Review

CHALLENGES IN PULPAL TREATMENT OF YOUNG PERMANENT TEETH – A REVIEW

Anantharaj .A\textsuperscript{1}, Praveen.P\textsuperscript{2}, Karthik Venkataraghavan\textsuperscript{3}, Prathibha Rani.S\textsuperscript{4}, Sudhir.R\textsuperscript{5}, Murali Krishnan.B\textsuperscript{6}

\textsuperscript{1}Professor and Head, \textsuperscript{2,3}Professor, \textsuperscript{4,5}Lecturer, \textsuperscript{6}Post Graduate Student
Department of Pediatric and preventive dentistry, D.A.P.M.R.V Dental College, Bangalore.

Abstract

The golden rule in the practice of Endodontics is to debride and obturate the canals as efficiently and three dimensionally as possible in an amount of time and appointments that are reasonable to the patient. It is reasonable to assume that most Pedodontists have achieved the necessary skills to manage predictably andcomfortably most of the endodontic cases in their practices. Unfortunately traumatic injuries to young permanent teeth are not uncommon and are said to affect 30\% of children. These injuries often result in pulpal inflammation or necrosis and subsequent incomplete development of dentinal wall and root apices.

The importance of careful case assessment and accurate pulpal diagnosis in the treatment of immature teeth with pulpal injury cannot be overemphasized. The diagnostic techniques for evaluating pulpal and periodontal healing subsequent to trauma are a major problem.
Depending upon the vitality of the affected pulp, two approaches are possible, apexogenesis or apexification. As always, success is related to accurate diagnosis and a full understanding of the biological processes to be facilitated by the treatment.

**Key Words:** Trauma, Diagnosis, Immature Apex, Apexification

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**Introduction**

The golden rule in the practice of Endodontics is to debride and obturate the canals as efficiently and three dimensionally as possible in an amount of time and appointments that are reasonable to the patient. It is reasonable to assume that most Pedodontists have achieved the necessary skills to manage predictably and comfortably most of the endodontic cases in their practices.

Before 1966 the clinical management of the “Blunder buss” canal usually required a surgical approach for the placement of an apical seal into the often fragile and flaring apex. Treatment was complicated when patient management required conscious sedation or general anaesthesia, especially with children.

Apexification with calcium hydroxide $\text{Ca (OH)}_2$ has proved to be a reliable and most welcome addition to the therapeutic armamentarium since Frank described it in 1966.
The present article is a review of various materials and methods which have been in practice mentioning the advantages and disadvantages of the same.

**Causes of open apices**

1. **Incomplete development**
   - The open apex typically occurs when the pulp undergoes necrosis as a result of caries or trauma, before root growth and development are complete (i.e. denture Cvek’s Stages 1-4).
   - Some other causes of incomplete development are
     - Dens in dente
     - Dentin dysplasia (type II)
   - An open apex can also occasionally form in a mature apex (Cvek’s stage 5) as a result of

2. **Extensive apical resorption**
   - Due to orthodontics, periapical pathosis or trauma.

3. **Root end resection**
   - During periradicular surgery

4. **Over-instrumentation**
   - In cases of establishing drainage though root canals and removing gutta percha points during retreatment, an apical constriction might sometimes be inadequately removed.

**Pulpal injury in teeth with developing roots**

Unfortunately traumatic injuries to young permanent teeth are not uncommon and are said to affect 30% of children. The majority of these incidences occur before root formation is complete in the 8 to 12 year age range and
most commonly involve maxillary anterior teeth. These injuries often result in pulpal inflammation or necrosis and subsequent incomplete development of dentinal wall and root apices.

The root sheath of Hertwig is usually sensitive to trauma but because of the degree of vascularity and cellularity in the apical region, root formation can continue even in the presence of pulpal inflammation and necrosis. Because of the important role of Hertwig’s epithelial root sheath in continued root development after pulpal injury, every effort should be made to maintain its viability.

**Common problems associated with open apices**

- Large open apices
  - Convergent
  - Parallel
- Divergent
- Thin dentinal walls
  - Which are susceptible to fracture before, during or after treatment.
- Short roots
  - Thus compromising crown-root ratio
- Fractures of crown.
  - Compromising esthetics especially in the anterior region
  - Necessitating post endodontic rehabilitation of both crown and root.

Discoloration in long standing cases

According to Morse et al there are at least 5 methods of treating a
tooth that has a necrotic pulp and an open apex. These methods are

1. **A customized cone (Blunt end, rolled cone)**

   Filling the root canal with the large (Blunt) end of a gutta percha cone or customized gutta percha cones with a sealer.

2. **A short fill technique**

   Filling the root canal well short of the apex (before the walls have diverged) with gutta percha and sealer or zinc oxide eugenol (ZOE) alone.

3. **Periapical surgery (with or without a retro grade seal)**

   Filling the root canal with gutta percha and sealer as well as possible and then performing periapical surgery with or without a reverse seal.

4. **Apexification (Apical closure induction)**

   Inducing apical closure by the formation of an apical stop (Calcium hydroxide, Ca(OH)$_2$ is generally used) against which a permanent root canal filling can subsequently be inserted.

5. **One visit apexification**

   Placing a biologically acceptable substance in the apical portion of the root canal (Dentinal chips or Tricalcium phosphate have been used) thus forming an apical barrier. This is followed by filling the root canal with gutta percha and sealer.

According to the studies done by Alfred Frank the types of maturation can be as follows.

1. Continued apical development with a definite though minimal, recession
of the root canal i.e. the apex develops normally.

2. Continued apical development without any change in the root canal space (Dome apexification) i.e. Apical maturation is produced without the root canal changing its form.

3. Thin calcific bridge, formation at the apex without apical development. The apex keeps its blunderbuss form but it closed by a thin walled calcified bridge.

4. Lack of apical development with a calcified bridge just coronal to the apex. The apex keeps its blunderbuss form and the bridge of calcified tissue is formed beneath it.

A 5\textsuperscript{th} type of canal closure has been reported by Gerald M. Cathey \textsuperscript{2} (Cathey’s apexification treatment). Continued apical development with calcific bridge just coronal to apex

**Review of apexogenesis**

Although vital pulp capping and pulpotomy procedures of curiously exposed pulps in mature teeth remain controversial, it is universally accepted that vital pulp therapy is the treatment of choice for vital immature teeth (incompletely developed apices).

Certain authors \textsuperscript{3} prefer that maturogenesis become the accepted term to use when dealing with the treatment of immature teeth with vital pulps.

Maturogenesis shows a concern not only for a wide open apex (apexogenesis) but also for roots having very thin and weak walls.
Apexogenesis involves removal of the inflamed pulp and the placement of calcium hydroxide on the remaining healthy pulp tissue. Traditionally this has implied removal of the coronal portion of the pulp.

The goals of apexogenesis, as stated by Webber \(^2\) are as follows.

1. Sustaining a viable Hertwig’s sheath, thus allowing continued development of root length for a more favorable crown to root ratio.

2. Maintaining pulpal vitality, thus allowing the remaining odontoblasts to lay down dentine, producing a thicker root and decreasing the chance of root fracture.

3. Promoting root end closure, thus creating a natural apical constriction for root canal filling. Generating a dentinal bridge at the site of the pulpotomy. While the bridging is not essential for the success of the procedure, it does suggest that the pulp has maintained its vitality.

**Review of apexification**

Apexification treatment is supposed to create an environment to permit Hertwig’s epithelial root sheath to continue its function of root development. The hardy sheath is often able to recover its function in spite of inflammation, infection, and mechanical or chemical trauma.

However, other healing mechanisms may be involved, as apical closure has been reported to
occur even when Hertwig’s sheath had been removed surgically by apical curettage during Ca (OH)₂ apexification treatment. 

**Different methods of apexification**

1. **Removal of infected necrotic pulp tissue**

Moller et al. have shown that infected necrotic pulp tissue induces strong inflammatory reactions in the periapical tissues. Therefore removal of the infected pulp tissue should create an environment conducive to apical closure without use of a medication.

Some believe that instrumentation may in fact hamper root development and that preparation of these canals should be done cautiously, if at all.

Cooke and Robotham⁵ hypothesize that the remnants of Hertwig’s epithelial root sheath, under favorable conditions, may organize the apical mesodermal tissue into root components.

2. **Use of antiseptic or antibiotic pastes.**

A number of investigators demonstrated apical closure using an antiseptic paste as a temporary filling material following root canal debridement and Ball successfully reproduced these results using an antibiotic paste. Rule and Winter used a polyantibiotic paste to close the apex, and in some cases, described continued root development.

3. **Induction of a blood clot in the peri radicular tissues.**
Nygaard-Ostby hypothesized that laceration of the periapical tissues until bleeding occurred might produce new vital vascularized tissue in the canal.

Ham et al. 1972 also reported closure of the end of the root, by ‘induced blood clot’. The periapical tissues were deliberately probed with a file until bleeding occurred.

Francisco Banchs and Martin Trope in a case report described wherein the canal was disinfected without mechanical instrumentation with the use of copious irrigation followed by a mixture of antibiotics (mixture of Ciprofloxacin, metranidazole and minocycline paste). A blood clot was then produced to the level of the cementoenamel junction (CEJ), followed by a deep coronal restoration with MTA.

A study done by N. Shah in 2009 where 14 infected immature teeth were treated by parapical revascularization method. The cases were followed up at regular intervals of 3 months; the range in follow-up was 0.5–3.5 years. There was radiographic resolution of periradicular radiolucencies, root length increase and thickening of dentinal wall. None of the cases presented with pain, reinfection, or radiographic enlargement of preexisting apical pathology.

4. **Calcium hydroxide**

Calcium hydroxide was introduced by Hermann in the 1920’s for endodontic treatment. The induction technique was first addressed in the United States in 1964 with separate presentations by Kaiser and Frank at the 21st...
annual meeting of the American Association of Endodontists

Mechanism of action of Ca(OH)₂ to induce formation of a solid apical barrier.

Some of the postulated mechanisms of the osteoconductive effects of Ca(OH)₂ are as follows ¹⁸

1. Presence of high calcium concentration increase the activity of calcium dependent pyrophosphatase.
2. Direct effect on the apical and periapical soft tissue
3. High pH, which may activate alkaline phosphatase activity
4. Antibacterial activity

**Mean time for apical barrier formation**

In a review of ten studies, Sheehy and Roberts ⁹ reported an average length of time for apical barrier formation ranging from 5 to 20 months. Finucane of Kinirons reviewed 44 non vital immature incisors undergoing calcium hydroxide apexification and found that the mean time to barrier formation was 34.2 weeks (range 13-67 weeks).

**Success rates**

Published case reports and several long term studies have stated a success rate of 74-96% ¹⁰. In a review of 10 studies, Sheehy an Roberts ⁸ reported that the use of calcium hydroxide for apical barrier formation was successful in 74-100% of cases irrespective of the proprietary brand used

**Mineral trioxide aggregate**

In recent times interest has centered on the use of mineral trioxide aggregate (MTA) for apexification. This material was first introduced in 1993 and...
received food and drug administration (FDA) approval in 1998.

A histomorphologocal study done where the pulp was capped either with ProRoot (Dentsply) or MTA-Angelus (Angelus) and restored with zinc oxide eugenol cement. After 30 and 60 days, teeth were extracted and processed for histological examination and the effects on the pulp were scored. Overall, 94% and 88% of the specimens capped with MTA-Angelus and ProRoot, respectively, showed either total or partial hard tissue bridge formation and it was concluded that MTA or ProRoot can be used in caries free tooth for apex closure.\(^{11}\)

A study done by Pinar Erdem et al\(^{12}\) in where Mineral trioxide aggregate was used for obturation of maxillary central incisors with necrotic pulp and open apices. They concluded that MTA can be considered a very effective option for apexification with the advantage of reduced treatment time, good sealing ability and high biocompatibility.

**Calcium – β-glycerophosphate**

calcium – β-glycerophosphate is a source of calcium and inorganic phosphate through hydrolysis by alkaline phosphates in blood and tissue fluid, and it is converted to hydroxyapatite.

Meguni Imai\(^{13}\) in a case demonstrates an artificial apical barrier formation by using calcium – β – glycerophosphate paste in a non vital permanent tooth with an open apex communicating with the maxillary sinus. The apical third of the root canal was medicated with ca – β glycerophosphate powder.
mixed with a .09% isotonic saline solution. One week later, an apical barrier (about 1mm in thickness calculated from the original working length)

**Collagen gel**

In 1980 Nevins et al in a subhuman primate study demonstrated that cross linked collagen gel can be used to induce regeneration. In 1977 one clinical case was reported by Nevins et al in which an immature partially vital maxillary lateral incisor was totally pulpectomized and filled with a collagen gel.

Alan Nevins, Paul Crespi reviewed the use of Zyplast collagen gel as a hard tissue induction material in fractured and undeveloped teeth and reported favorable outcomes using collagen-calcium phosphate gel

**Bone morphogenic proteins**

BMP’S are used to promote bone formation. Stimulates proliferation of mesenchymal cells that subsequently differentiate into osteogenic lineagesRutherford et al reported in a subhuman primate study that the addition of bone morphogenic protein in a collagen carrier matrix when applied to partially debried root canals allowed for more tissue growth than collagen matrix alone.

**Conclusion**

Every effort should be made to attain the genetically programmed closure of foramen that remains open because of early pulp death. This can be accomplished by apexification a method of
recharging the growth potential and restoring root growth and foramen closure. The present article gives a comprehensive review of the various materials and methods used for apical closure.

References
8. Mary Rafter, Apexification : a review. Endodontic Dental Traumatology 2005 : 21 (1) : 1


11. Evaluation of two mineral trioxide aggregate compounds as pulp-capping agents in human teeth, IEJ Jan 2009


**Correspondence**
Dr. Anantharaj A, Professor and Head, Department of Pediatric and Preventive dentistry, D.A.P.M.R.V Dental College, Bangalore
Email: dranantharaj@gmail.com