International Journal of Enhanced Research in Medicines & Dental Care (IJERMDC),
ISSN: 2349-1590, Vol. 12 Issue 9, September 2025

Present status and future directions: Apexification

Himanshi Verma[1], Rinda Sharma[2]

[1]Department of Conservative Dentistry & Endodontics, Post Graduate Institute of Dental Sciences, PGIDS, Rohtak
[2]Department of Periodontics, Post Graduate Institute of Dental Sciences, PGIDS, Rohtak

ABSTRACT

The success of apexification is influenced by several factors, including the material used, the ratio between the open apex diameter and root length, and the technique adopted. This review aims to provide an updated perspective on the current management of open apices and to identify the factors and clinical situations that may affect the success of apexification with various materials and methods. Future research should emphasize developing predictable nonsurgical approaches for treating open apices associated with large periapical lesions. Earlier, the predictability of such nonsurgical outcomes was uncertain; however, the introduction of the dental operating microscope has significantly improved treatment accuracy and prognosis. Moreover, advancements in materials and armamentarium have minimized the need for multiple appointments, making apexification more efficient, predictable, and clinically feasible.

INTRODUCTION

Root development and apical closure are usually completed within three years after tooth eruption. During this period, immature teeth are highly susceptible to trauma, which can arrest root formation and result in wide canals with open apices, complicating endodontic management[^1]. Traumatic injuries to anterior teeth, especially maxillary incisors, affect nearly 16%–17% of the population and may lead to pulp inflammation or necrosis[^2].

Although regenerative endodontic procedures have gained popularity for promoting continued root development in nonvital teeth, their predictability remains limited. Apexification, therefore, continues to be a widely accepted approach for treating pulpless permanent teeth with open apices (“blunderbuss” canals), aiming to induce apical healing and hard tissue barrier formation[^3]. However, managing immature necrotic teeth remains challenging due to complex root anatomy, difficulty in canal instrumentation, absence of an apical stop, and thin, fragile dentinal walls[^4,^5].

ETIOLOGY OF OPEN APEX

An open apex may result from several causes, including pulp necrosis secondary to dental caries or trauma, extensive apical root resorption associated with orthodontic treatment, or periapical pathosis following trauma. Iatrogenic factors such as over-instrumentation, thermal, or chemical injuries can also contribute. Developmental anomalies like dens invaginatus and dentin dysplasia may present with similar clinical features.

Teeth with open apices present multiple clinical challenges: thin dentinal walls that increase the risk of fracture, possible periapical pathology with or without apical resorption, and a reduced crown-root ratio that compromises long-term prognosis. Additionally, large open apices make determining working length, canal preparation, and obturation more complex[^6].

DIAGNOSIS

Diagnosis of immature teeth with open apices requires both clinical and radiographic assessment. Pulp vitality tests, including electric and thermal tests, often produce variable results in such teeth[^7]. Advanced methods such as Doppler flowmetry can evaluate pulpal blood flow, while pulse oximetry provides a reliable measure of pulp vitality by assessing oxygen saturation levels[^8,^9]. A comprehensive dental and pain history—including duration, character, and aggravating or relieving factors—should accompany clinical examination to assess swelling, discoloration, caries, mobility, and periodontal status[^10].

Radiographic interpretation can be challenging, as distinguishing between normal developing apices and radiolucency due to pulp necrosis is not always straightforward. Comparison with the contralateral tooth may aid diagnosis[^11]. Modern imaging modalities such as cone-beam computed tomography (CBCT) and digital volume tomography (DVT) offer superior visualization and accurate assessment of dentinal wall thickness and periapical lesion size. Early and precise diagnosis enables timely intervention and supports pulp-preserving approaches that promote continued dentin deposition and root development[^12]

WORKING LENGTH DETERMINATION

Wein's guidelines for establishing working length are based on the extent of radiographic evidence of root and bone resorption. When no root or bone resorption is present, canal preparation should terminate 1.0 mm short of the apical foramen. If bone resorption is observed without root resorption, the working length should be reduced by 1.5 mm. In cases where both root and bone resorption are evident, the length should be shortened by 2.0 mm[^21].

Disinfection

Successful apexification relies heavily on thorough disinfection of the root canal system, as the presence of infection can significantly compromise healing and stem cell activity. Microbial contamination impairs the regenerative potential of periapical tissues, underscoring the importance of effective yet biologically compatible disinfectants. Irrigants and intracanal medicaments should not only exhibit bactericidal or bacteriostatic properties but also support stem cell viability and proliferation to ensure favorable treatment outcomes[^22].

Irrigation

Current guidelines recommend irrigation with 5.25% sodium hypochlorite (NaOCl) for one minute. However, Mohmmed et al[^23] reported that this protocol was ineffective in eliminating *Enterococcus faecalis* biofilms. Similarly, Martin et al[^24] demonstrated that 1.5% NaOCl caused less damage to dentinal walls compared to 6% NaOCl.

Effective three-dimensional canal debridement can be achieved using a combination of 17% EDTA and heated 5.25% NaOCl activated ultrasonically. The tissue-dissolving capacity of NaOCl increases with concentration, but so does its potential for cytotoxicity. For teeth with mature apices, a final irrigation sequence of 5.25% NaOCl followed by 17% EDTA is recommended. In contrast, immature teeth are more prone to irrigant extrusion; hence, these cases must be managed with extreme caution[^22].

To minimize apical extrusion, negative pressure irrigation systems such as EndoVac have proven beneficial. Studies, including that by Gade et al[^25], have shown that EndoVac and microcannula systems significantly reduce apical irrigant extrusion compared with conventional needles.

INTRACANALMEDICAMENTS

The use of intracanal medicaments plays a critical role in achieving complete disinfection of the root canal system. An ideal medicament should provide a sustained antibacterial effect after placement. Calcium hydroxide, first introduced by Herman in 1920, remains one of the most commonly used agents. It should be applied using an appropriate carrier and viscous vehicles are preferred because they increase radiopacity and enhance retention within the canal[^26].

Triple antibiotic paste (TAP), introduced by Banchs and Trope, combines metronidazole, ciprofloxacin, and minocycline. Developed under the concept of lesion sterilization and tissue repair (LSTR), TAP targets mixed microbial populations within infected dentin, pulp, and periradicular tissues[^27]. Metronidazole primarily targets obligate anaerobes, while the combination provides broad-spectrum coverage. TAP has demonstrated superior efficacy in reducing bacterial load and eliminating *E. faecalis* even at low concentrations (1 mg/mL to 0.01 mg/mL), with minimal negative effects on stem cell viability[^28]. However, prolonged use may result in tooth discoloration due to minocycline content[^26–29]. Modified pastes containing only ciprofloxacin and metronidazole have been proposed to minimize this drawback[^27].

Recently, Emdogain has emerged as a promising intracanal medicament with potent antibacterial properties and minimal adverse impact on stem cell activity, offering an advantage over conventional agents[^29].

Armamentarium

The essential armamentarium for apexification includes:

- **Rubber dam** for effective isolation and prevention of contamination.
- **Paper points and condensers** for drying and compacting canal materials.
- **Collagen sponge** to serve as an apical matrix or barrier.
- **Dental operating microscope (DOM)** to enhance visualization and precision during material placement.

- **Bioactive materials** such as Mineral Trioxide Aggregate (MTA), OrthoMTA, MTA Plus, Biodentine, EndoSequence, Bioaggregate, MTA Putty, and EndoCem.
- **Micro–apical placement systems** designed for precise delivery of bioactive materials into the apical region.
- **Nickel–Titanium (NiTi) pluggers** for controlled condensation and adaptation of the apical barrier material.

Treatment

When canal walls are parallel or slightly convergent with an apical diameter less than 0.8 mm and the master cone shows a proper "tug-back," obturation with gutta-percha and a bioceramic sealer is recommended. In cases where the apex size exceeds 0.8 mm but the canal remains parallel or slightly convergent (non-blunderbuss type), obturation should include at least a 5 mm apical plug of bioceramic cement, irrespective of the tug-back of the master cone. For canals with divergent or funnel-shaped walls (blunderbuss apex), placement of a minimum 5 mm bioceramic plug is mandatory. Following plug formation, obturation may be completed with gutta-percha and sealer; however, using a bioceramic sealer alone or in combination with gutta-percha significantly enhances the long-term prognosis

Clinical Protocol for Teeth with Open Apices

- **1ST VISIT**
- A thorough pre-evaluation, including clinical and radiographic examination, is performed. After achieving rubber dam isolation, access opening and working length determination are completed. Cleaning and shaping are carried out using copious irrigation with 1.5% sodium hypochlorite (20 mL) and saline (40 mL), delivered through 27/30 G double-sided vented needles placed 3 mm short of the working length. Final irrigation is performed using either 2% chlorhexidine gluconate or 1% alexidine digluconate (5 mL). All irrigants are internally heated and activated using sonic or ultrasonic devices positioned 3–4 mm from the working length. An intracanal medicament such as calcium hydroxide, double antibiotic paste, modified TAP, or Emdogain is then placed before temporary sealing.

- **2ND VISIT**
  Re-evaluation includes assessment of pain and a follow-up radiograph. The medicament is removed by saline irrigation, followed by activation with 1.5% sodium hypochlorite. Final irrigation with 17% EDTA (20 mL for 5 minutes) is performed before drying the canal with paper points. The tooth should be completely asymptomatic and free of debris. A 5 mm bioactive cement plug is then placed apically, followed by obturation and coronal restoration with composite resin. In cases with visible craze lines or fractures, apexification should be followed by full-coverage crown placement.
  - **Follow-up:**
    Post-treatment evaluations are recommended at 1, 3, and 6 months, and subsequently at 1, 2, and 5 years. Cone-beam computed tomography (CBCT) after one year helps assess dentin thickness and apical healing.

CONCLUSION

Successful nonsurgical management of teeth with open apices and chronic periapical lesions depends on effective disinfection through three-dimensional cleaning, proper irrigant activation, and the use of intracanal medicaments. The creation of an apical plug using bioactive cement under magnification provides a superior apical seal and predictable healing. Incorporating the dental operating microscope with bioceramic materials enhances precision, reduces chairside time, and improves overall treatment outcomes. Apexification remains the most reliable and efficient approach for managing nonvital immature teeth with wide open apices. Recent advances in bioactive materials, bioceramic sealers, and magnification have significantly improved the prognosis and clinical success of these challenging cases[^6].

REFERENCES

[1]. Gill I, Mittal S, Kumar T, Keshav V. Open Apex and its Management: Review Article. J Pharm Bioallied Sci 2024; 16: S31-S34 [PMID: 38595371 DOI: 10.4103/jpbs.jpbs_615_23]

[2]. Nj N, S P, Ms R, Kumar TS. Endodontic management of an open apex with apexification using Mineral trioxide aggregate: A case report. Med Sci 2022; 26 [DOI: 10.54905/disssi/v26i125/ms315e2331]

[3]. Singh N, Mittal N, Baranwal H, Tripathi R, Wang C. Single-visit apexification in immature necrotic teeth using mineral trioxide aggregate as an apical plug: Case series. SRM J Res Dent Sci 2019; 10: 239 [DOI: 10.4103/srmjrds.srmjrds_41_19]

[4]. Rafter M. Apexification: a review. Dent Traumatol 2005; 21: 1-8 [PMID: 15660748 DOI: 10.1111/j.1600-9657.2004.00284.x] Chauhan S et al. Apexification under magnification WJM https://www.wjgnet.com 7 March 20, 2025 Volume 15 Issue 1

[5]. Graziele Magro M, Carlos Kuga M, Adad Ricci W, Cristina Keine K, Rodrigues Tonetto M, Linares Lima S, Henrique Borges A, GarciaBelizário L, Coêlho Bandeca M. Endodontic Management of Open Apex Teeth Using Lyophilized Collagen Sponge and MTA Cement: Report of Two Cases. Iran Endod J 2017; 12: 248-252 [PMID: 28512495 DOI: 10.22037/iej.2017.48]

[6]. Bhasin P, Saraf BG, Chauhan S, Kumar H, Wahi P, Vats V. The Successful Interdisciplinary Outcome of Blunderbuss Canal with an Open Apex Using MTA under Magnification: A Case Report. Int J Clin Pediatr Dent 2024; 17: 97-101 [PMID: 38559864 DOI: 10.5005/jp-journals-10005-2740]

[7]. Brandt K, Kortegaard U, Poulsen S. Longitudinal study of electrometric sensitivity of young permanent incisors. Scand J Dent Res 1988; 96: 334-338 [PMID: 3166198 DOI: 10.1111/j.1600-0722.1988.tb01564.x]

[8]. 8 Jafarzadeh H. Laser Doppler flowmetry in endodontics: a review. Int Endod J 2009; 42: 476-490 [PMID: 19459999 DOI: 10.1111/j.1365-2591.2009.01548.x]

[9]. Setzer FC, Kataoka SH, Natrielli F, Gondim-Junior E, Caldeira CL. Clinical diagnosis of pulp inflammation based on pulp oxygenation rates measured by pulse oximetry. J Endod 2012; 38: 880-883 [PMID: 22703647 DOI: 10.1016/j.joen.2012.03.027]

[10]. Pileggi R, Dumsha TC, Myslinksi NR. The reliability of electric pulp test after concussion injury. Endod Dent Traumatol 1996; 12: 16-19 [PMID: 8631284 DOI: 10.1111/j.1600-9657.1996.tb00089.x]