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REVIEW ARTICLE

MTA : Boon to Apexification

Kaur H[1], Chaudhary S[2], Tangde P[3]

ABSTRACT

A significant problem associated with the endodontic treatment of necrotic teeth with open apices is achieving an acceptable seal in the apical area to allow compaction of root filling material. The procedure to create an apical barrier with a hard tissue at the root end is termed as Apexification. Calcium hydroxide is currently the most accepted material for the same. Because of the certain inadequacies associated with Calcium hydroxide Apexification, employing of an apical plug using MTA (Mineral Trioxide aggregate) has gained popularity in recent years. This article is thus an insight to the evolution and recent trends in Apexification.

Keywords: MTA, Apexification, Calcium hydroxide.

[1]Reader
Department of Paediatric Dentistry
Kothiwal Dental College, Moradabad,
Uttar Pradesh (INDIA)

[2]Professor and Head
Department of Paediatric Dentistry
Kothiwal Dental College, Moradabad,
Uttar Pradesh (INDIA).

[3]Professor and Head
Department of Public Health Dentistry
Kothiwal Dental College, Moradabad,
Uttar Pradesh (INDIA).

Contact Author

Dr. Harsimran Kaur
drsim2006@yahoo.co.in

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INTRODUCTION

Management of young permanent tooth, either due to trauma (in anterior teeth) or caries (in posterior teeth), having immature roots pose a significant challenge for the dentist. Root completion in permanent teeth occurs approximately 3yrs after eruption of the teeth(1). Root development is through the continuous deposition of dentine and cementum by stimulation and differentiation of Hertwig's Epithelial Root Sheath (HERS) and surrounding undifferentiated progenitor cells(2).Interruption of this process by trauma or infection can lead to incomplete root development causing an open apex and a wide funnel shaped canal called as "blunder buss" canal (Figure 1) which impedes the possibility of obtaining a hermetic seal post obturation.

VITALITY OF HERS

HERS is particularly sensitive to trauma because of the degree of vascularity and cellularity in the apical region. It is evidenced that root formation, in the presence of HERS, can continue even with pulpal inflammation or necrosis(3).Thus utmost effort should be made to preserve HERS as it (4):

- Provides a source of undifferentiated mesenchymal cells which give rise to further hard tissue formation
- Protect against the in growth of periodontal ligament cells into the root canal, which otherwise can lead to intracanal bone formation and arrest of root development.

Clinical assessment requires(5,6)

- Thorough history of subjective symptoms,
- Careful clinical and radiographic examination

By summation of the above mentioned factors, an accurate clinical diagnosis of pulpal vitality should be made. When the pulp is deemed vital, apexogenesis can be

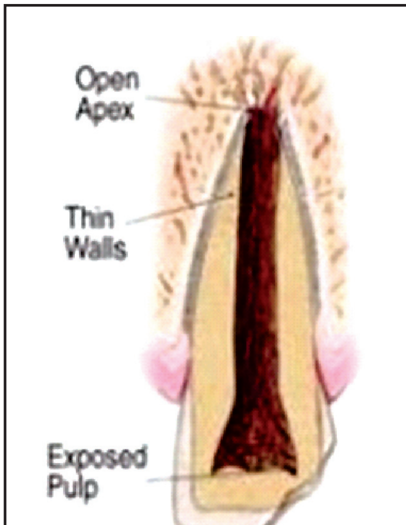

Figure 1: *Young Permanent tooth*

attempted else necrotic pulp condemns the tooth to apexication. (7, 8)

Apexification

Is defined as a method to induce a calcified barrier in a root with open apex or the continued apical development of an incomplete tooth with the necrotic pulp. (9)

Some of the conventional techniques for the management of teeth with open apex:

- Placement of a customized gutta-percha cone with sealer at the apex(10)
- Placement of gutta-percha with sealer or zinc-oxide/eugenol short of the apex(10)
- Paste fills(11)
- Peri-apical surgery(10,12)

Limitations of the above mentioned conventional techniques (5):

- The use of customized gutta-percha cones made the apical portion of the root wider than the coronal portion, hindering adequate condensation of the gutta-percha.
- Apicoectomy further reduces the root length resulting in an unfavourable crown root ratio.

EVOLUTION OF APEXIFICATION (5)

Proposed that	Author
Laceration of the periapical tissues until bleeding occurred might produce new vital vascularized tissue in the canal which 'may result in further development of the apex'	Nygaard-Ostby(1961)
Calcium hydroxide mixed with Camphorated parachlorophenol would induce the formation of calcified barrier across the apex.	Kaiser (1964)
Demonstration of apical closure using an antiseptic paste as a temporary filling material following root canal debridement.	Ball JS (1964) Holland R et al (1971)
Debridement of the root canal and removal of the necrotic pulp tissue and microorganisms along with a decrease in pulp space to be the critical factors in apexication.	McCormick et al. (1983)
The remnants of HERs, under favorable conditions, may organize the apical mesodermal tissue into root components.	Cooke and Robotham 1988
One visit Apexification	Morse DR et al 1990

Some of the agents used for Apexification process

Materials tested	Author
tricalcium phosphate	Koenigs JF et al. (13)Roberts SC et al. (14) Coviello and Brilliant. (15)
collagen-calcium phosphate gel	Nevins et al. (16)
freeze dried bone	Rossmeisl R, Reader A, Mel R, et al. (17)
freeze-dried dentin	Rossmeisl R, Reader A, Mel R, et al.(18)
Calcium hydroxide	Schumacher and Rutledge. (19)
MTA	Torabinejad and Chivian. (20)

CALCIUM HYDROXIDE

Originally introduced by Herman in 1930 as pulp capping agent, now been extensively used to accomplish apical closure due to its apparent ability to stimulate hard tissue formation(21). Calcium hydroxide can be mixed with a number of different substances (CMCP, distilled water, sterile saline, anesthetic solutions and recently chlorohexidine) to induce apical closure. Many studies have reported a high level of clinical success with the use of calcium hydroxide in combination with CMCP (22,23).

Heithersay and others have used calcium hydroxide in combination with methylcellulose (Pulpdent Corporation, Watertown, MA, USA), which has the advantage of decreased solubility in tissue fluids and a uniform physical consistency (24).

The relatively good success rate of calcium hydroxide has been attributed to the following properties: (a) the high pH; (b) the calcium ion;(c) the hydroxyl ion; and (d) the antibacterial effect (25).

MECHANISM OF CALCIUM HYDROXIDE

Holland *et al*. have demonstrated that the reaction of the periapical tissues to calcium hydroxide is similar to that of pulp tissue. Calcium hydroxide produces a multilayered necrosis with subjacent mineralization. Calcium is attracted to the area and mineralization of newly formed collagenous matrix is initiated from the calcied foci. Apparently, high pH of calcium hydroxide is an important factor in its ability to induce hard tissue formation.

The hard tissue barrier described by Ghose *et al*. as a cap, bridge or ingrown wedge, composed of cementum, dentin, bone or 'osteodentin. Serial sections showed that cementum formation proceeds from the periphery of the original apex towards the center in decreasing concentric circles. Histological examination reveals that the barrier is porous (5).

No of visits by Calcium Hydroxide: Controversy exists as to whether or how often the calcium hydroxide dressing should be changed. Chawla suggested that that it suffices to place the paste only once and wait for radiographic evidence of barrier (26). Abbot concluded that the ideal time to replace a dressing depends on the stage of treatment and the size of the foramen opening. This must be assessed for each individual tooth at each stage of development (27).

Disadvantages of Calcium Hydroxide:

- The treatment involves numerous visits over a prolonged period 3 to 21 months causing failure of patient's compliance.
- May also lead to a loss of temporary dressings and re-infection of teeth.
- More prone to cervical root fractures during or following treatment, due to thin dentinal walls in immature teeth as well as to weakened dental structure induced by calcium hydroxide (28).

To avoid these inconveniences, the use of new materials potentially inducing mineralisation such as Mineral Trioxide Aggregate (MTA) was suggested (29).

MTA

First introduced in 1993 and received Food and Drug Administration (FDA) approval in 1998 (5).

Composition

MTA is presently available in two colours: an original grey and a newer white. White Pro-Root was introduced as an aesthetic improvement over the original grey MTA. Both the materials are available in the form of a biocompatible, hydrophilic powder that sets in the presence of moisture consisting of (30):

- Tricalcium silicate
- Tricalcium aluminate
- Tetracalcium aluminoferrite(absent in white MTA)
- Calcium sulphate dihydrate
- Silicate oxide and other mineral oxides
- Bismuth oxide powder (for radio opacity)

PHYSICAL PROPERTIES (30)

pH

Similar pH of MTA (12.5 at 3hrs) to that of calcium hydroxide, contributes to its inductive potential and the resultant hard tissue formation.

Sealing ability and marginal adaptation

MTA has shown superior results in studies regarding quality of apical seal for different retrograde materials through degree of penetration by dyes, radioisotope, bacterial, electro-chemical means, ûuid ltration techniques. The superior sealing ability of MTA is due to the setting expansion it undergoes in moist environment.

Compressive strength

Has a relatively low compressive strength; however, this does not compromise its success as it is used in situations that experience low compressive forces.

Biocompatibilty

Material analysis of MTA showed it to be divided into calcium oxide and calcium phosphate (Koh *et al* 1997). The scanning electron microscopic studies revealed that amorphous calcium phosphate showed maximum ingress and growth of cells. Thus concluded that MTA offers a biological substrate the change in cell behaviour, that stimulated growth over MTA.

Inductive potential

Torabinejad *et al.* prepared premolars to receive gutta-percha root-filling which were left to contaminate by open access followed by resection of root and retrograde fillings with MTA or amalgam. Histologic findings at 10-18 weeks post-surgery confirmed the formation of cementum exclusively over the root ends with MTA, which included the MTA itself. This led to the conclusion that MTA could be used as a root end filling.

Cytotoxicity

An *in vitro* study by Osorio *et al.*(1998), compared different root canal sealers and root end filling materials using two assay systems and two different mammalian fibroblast cell line. Among the materials tested, MTA was the least cytotoxic in the cell culture tests.

MANIPULATION

It is currently dispensed as powder, in 1g sachets to be stored in a dry environment. Pro Root R MTA is mixed immediately before its use in a ratio of 3:1 powder to sterile water ratio which results in hydration (pH 12.5), setting in approximately four hours. The manufacturers recommend mixing the powder with water for one minute to ensure hydration of all particles. A thick creamy consistency is recommended. If the area of application is too wet, a piece of foam can be applied to remove extra moisture. The mix can be carried to the site with plastic or metal instruments (31).

CLINICAL APPLICATIONS (30)

- Root-end filling material or
- Repair of a root perforation.
- Pulp capping
- One visit apexication (Figure 2-4)

Morse *et al.* dened one-visit apexication as the non-surgical condensation of a biocompatible material into the apical end of the root canal, to establish an apical stop that would enable the root canal obturation immediately (32).

Witherspoon and Ham asserted that MTA provides scaffolding for the formation of

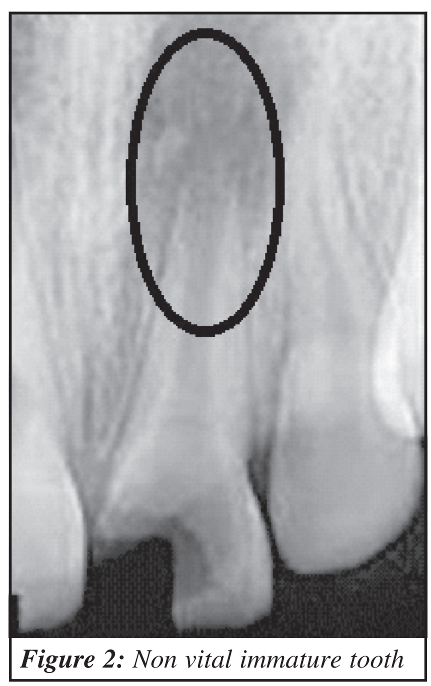

Figure 2: *Non vital immature tooth*

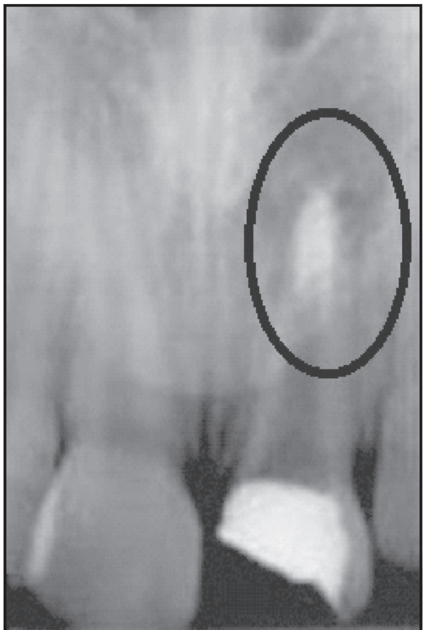

Figure 3: *MTA Apical Plug with open Apex*

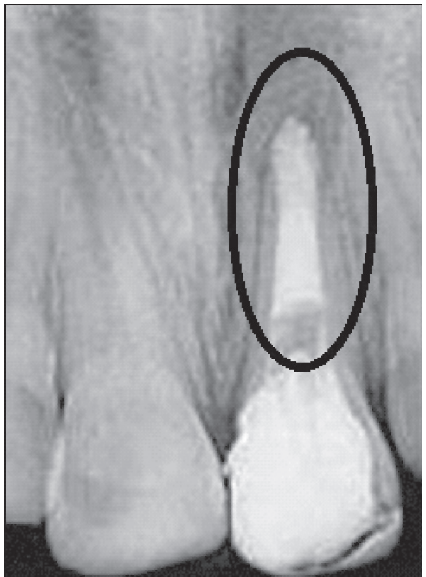

Figure 4: *Obturation after MTA apexification*

hard tissue and the potential of a better biological seal and considered it as an effec as an alternative to calcium hydroxide apexication for immature permanent teeth. Furthermore, the potential for fractures of immature teeth with thin roots is reduced, as a bonded core can be placed immediately within the root canal (33).

Properties of MTA favouring Apexification

The deposition of hard tissue over the material (MTA) is related to its features such as:

- The capacity to attract blastic cells
- To promote a favourable environment for cementum formation
- The stimulus to adhesion and cell proliferation
- Stimulus to expression of alkaline phosphatase by fibroblasts
- Osteocalcin and other interleukins by osteoblasts.

Type of barrier formed

The barrier formed by MTA has been identified as two distinct continuous layers, without precise limits between them. The outermost layer, towards the periodontal ligament, is irregular, more compact and with few included cells. The innermost layer, facing the MTA, is irregular and with frequent gaps with cell and tissue inclusions(34).

COMPARISON OF CALCIUM HYDROXIDE AND MTA (35)

	Calcium Hydroxide	MTA
No of visits	Numerous	Single visit or 2-3 visits
Type of barrier formed	Porous	Hermetic seal at the apex
Risk of cervical fracture	Present	Not present
Duration of treatment	5-21 months	Single visit
Patient compliance	Less	Better
Cost	Lost income due to missing work for more appointments	More initial cost but overall cost is less because of less appointments

MODIFIED MATRIX CONCEPT

In some cases with wide open apices, adequate condensation of MTA is difficult to achieve as the material might extrude beyond the apex. Therefore an apical matrix is used for the controlled placement of MTA to a desired level. Various biocompatible materials that have been tried as apical matrix in the past include: tricalcium phosphate, collagen calcium phosphate, osteogenic protein-1, bone growth factor and oxidized cellulose etc. (36).

FUTURE PROSPECTS

Apexication contrasts with apexogenesis in terms of its inability to obtain apical maturation and normal root thickness. Recently, two new clinical concepts have emerged. One involves a *revitalization* approach to achieve tissue generation and regeneration. In this method, new living tissue is expected to form in the cleaned canal space, allowing continued root development in terms of both length and thickness. The other is the active pursuit of pulp/dentine regeneration via tissue engineering technology to implant or re-grow pulps. Although the technology is still at its infancy, it has the potential to benet immature pulpless teeth by allowing continued growth and maturation. With this understanding, it may be predicted that apexication will become less needed in years to come (37).

CONCLUSION

Some traditional treatment options like calcium hydroxide have stood the test of time but the inconveniences associated with the same paved the way for MTA, which has shown to be a very effective for sealing immature root canals with open apices that could otherwise impose technical challenges in obtaining adequate obturation. MTA thus has appeared as a boon for management of young permanent teeth.

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