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The Differences of the Calcium Hydroxide and the Mineral Trioxide Aggregate in the Apical Closure of Immature, Non-Vital Permanent Teeth

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ABSTRACT: When an immature tooth comes into contact with trauma, the dental pulp in the developing tooth can die, which can cause the absence of root and apical closure. Apexification is a technique used to repair these abnormalities. This method allows us to promote the growth of a hardened root end block. MTA and Ca $(OH)_2$ are two materials that can be used in this process. Either MTA or calcium hydroxide have a good chance of producing positive clinical results. MTA is favored over calcium hydroxide for its significantly shorter time for apical barrier formation, low solubility, easy approach, and ability to prevent root fracture, while calcium hydroxide is preferred over MTA for root length elongation in open apex teeth. The limitations of calcium hydroxide include the fact that it takes more time and multiple visits to form the root-end barrier, is more prone to fracture, and has the potential for reinfection. The goal of this review is to collect revisions on inducing root formation and synthetic barrier approaches and consider the advantages and disadvantages of calcium hydroxide versus MTA.

KEYWORDS: Apical barrier, Calcium hydroxide, MTA, Non-vital Immature tooth, obturation. Obturation, periapical.

INTRODUCTION

When an immature tooth comes into contact with trauma, the dental pulp in the developing tooth can die, which can stop the growth of the radix and make the apical pulp cavity (root canal) wider and the apex remain open. A wide root canal and open apex make treatment extremely difficult. Prior to inserting a root canal filling, apexification enables the creation of a strong tissue obstacle over the wide apex. The preferred strategy for promoting periapical healing and the absence of clinical symptoms has traditionally been used. As a result, numerous damaged, developing teeth were able to survive because of the efficacy of this therapy. There have been two types of materials (MTA and $Ca(OH)_2$) suggested to enable apexification in developing teeth (Guerrero, 2018).

Calcium Hydroxide

Calcium hydroxide is a versatile compound with a broad scope of uses. In 1920, Hermann brought it to dentistry in Germany (Sheldon Best DMD, 2021).

In the present, water is used as the main component for making a paste of calcium hydroxide, which constrains the dissolution of the calcium hydroxide and increases the PH. It has a high PH (between 12.5 and 12.8), a low solubility in water (which declines with increasing temperature), and is insoluble in alcohol. Since it takes some time until it is dissolved in extracellular fluid when in close contact with important tissues, the low solubility is a positive therapeutic trait. Calcium hydroxide was used for pulp therapy (direct and indirect pulp capping), apex formation (apexogenesis and apexification), and management of resorption, perforations, root fractures, and replantation of teeth. It was also used for interappointment dressing (Walsh, 2017).

Clinical Approach

After anesthesia, isolation of the tooth, and gaining access to the canal orifice, completion of the cleaning and debridement is important, which removes germs and non-vital tissue from the radicular pulp cavity. Canal shaping is not permitted because the canal is already wide. Place the calcium hydroxide, then place a dry cotton pellet and seal the canal (Nisha Garg, 2019).

Calcium hydroxide and water paste have proven to be the most effective. Other medications added to calcium hydroxide do not improve apexification. When employed as a transient obturating substance, calcium hydroxide has a bactericidal action that may encourage apical calcification. The literature is divided on how frequently the radicular pulp cavity must be replaced with calcium hydroxide to achieve apex end formation, and the choice appears to be based on experience. Long dressing with non-setting calcium hydroxide in juvenile teeth has been shown to reduce dentine microhardness, which predisposes these teeth to fracture (M. Duggal, 2017).

In 2019, According to Nisha Garg and Amit Garg, the patient is recalled after 3 months, and the dentists clinically evaluate the apical barrier formation. If the apexification has formed, the canal should be obturated with the GP; if the apical closure is not present, the dentists should replace the calcium hydroxide dressing (Nisha Garg, 2019).

Some of the other researchers recommended repacking with calcium hydroxide and frequent recalls in cases where radiographic proof of paste resorption is seen or if the apexification is not completed (Adel S. Alobaid, 2014) (Charu Grover, 2014). In 2016, Katharina Bücher et al. proposed that the Ca (OH)2 dressing be reapplied if clinical symptoms persist or the canal cannot be dried due to an apical infection (Katharina Bücher, 2016).

MTA

MTA (Mineral trioxide aggregate) is a reactive silicate substance that stimulates the regeneration of cementum and the periodontal ligament while being non-irritating to periapical tissues (Saad Al-Nazhan, 2022).

When immune cells are induced to release the lymphokines necessary for cementum reconstruction and regeneration as well as the osseous pairing critical elements that are required for bioremineralization and recovery of alveolar periradicular lesions, silicate cement acts as an osteoinductive and cementogenic agent. Adhesion of human osteoblasts to the substance suggests positive physiologic reactions and biocompatibility (Chirag Macwan, 2014).

The osteoblastic phenotype may be modified through a mechanism that is afforded by the texture of the healed MTA. Osteoblasts that have been exposed to MTA produce more interleukin (IL), which can result in higher concentrations of interleukin-1 (alpha and beta), interleukin-6, and M-CSF (macrophage-colony-stimulating factor). When we use mineral trioxide aggregate in apexification, it can stimulate hard tissue deposition (Camila M. Corral Nu~nez, 2014).

It is a revolutionary material, because when a lot of studies described MTA in the 1990's, it was used as a multipurpose agent in endodontics. MTA has undergone substantial research and is being employed for pulpotomies, apexifications, regeneration operations, apexogenesis, and perforation repairs. MTA has received the greatest research attention in the last 20 years as an endodontic material. MTA consists of calcium, aluminum, and selenium. Mineral trioxide aggregates are very important in dentistry for their properties such as biocompatibility, sealing ability, low solubility, hydrophilicity, and radiopacity. Greater biocompatibility promotes the best recovery outcomes (Peter Z Tawil D. M., 2015) (M Torabinejad, 2017).

MTA has dentin-like expansion and contraction characteristics, which result in great resistance to peripheral permeability and infection invasion into the radicular pulp cavity. The seal is thus accomplished. One of the most important elements that promote clinical effectiveness is a robust barrier against bacterial and fluid leaks. MTA has a number of disadvantages, including difficult handling, a prolonged setting time, an increased price, the lack of a specific solvent, and difficulty in removal once applied (R Sharifi, 2015) (Rustem Kemal Subay, 2013).

Clinical Approach

First, the necrotic tissues are removed from the canal by cleaning and debridement, and then MTA is pushed down the root canal with a special carrier. The doctor should evaluate the thickness of MTA placed in the canal by applying a rubber stopper to his GP (gutta percha point). Close the cavity with wet cotton pellets and GIC. Once one-third of the radicular pulp cavity is filled with mineral trioxide aggregate measuring about 3 to 5 mm, the patient should be scheduled for another visit. During the following visit, the residual area should also be filled with warm gutta percha (Nisha Garg, 2019) (Peter Z Tawil D. M., 2015) (Karla Vidal, 2016).

The differences between calcium hydroxide and MTA

The broad-open (blunderbuss) apex of non-vital juvenile permanent teeth has been difficult to endodontically treat in the past and now. The methods that were used previously for the treatment of wide apexes in necrotic teeth include paste fills, custom-fit fillings, and apical surgery. However, these methods are no longer recommended because the apical one-third of the root is usually broader than the coronal one-third, which precludes appropriate obturation of the root canal by gutta percha. If the apical section is sufficiently wider than the coronal part of the root, the root will be substantially weaker and more susceptible to fracture (G. Kandemir Demirci e. a., 2020).

It has been suggested to use a variety of techniques such as apexification to create root end barriers. Historically, treatment of open apex teeth with calcium hydroxide has been used for a long time, but it required multiple visits and could take more time for apical end formation, which increased the chance that the affected root would fracture (G. Kandemir Demirci e. a., 2020).

In 2020, H. Boufdil et al. state that, with calcium hydroxide, apexification typically takes 6 to 24 months. But, in one instance, calcium hydroxide therapy reportedly took four years (Adel S. Alobaid, 2014).

Apexification may require a single session or numerous appointments each month to inject calcium hydroxide (Ca $(OH)_2$) into the radicular pulp cavity and eradicate the root canal pathogen, which triggers remodeling and results in the apical end formation. The walls of the radicular pulp cavity should seem thicker and have a rounded apex radiographically after multiple monthly visits, enabling the radicular pulp cavity to be sealed using standard methods with obturation material (gutta percha and a sealant). It has a success rate of 74% to 100% and is the least costly method of inducing a calcified apical barrier. (Fabricio Guerrero, 2018) (G. Kandemir Demirci e. a., 2020). (Hargreaves, 2013).

The characteristics of odontoblasts (dentin) can be altered by calcium hydroxide, which makes these teeth more susceptible to root fracture (Sam L.Kahler BBio MedSc, 2018) (Hargreaves, 2013) (Martin Brüsehaber, 2016) (Demirci, 2020)

MTA is a one-step method, which is the primary benefit of MTA material, and is gradually taking the place of the conventional use of calcium hydroxide to achieve apexification (Purra, 2016) (Yadav, 2015) (Boufdil, 2020). MTA has emerged as an effective, dependable choice to manage open apexes (G. Kandemir Demirci e. a., 2020).

Mineral trioxide is used as an apical barrier after dressing with calcium hydroxide to produce disinfection, or it can be used as a canal filing material (al R. P., 2014) (Chang, 2013).

The following highlights explain the benefits of MTA over calcium hydroxide for handling open apexes:

- Fewer appointments for therapy.
- Less time-consuming for both healthcare staff and patients.
- Decreased chance of root fracture and re-infection (chala, 2012).

Clinical Evaluation

According to Eric Bonte et al., in 2014, they conducted a clinical trial in which 30 patients with necrotic open apex permanent anterior teeth were treated in two groups: 15 patients with MTA and 15 patients with calcium hydroxide. The percussion test is negative, and pain is gone in both groups after 120 days of control. All periradicular lesions (edema, abscess, and sinus tract) were healed at the three-month control for the entire MTA and for eighty percent of the calcium hydroxide group. Without one tooth in the calcium hydroxide group, all 29 teeth were free of all symptoms at the end of 12 months. Both groups did not experience any new trauma, although throughout the observation period, four out of 15 CH patients had cervical root fractures. The apexification of the MTA group had 100% success, while the calcium hydroxide apexification group had 73.3% success (failure of 4 teeth) up to 12 months. (Eric Bonte, 2014).

In 2012, according to Chala and his colleagues, if there are no radiographic signs of alveolar bone regeneration (the barrier), that is an indication of failure (chala, 2012).

In 2016, Jia-Cheng Lin et al. included four studies for meta-analysis and described two groups (MTA and calcium hydroxide). The number of teeth in each group (MTA and calcium hydroxide) is 10 to 15; the ages of the associated patients are between 6 and 12 years; clinically, the calcium hydroxide groups achieved between 87% and 100%, while the MTA groups achieved between 93% and 100%. The calcium hydroxide success rate was 87%–93%, and MTA was 100% in the radiograph. The required time for apical closure in MTA varied from 3 to 4.5 months and from 7 months to above seven months for calcium hydroxide (Lin, 2016) .

In 2014, Adel S. Alobaid et al. described that apexification does not cause actual root development, but the radiological sign of remodeling (calcified tissue) at the root end provides the idea that it does (Adel S. Alobaid, 2014).

The total number of necrotic teeth treated with MTA or Ca $(OH)_2$ hydroxide was 90. 45 teeth were treated with calcium hydroxide, while 45 teeth were treated with MTA. For the first year, patients were recalled one, three, six, and twelve months after starting treatment, while for the second year, patients were recalled every six months. After the second year, patients recall once a year until the completion of the study. For both groups, clinical and radiographic examinations were done by them. Among the MTA group, 39 teeth cooperated on recall, and from the calcium hydroxide group, 34 teeth cooperated on recall. There were 29 visible apical barrier formations in 39 MTA groups, seven of which healed and three of which had persistent lesions. From 34 teeth, there were

27 evident apical barrier formations; four teeth healed, and three had persistent lesions. It is preferable to disinfect the canals with intracanal medicaments ($Ca(OH)_2$) paste before applying MTA for the apical barrier in such juvenile teeth. (G. Kandemir Demirci .. a., 2019) (M. Duggal, 2017).

S. G. Damle et al. described the treatment (apexification) of 22 non-vital teeth in two groups (MTA and calcium hydroxide) in 2016. Apical barriers formed in the MTA group at 4.90 months and in the calcium hydroxide group at 5.33 months. (S. G. Damle, 2016).

In a randomized clinical trial comparison, Eric and colleagues found that the incisors of secondary dentitions with pulp death required more time for apex formation with calcium hydroxide than MTA. A calcified end was seen in fifty percent of participants in the calcium hydroxide group and 82% in the MTA group up to 12 months (Eric Bonte .. a., 2015).

In 2015, according to Lee and colleagues in a clinical comparison study, among fifteen teeth treated with calcium hydroxide, four suffered radicular fractures but none in the MTA group (Lee, 2015).

The quickest method for forming the apical hard tissue barrier was ultrasonic filing combined with MTA, although calcium hydroxide apexification is more important for lengthening the apical root than MTA
(P. Chailertvanitkul, 2014).

In 2014, Patricia et al. described the treatment (apexification) of forty necrotic, immature secondary anterior teeth with calcium hydroxide and MTA and noted the successful clinical points, such as the absence of all subjective and objective findings and the absence of all periradicular radiographic abnormalities. They also noted the increased length of the root apex with the creation of the apical barrier. MTA takes little time to form an apex, whereas calcium hydroxide-treated teeth take much longer. Regardless of whether calcium hydroxide or MTA was used intracanally, periapical radiography revealed root growth with the formation of a conical root apex and a significant extension of the apical root length (Patricia, 2014).

In 2017, M. Duggal et al. described that to achieve continued root development, and prevent apical tissue from being disturbed, MTA should be placed instead of the apical root in the coronal root canal (M. Duggal, 2017).

CONCLUSION

MTA and calcium hydroxide have comparable clinical and radiographic outcomes. The apical sealing rates are also similar. MTA differs from calcium hydroxide in that it takes less time to form an apical barrier; it is also less soluble, and MTA-apexified roots are resistant to fracture. While calcium hydroxide requires more time and multiple visits for apical barrier formation. Calcium hydroxide-apexified teeth are susceptible to fracture and have the potential for reinfection. In contrast to root elongation, calcium hydroxide apexification is significantly more important than MTA for root length elongation in immature teeth. So, dentists should first use calcium hydroxide to clean the canal before injecting MTA into the coronal and apical root canals.

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