the tooth, thus the risk of future root fracture exists but less than $Ca(OH)_2$ therapy
- Higher cost of MTA.

Modified apexification

A modified apexification procedure allows immature permanent teeth with necrotic pulp/apical periodontitis to use post/core for final restoration with the potential for continued apical root development, which has an advantage over current apical barrier techniques.

Criteria

1. Immature permanent teeth with lost substantial coronal tooth structure for final restoration using post/core may reinforce the strength of these teeth against masticatory force to avoid cervical root fractures
2. Immature permanent teeth at the 3rd and 4th stage shows root development because they have achieved adequate thickness in canal walls and root length for post/core placement
3. To encourage continued root development Modified apexification procedure can be implied as an alternative to traditional apexification.

Advantage

- The coronal aspect of the root can be used with either a post or composite resin placement which strengthens its roots against fracture (Flowable composite resin, dual-cure composite, and fiber posts of depth 3 mm can be used.)
- Potential for further root maturation, unlike traditional procedures.[10]

Procedure[10]

Isolate the tooth using rubber dam. under local anesthesia

↓

Then chemo-mechanical preparation followed by adequate disinfection of the root canal walls

↓

Then a resorbable, biocompatible approx. 3-mm thick collagen matrix is placed 1–2 mm short of open apex to avoid extrusion of MTA/ Biodentine into the periapical area

↓

A 3-mm thick MTA/Biodentine plug is placed over the collagen matrix. then placed over the collagen matrix

↓

The remaining canal space is with thermoplastisized gutta-percha using vertical compaction. compaction technique

↓

Then access cavity is restored using permanent restorative materials

↓

The collagen matrix will eventually get resorbed, leaving behind 4–5 mm of unfilled canal space. apical root development.

Revascularisation

It is defined as re-establishment of vascular supply in immature permanent teeth.

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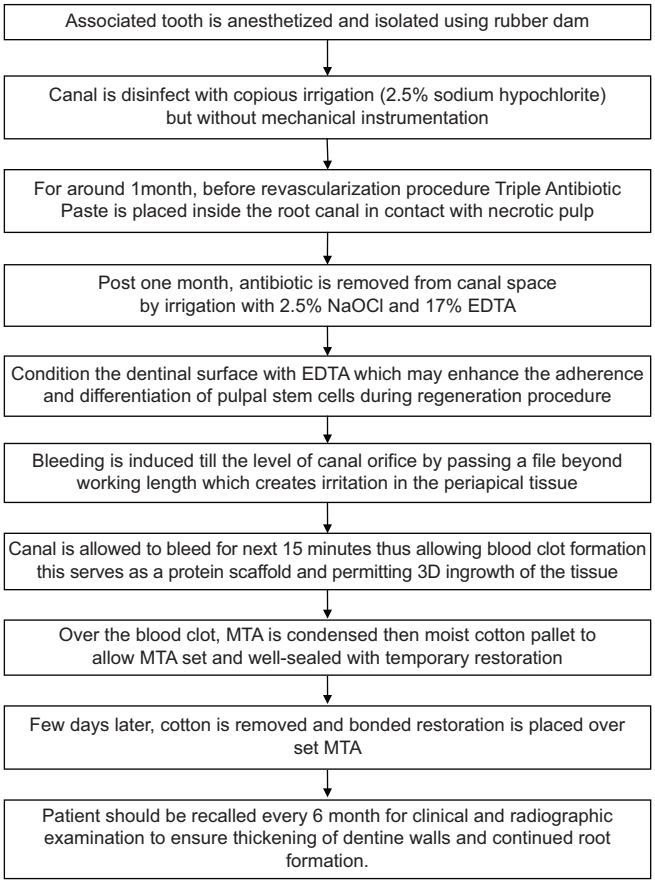
Ideal goal

Is to create an environment inside the root canal space (i.e., absence of bacteria and necrotic pulp tissue, presence of scaffold, and a tight coronal seal) that promotes repopulation of stem cells, regeneration of pulp tissue, and thus achieving continued root development.

Indications

- In immature permanent tooth with open apex comprising width of 1.1 mm diameter or even larger with exposed pulp.
- A non-vital traumatized tooth where apexogenesis, apexification, partial pulpotomy, or root canal treatments cannot be performed.
- In children among 7–16 years age group, who are mentally and physically sound and parents agreeing for multiple appointments.
- In patients non-allergic to anesthetic without a vasoconstrictor (used when attempting to induce bleeding into the canal).
- In tooth that can be restored with resin-modified glass ionomer to help prevent microleakage.[11]

Procedure[12]



Regenerative endodontics

Definition

Regenerative dentistry is the branch of regenerative medicine that focuses on the regeneration of oral and dental tissues.

It follows the conceptual triad of tissue engineering comprising stem cells, scaffolds, and bioactive molecules (growth factors).

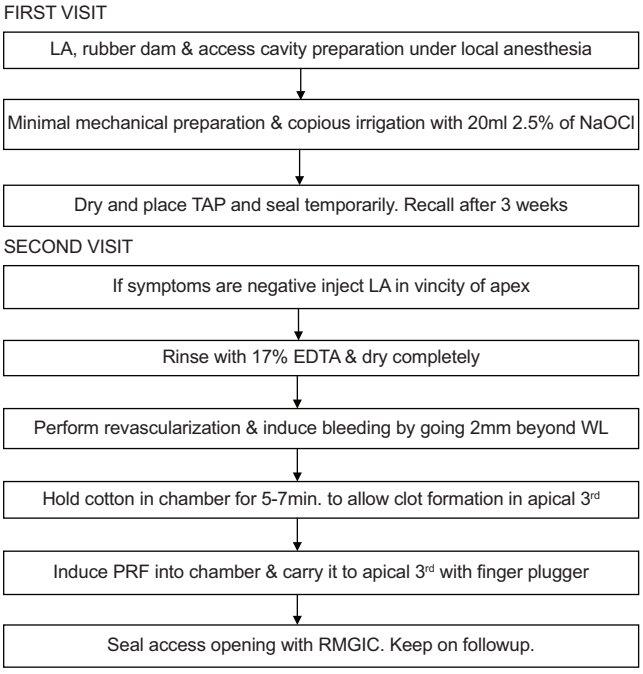
The goals of regenerative endodontic procedure include:

- Primary goal: To treat apical periodontitis and successfully allow healing of damaged apical tissue, eliminating clinical symptoms and signs
- Secondary goal: To regenerate the structure and function of the dentin-pulp complex. (Though apexification methods using either long-term calcium hydroxide or a one-visit MTA plug that resolves apical periodontitis, these approaches cannot restore the original anatomic structure and physiological function of the dentin-pulp complex).
- Tertiary goal: To regain the tooth vitality (Positive response to vitality testing).[13]

Current approaches for pulp-dentine regeneration

1. Traditional rep for permanent teeth with open apex
   Traditional REP is performed by inducing bleeding into the canal by over-instrumentation in immature permanent teeth.
2. Rep using platelet-rich plasma for permanent teeth with open apex
   Liu *et al*. showed that PRP stimulates cell proliferation and differentiation of the dentin-pulp complex, which suggested that PRP could be used as a scaffold for pulp capping.
3. Rep for adult mature permanent teeth
   This procedure includes dental pulp and dentin regeneration in mature permanent teeth in adults. Broadly, there are two distinctive strategies which include cell transplantation of ex vivo cultivated stem/progenitor cells and cell homing by molecules that recruit the patient's resident cells.[14]

Procedure



In sings/symptoms persist-delay REP until symptoms subside.

REP procedure using Platelet Rich Plasma for permanent teeth with open apex[15]

Limitations of regenerative endodontic therapy

- Patient compliance is important since it's a multiple appointment approach and requires slightly longer duration of working hours
- Crown discoloration associated with minocycline in TAP and MTA (gray/white)
- Rather than true regeneration, there is histologic evidence of repair after RET
- In some cases, root fractures were seen
- Internal ankylosis maybe seen due to ingrowth of cementum, PDL, and bone into the canal space
- Intracanal calcification maybe seen in few cases
- Another crucial factor for the success of RET is patients age
- More successful in younger patients than older ones

Advantages

- Continued root development (root lengthening) and strengthening due to reinforcement of lateral dentinal walls because of deposition of new dentin/hard tissue.
- Obturation of the canal is not required (inherent danger of fracturing the roots during lateral condensation can be avoided).
- Once the infection is controlled, procedure can be completed in a single visit.

Disadvantages

- Discoloration due to use of minocycline in TPA (revealed by Kim *et al*.)
- Prolonged treatment period and more appointments (compared with one-visit MTA apical barrier technique).[16]

Conclusion

Management strategies for treating immature, permanent teeth with necrotic and infected pulps with open apices are changing from apexification procedure toward regenerative endodontic procedures and major reason behind this is it allows continued root development. No strict guidelines for case selection for REP are available and need for future clinical trials to investigate REP that allows clinicians to make evidence-based decisions regarding its place in the clinical management of infected, immature permanent teeth.

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