ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 4, Issue – 1, January - 2021, Page No. : 11 - 16

Apexification- Methods and Materials Employed

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Citation of this Article: Naik Soumya Suresh, Shyamoli Sanjay Bhemat, Dr Amit Patil , "Apexification- Methods And Materials Employed", IJDSIR- January - 2021, Vol. – 4, Issue - 1, P. No. 11 – 16.

Type of Publication: Review Article

Conflicts of Interest: Nil

Abstract

A tooth with open apex and/or blunderbuss canal can be an endodontic canal can be an endodontics challenge as it is difficult to obturate an apical seal with thin radicular walls which are prone to fracture. pulp necrosis in permanent teeth with incompletely formed apex will result in inadequate crown root ratio due to short root. Apexification is a technique to create a calcific barrier in the root with open apex or incomplete root in the necrotic pulp.

This paper discussion briefs the different method employed initially for treatment of teeth with open apex and a non-vital pulp (customized cone, short fill technique and periapical surgery) and reviews material used for apexification. The material discussed includes calcium hydroxide, mineral trioxide aggregate, bio dentine and various types of scaffolds used for apexification.

Keyword: Calcium Hydroxide, MTA, Bio dentine, Scaffolds.

Introduction

Any trauma or caries involving pulp of immature permanent tooth can damage pulp vitality leading to pulp necrosis, which can affect their further development of root leading to short root and thin fragile wall which tend to fracture, such tooth is treated with apexification

Apexification is defined as a method to induce calcified barrier in a root with an open apex or the continued apical development of an incomplete root in teeth with necrotic pulp. [1] Mostly done with materials like calcium hydroxide, MTA, Bio dentine. After several follow up and radiographically apical seal with rounded apex is seen then conventional endodontic treatment can be done

Diagnosis and Case Assessment

A careful case assessment and accurate pulpal diagnosis is vital in the treatment of immature teeth with pulpal injury. Clinical evaluation of pulpal status demands for a thorough history of subjective symptoms, detailed clinical and radiographic examination and along with diagnostic tests.

Objective tests are necessary for verification, for instance visual examination, percussion testing and thermal and electronic pulp testing. In the immature teeth, pulp vitality testing usually gives erratic response because the sensory plexus of nerves in the sub odontoblastic region is not well developed as root formation is incomplete, and any injury to it give unreliable responses. [2,3] Over-dependence, in immature teeth, on the results of pulp vitality tests, especially the electric pulp testing is not recommended.

When the pulp is estimated vital, apexogenesis techniques can be undertaken and apexification is performed for necrotic pulp with open apices. [3]

In young permanent tooth with an open apex can use laser doppler flowmeters that are objective which relies on blood flow and not on sensory nerve response. Additionally, the procedure is pain-free and should be effective in case of immature apices.

Causes of open apices

Carious tooth or tooth undergone trauma resulting in pulp necrosis prior to completion of root development.

At times, open apex can be seen in mature tooth, for instance, as an outcome of extensive apical resorption (orthodontics, periapical pathosis or trauma), root end resection (peri radicular surgery) and over-instrumentation.

Treatment Options for Open Apex

The methods for treatment of teeth with an open apex and a non-vital pulp are as follows:

Customized Cone (Blunt-End Or Rolled Cone)

It consists of obturating the canal with large (blunt) end or customized gutta percha cones with a sealer.

Short Fill Technique

Removal of the necrotic pulpal tissue and filling the canal (before the walls have diverged) short of the apex by gutta percha and sealer or zinc oxide-eugenol (ZOE) alone.

Mood nick (1963) proposed use of Diaket, a compound of beta ketones and zinc oxide instead of gutta percha to enhance healing.

Periapical Surgery

Filling the canal with gutta percha followed by periapical surgery with or without a reverse seal. It can be undertaken in cases where more conservative approach is not feasible

Material Used For Apexification

Calcium Hydroxide : Calcium hydroxide was first introduced by “KAISER”-1964: - use of calcium hydroxide with (CMCP) camphorated Para chlorophenol which formed calcific barrier in the apex

Properties: It is an antibacterial agent and it has been shown to be the most effective anti-bacterial root canal medicament. Tissue repair is encouraged by a high pH environment. It has tissue dissolving capabilities, dissolve pulp tissue directly. It acts as a physical barrier for ingress of bacteria and limiting space for multiplication and holding substrate for growth. It inhibits DNA replication and inactivates the activity of LPS.

From the histological perspective, the calcified tissue that forms over the apical foramen has been identified as an osteoid or cementoid material (Ham et al. 1972).[4]

The odontoblastic layer associated with the pulp tissue resume their matrix formation and subsequent calcification is guided by the reactivated Hertwig epithelial root sheath (HERS).[4]

It has irregularly arranged cementum like tissue, soft and calcified tissue, this soft tissue interspersed within this barrier impart characteristic of swiss cheese appearance.

Disadvantages

The time taken for formation of a hard tissue-barrier to calcium hydroxide, ranges from 2–3 months and 6–18 months in the apexification procedures respectively (3–5). This extended treatment time may inconvenience both the dentist and the patient. Calcium hydroxide affects the mechanical properties of dentin when used for a longer period of time rendering the tooth susceptible to fracture

The long-term use of calcium hydroxide as an intra-canal medicament leads to changes in ph. This may affect the acidic organic components in the dentin tissue resulting in dentin weakening result in ultrastructural modifications within the radicular dentin and thus making the tooth more susceptible to fractures.

Mineral Trioxide Aggregate: Mahmoud Torabinejad at Loma, Linda University, California, USA introduced MTA. 1993, the first literature about MTA appeared. It is similar to Portland cement with addition of bismuth oxide which increases the radiopacity. [5,6]

MTA not only exhibits good sealing ability; it has excellent long-term prognosis. It has also comparative ease of manipulation and nice biocompatibility also favours tissue regeneration as well.

MTA is an alternative to calcium hydroxide, MTA is used as an apical obstruction for teeth with not fully formed apices, repair of root perforations, root-end closure, pulp capping, and pulpotomy procedures.

It also has a shorter treatment period in comparison with calcium hydroxide, and has more conventional time to apical closure.

It has antimicrobial activity and preclusion of bacterial leakage, no cytotoxicity, and can encourage cytokine release from bone cells to initiate up hard tissue formation.

Types of MTA

There are two types of MTA

GREY MTA: It consists of tetra calcium aluminoferrite (ferrous oxide), which is responsible for grey discolouration, the tooth gets discoloured so it cannot be used in anterior teeth. It has larger particle size and takes longer setting time, has greater comprehensive strength.

WHITE MTA: Ferrous oxide is replaced with magnesium oxide, which doesn't cause discolouration of the tooth. It has smaller particle size with less setting time and less comprehensive strength.

commercially available MTA are Pro Root MTA(Dentsply), White Pro Root, MTA (Dentsply), MTA- Angelus (Solucoes Odontologicas), MTA- Angelus Blanco (Solucoes Odontologicas), MTA Bio (Solucoes Odontologicas).

Properties: Its excellent sealing ability.3 mm to 5 mm is sufficient to provide a good seal. Hydrated MTA has an initial pH of 10.2, which rises to 12.5, 3 hours after mixing and following setting. and the pH decreases as time progresses. [7,8] The initial compressive strength following 24 hours is 40 MPa, which increases to 67.3 MPa after 21 days. [9,10] Radiopacity of 7.17 mm is seen, it has a similar radiodensity to zinc oxide eugenol and slightly greater radiopacity than dentin. [11,12] MTA is less cytotoxic than amalgam, super EBA, and IRM and set MTA is less cytotoxic than fresh MTA. MTA has also shown to have a better stimulating effect on human dental pulp cells than calcium hydroxide. It has antibacterial activity of against M. luteus, S. aureus, E. coli, P. aeruginosa, E. faecalis, and S. sanguis. [11,13] MTA has the capacity to induce bone, dentin, and cementum formation and regeneration of periapical tissues

Biodentine

It is a calcium-based material used for various applications like apexification, resorptive lesion, retrograde filing

material and also dentin replacement.[14] To overcome the disadvantages of calcium hydroxide, bio dentine was introduced. It resulted in the formation of calcium silicate hydrate and calcium and hydroxide. It was further described as having calcium carbonate in powder, this act as nucleation site and enhancing the microstructure.

Properties: The setting time of Bio dentine was determined as 45 minutes. However, 9–12 minutes indicated initial setting time by Grech. According to Grech et al. Bio dentine showed the highest compressive strength compared to the other tested materials.[15] Kayahan et al. concluded that acid etching procedures after 7 days did not reduce the compressive strength of and Biodentine.[16] Studies showed that Biodentine exhibited higher surface microhardness compared to the other materials when unetched. On the other hand, there was no difference in the microhardness of different materials when they were etched. [17] Zirconium oxide is used as a radio pacifier in Biodentine which possesses biocompatible characteristics and is indicated as a bioinert material with favourable mechanical properties and resistance to corrosion. [18] Aggarwal et al. results showed that the 24hr push-out strength of MTA was less than that of Biodentine and blood contamination affected the push-out bond strength of MTA Plus, Biodentine didn't showed any alteration in push out strength [19]. In a study by Guneser et al. Biodentine showed considerable performance as a repair material even after being exposed to various endodontic irrigation solutions, such as NaOCl, chlorhexidine, and saline, whereas MTA had the lowest push-out bond strength to root dentin. [20] The washout resistance of Bio dentin is low. Washout resistance is the tendency of material to disintegrate on exposure to blood or fluids

Scaffolds

Types of Scaffold Used For Apexification Are

1) PRP (PLATELET RICH PLASMA)
2) PRF (PLATELET RICH FIBRIN)
3) POLYMERS
4) BIOCERAMICS

Scaffolds are the solid material used for cell location and also help in proliferation and differentiation by acting as transport for nutrients, gases and growth factor.

Minimal inflammatory reaction is seen with this.

Classification of scaffolds

• Based on degradability of matrices.
• Based on form.
• Based on presence or absence of cells.
• Based on origin

Platelet Rich Plasma (PRP)

It is a autologous first generation plasma concentration rich in source of growth factor+ [21]

Concentration is around 1million/ml, more than normal count. This helps in proliferation of steam cells for healing and regeneration of tissue.

It includes PDGF, TGF-b, IGF, VEGF, epithelial growth factor and epithelial cell growth factor.[22]

Benefits of PRP include elevated rates of angiogenesis and revascularization, which are fundamental for a successful RET.

Drawback is that it is limited in the young patients from drawing blood using special instruments and reagents. [23]

Platelet Rich Fibrin (PRF)

It is the second-generation platelet concentration, where blood is collected in test tube without anticoagulant and centrifuged. [24] It is centrifuged for 10 min at 3000 rpm. [25]

After which three layers are formed

1) First layer is red blood cells.
2) Second is the buffy coat layer
3) Supernatant layer which has acellular plasma.

PRP clots in root canal in 5 mins. easy application without anaesthesia.

Benefit of slow release of growth factor for 7-14 days.

Polymers

1) POLYGLYCOLIC ACID(PGA)
2) POLYACTIC ACID (PLA)
3) POLY-LACTIC -COGLYCOLIDE
4) POLY-L-LACTIC ACID (PLLA)

PGA was used in suture of head and neck implant of bone, regeneration, cartilage repair.no inflammatory response was seen.

PLLA promotes pulp cell differentiate into endothelial cells and odontoblast. [26,27]

PLGA shows dentin like tissue and pulp like tissue formed around 3-4 months [28]

Drawbacks are due to low PH it causes localized inflammatory reaction. [29]

Bio ceramics

Most widely used are

1) CALCIUM PHOSPHATE CERAMICS

A) HYDROXYAPETITE (HA)

B) BETA-TRICALCIUM PHOSPHATE (β -TCP).

C) BIPHASIC CALCIUM PHOSPHATE.

Advantages

Bone regeneration

Biocompatibility

Low immunogenicity

Osteoconductive

Mechanical strength is increased by adding SIO2

And ZnO also helps in crystallization.

Another combination

Polymer: [poly (D, L-Lactide-co-glycolide)] and ceramics (- TCP) showed excellent results in mechanical and physicochemical properties.

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