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Success rate of Calcium Hydroxide vs Mineral Trioxide Aggregate as Apexification Agents: A Systematic Review

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ABSTRACT
Background: Trauma and deep caries may require endodontic treatment in young, immature permanent teeth which have open apices that complicate instrumentation. Hence, apexification with materials like calcium hydroxide or Mineral trioxide aggregate (MTA) is required to obtain an apical seal.
Aim: This study aims to compare the two materials i.e., Calcium hydroxide and MTA, used for apexification in young, immature permanent teeth with the help of a systematic review of studies in literature.
Source of literature: PUBMED, Medline, Cochrane and Scopus databases were searched for terms “calcium hydroxide” and “Mineral trioxide aggregate” and “Apexification”.
Results: The radiographic and clinical evaluations of apical closure did not have statistically significant differences but there was a significant variance in the time taken for apexification for both the groups. MTA showed significantly faster formation of apical barrier as compared to Calcium hydroxide.
Conclusion: Although MTA gives comparable clinical and radiographic evidence of apical closure, it seems to be faster in formation of the apical barrier as compared to Calcium hydroxide in immature necrotic permanent teeth.
Key words: Calcium Hydroxide, Mineral Trioxide Aggregate, Apexification.

INTRODUCTION

Traumatic injuries to immature permanent teeth pose a diagnostic and clinical challenge to the dentist. In such cases, the clinician might need an endodontic interference for treatment which might be complicated with instrumentation and obturation issues due to the wide canal and thin dentinal walls.[1] Endodontic treatment of such teeth is aimed at obtaining an optimal

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seal of the root-canal system. Apexification (induction of a calcific barrier at open root apex of non-vital teeth) is a non-surgical approach for obtaining apical barrier so as to prevent passage of toxins and bacteria into peri radicular tissue. This barrier facilitates the placement of an appropriate root canal sealant and filling material, whilst reducing the possibility of their extrusion into periapical tissues.[2] A number of materials have been tried to induce apical closure in the procedure of apexification. One of the premier materials was calcium hydroxide which was initially used in dentistry by Hermann[3] who first reported the use of Calcium Hydroxide for apical closure. Calcium hydroxide being strongly basic (pH 12.5-12.8) in nature, its mechanism of action is via dissociation of calcium and hydroxyl ions and their effect on vital tissues leading to hard-tissue deposition and being antibacterial. The hydroxyl group is considered to be the most important component of Calcium hydroxide as it provides an alkaline environment, which encourages repair and active calcification. The alkaline pH not only neutralizes lactic acid from osteoclasts, thus preventing dissolution of the mineral components of dentine, but could also activate alkaline phosphatases that play an important role in hard-tissue formation[4]. Another experimental material, mineral trioxide aggregate (MTA), was then introduced as a potential alternative. It was shown that MTA promotes regeneration of the original tissues when it is placed in contact with the dental pulp or peri radicular tissues by Torabinejad[5]. It is a bioactive material that is mainly composed of calcium and silicate which is known to conduct and induct hard tissue formation. From the time that MTA is placed in direct contact with human tissues, it appears that the material does the following:

1. Forms CH that releases calcium ions for cell attachment and proliferation.
2. Creates an antibacterial environment by its alkaline pH.
3. Modulates cytokine production.
4. Encourages differentiation and migration of hard tissue– producing cells.
5. Forms HA (or carbonated apatite) on the MTA surface and provides a biologic seal.[6]

This article aims to compare Calcium hydroxide with MTA for apexification in young, immature permanent teeth using a systemically compiled data available in literature.

Study selection:
Controlled studies comparing calcium hydroxide and MTA in immature permanent teeth in the process of apexification where the outcome was evaluated by clinical and radiographic evidence for the formation of apical barrier was recorded, were included.

Inclusion Criteria

1. Study design: randomized clinical trials,
2. participants: patients with immature necrotic permanent teeth,
3. Treatment: Pulpectomy for purposes of apexification
4. Have assessed success based on clinical and radiographic outcomes, and
5. Articles published in English.

Source of articles: PUBMED, Medline, Cochrane and Scopus databases were searched for terms “calcium hydroxide” and “Mineral trioxide aggregate” and “Apexification”.

Results:
The literature search done on the basis of the above-mentioned criteria and the rules of inclusion yielded 5 significant studies[7-11].
The basic characteristics of these included studies are tabulated and presented in Table 1.

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1. Clinical and Radiographic success rate:

According to the study by El Meligy et al[7], the clinical and radiographic success rates for the calcium and MTA groups were 87% and 100%, respectively where 2 out of 15 teeth in the calcium hydroxide group showed signs of clinical as well as radiographic failure. The clinical failure manifesting as persisting tenderness to percussion even after retreatment after 12 months. The same 2 teeth showed radiographic failure as well showing widening of lamina dura and periapical radiolucencies even after 6 months. There was no statistically significant difference between the 2 groups, clinically or radiographically, using the chi-square test (chi-square=2.14; P=.16). Whereas according to Bonte et al[10] the clinical effectiveness (functional asymptomatic teeth) of the treatment at 12 months was 100% for the MTA group and 73.3% (loss of four teeth) for the Calcium hydroxide group. The radiographic success rate was 50% and 82.4 % in the Calcium hydroxide and MTA groups respectively. Damle et al[9] showed that all 15 teeth in the MTA group were clinically asymptomatic at twelve months follow up (100%), while in Calcium Hydroxide group 14 teeth were asymptomatic with success rate of 93.33%. In MTA group all 15 teeth revealed calcific barrier formation, with no evidence of periapical pathology on radiographs. In Calcium Hydroxide group, a single tooth exhibited failure which was evident radiographically due to internal resorption which was seen at the end of twelve months and radiographic success was calculated at 93.33%. Both these radiographic and clinical results were evaluated statistically with Chi square test (p=0.38) which was not significant.

2. Time required for apical barrier formation:

According to Pradhan et al[8] the mean time taken for apical biological barrier formation was 3 +/- 2.9 months for MTA group and 7 +/- 2.5 months for calcium hydroxide group. Lee et al[11] reported the mean duration of apical hard tissue barrier formation for MTA group (6.6 +/- 1.9 weeks) was significantly shorter than those treated with calcium hydroxide (12.2 +/- 1.6 weeks). Student t test showed significant differences in mean duration of apical barrier formation these two groups ($p < 0.001$). Damle et al[9] mentioned the mean time taken for completion of lamina dura in MTA group was 4.07+/-1.49 months whereas the time period for calcium hydroxide group was 6.43+/- 2.59 months. Unpaired t test showed the differences in this data to be highly significant (P =0.0002).

3. Other Findings:

Bonte et al[10] reported that although no new trauma occurred for either group, but cervical root fractures occurred in 4 out of 15 Calcium hydroxide patients.
According to Lee et al[11], all of the 20 incisors treated with MTA showed a blunt root apex and of the 20 incisors treated with calcium hydroxide, 16 exhibited a conical or nearly conical root apex and 4 showed a blunt root apex.

DISCUSSION

In this review article we observed that the data on clinical and radiographic success is comparably similar between Calcium hydroxide and MTA. However, the time taken for apical barrier formation for MTA is considerably lower for MTA as compared to calcium hydroxide. Calcium hydroxide takes a longer time for the apical closure causing increase in the number of appointments and poor patient follow up which may lead to failures. On the other hand, MTA treated teeth showed faster apical closure. This may be attributed to the fact that MTA has an alkaline pH similar to Calcium hydroxide. MTA has several calcium salts in its composition providing antimicrobial properties. Its pH is also able to activate alkaline phosphatase. The high concentration of calcium ions increases the activity of calcium-dependent pyrophosphatase, which promotes bone healing.[12] Hence it is noteworthy that the

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MTA induced apexification demands fewer appointments and is less time-consuming. Moreover, Calcium hydroxide may increase dentin brittleness[13] when placed for long periods, thus increasing the risk of root fracture. These findings may support the use of MTA in apexification approaches. Among the recent studies using MTA to perform apex barrier apposition, there is a study by Yadav et al.[14] who analyzed the apexification in one visit by placing a platelet-rich fibrin apical plug (PRF) and MTA, in which PRF was used as an apical matrix and subsequent placement of the MTA since the fibrin rich in platelets have several advantages, including ease of preparation and lack of biochemical manipulation of the blood, which makes this preparation strictly autologous. PRF is also associated with slow and continuous increase in cytokine levels. Leukocytes in the PRF act as anti-inflammatory, an anti-infective agent, the regulator of the immune response, and provide the vascular endothelial growth factor to promote angiogenesis. Hence, either a combination or alternative options should be considered in a bid to achieve a better and faster endo-apical seal.

CONCLUSION

While both calcium hydroxide and MTA provide similar success rates, the shorter treatment time with MTA may translate into higher overall success rates because of better patient compliance.

Study	No. of patients	Age of Patients	Total no. of teeth	Outcome assessment
El Meligy et al (2006)[7]	15	6-12 years	30	3,6,12 months
Pradhan et al (2006)[8]	20	8-15 years	20	11 months (evaluated once each month)
Damle et al (2012)[9]	20	8-12 years	30	1,3,6,9,12 months
Bonte et al (2014)[10]	34	6-18 years	30	3,6,12 months
Lee et al (2015)[11]	40	6.5-10 years	40	Evaluation done every week for MTA and once in 3 weeks for CH.

Table 1: Systematic Review of Studies in Literature

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