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COMPARISON BETWEEN CALCIUM HYDROXIDE AND MTA WHEN USED FOR APEXIFICATION: A SYSTEMATIC REVIEW

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ABSTRACT

Apexification is a way to treat young permanent teeth whose roots have stopped growing and developing because the pulp has died. Its goal is to make the root end close without the canal wall getting thicker or the root getting longer. There are two ways to do it: first, with a lengthy operation that employs a calcium hydroxide dressing to allow the body to produce a strong tissue barrier; or second, with a recent short-term procedure that creates an artificial plug at the top of the tooth using MTA or similar bioceramic material. Using the PubMed, Medline, and ScienceDirect databases, a thorough evaluation of the literature spanning 2010 to 2022 was conducted. "Calcium hydroxide," "MTA," and "apexification" were the keywords utilized. The selection of the searched articles was further explained using the PRISMA flowchart. The quality of the included studies was evaluated using the Cochrane risk of bias assessment technique. A total of 7 studies were included in this systematic review, out of which all studies concluded that MTA was a better choice for apexification as compared to calcium hydroxide. MTA was found to be superior to conduct the procedure of apexification successfully as compared to calcium hydroxide. Therefore, it can be used as a material of choice by endodontists in their practice.

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Introduction

Apexification is a way to treat young permanent teeth whose roots have stopped growing and developing because the pulp has died. Its goal is to make the root end close without the canal wall getting thicker or the root getting longer. There are two ways to do it: first, a lengthy operation that employs a calcium hydroxide dressing to allow the body to produce a strong tissue barrier; or second, a newer, shorter-term procedure that creates an artificial plug at the top of the tooth using MTA or similar bioceramic material. Primarily, apexification is performed on incisors that have lost their vitality due to trauma or cavities, as well as on teeth with structural peculiarities, such as dens invaginatus with an immature root. An immature tooth's tip might have a parallel to convergent shape, or it can be divergent, with a flared apical foramen (blunderbuss apex). It is challenging to determine this shape from a dental radiograph because of the lack of depth perception. Both conditions exclude the use of conventional endodontic treatment due to the difficulty, if not impossibility, of achieving an apical seal that would prevent the filling material from leaking [1].

Because it doesn't cause any unfavorable periapical reactions, produces predictable results, and can be combined with a variety of other substances to cause apical closure (camphorated monochlorophenol, distilled water, saline, anesthetic solutions, chlorhexidine, and cresatin, among others), calcium hydroxide is frequently used for apexification. But calcium hydroxide has several problems, such as a treatment time that can be anywhere from 5 to 20 months, an uncertain rate of apical closure based on treatment time, a higher risk of tooth breakage, and a low rate of follow-up because of the long treatment time [2].

Apical barriers, root perforations, filling the root tip, capping the pulp, and pulpotomies are all situations in which mineral trioxide aggregate (MTA) is used. Using wet, big paper points or brushes, MTA is scrubbed from the canal walls. Cleanup

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must be meticulous for future composite resin restoration, which will reach deeply into the canal and provide internal strengthening of the weak root, to adhere properly [3]. MTA has a number of advantageous properties, including biocompatibility, antibacterial activity and the prevention of bacterial leakage, the absence of cytotoxicity, and the ability to trigger the release of cytokines from bone cells in order to promote the formation of hard tissues. In addition, it offers a more predictable time for apical closure and a shorter treatment period than calcium hydroxide. However, MTA has significant drawbacks, including the cost premium over calcium hydroxide and the inability to improve root canal dentin. Also, not many studies have looked at how well MTA works in the long run for endodontic therapy in primary teeth [4].

Materials and Methods

A systematic literature review from 2010 to 2022 was performed using PubMed, Medline, and ScienceDirect databases. The keywords used were "calcium hydroxide," "MTA" "and "apexification" **(Table 1)**. In addition, the PRISMA flowchart was used to describe the selection process of searched articles **(Figure 1)**.

Table 1. Inclusion and exclusion criteria

№	Inclusion criteria	Exclusion criteria
1.	Case-control, randomized control studies, systematic reviews.	Expert opinions, or narrative reviews
2.	Published between 2010 and 2022	Out of the specified time range
3.	Studies including calcium hydroxide and MTA.	Studies using methods other than calcium hydroxide and MTA
4.	English language of publication	Language other than English
7.	In vivo (humans)	In vitro

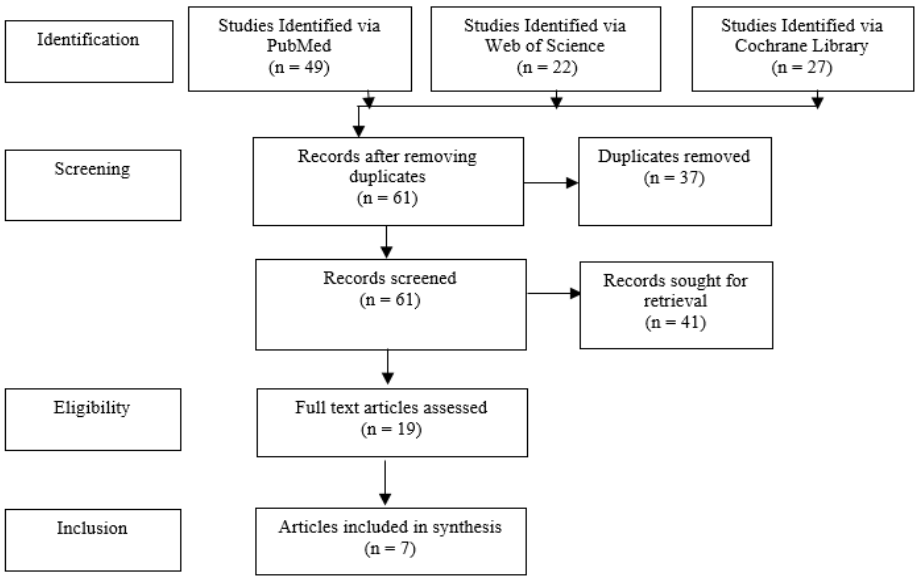

Figure 1. PRISMA Flow Diagram

Risk of Bias Assessment

The quality of the included studies was evaluated using the Cochrane risk of bias assessment technique **(Table 2)**.

Table 2. Summary of Cochrane Risk of Bias Assessment

Study	Selection Bias/Appropriate control selection/baseline characteristics similarity	Selection bias in randomization	Selection bias in allocation concealment	Performance-related bias in blinding	Reporting bias/Selective reporting of outcomes	Detection bias Blinding outcome assessors	Accounting for confounding bias
Damle *et al.*, (2012) [5]	+	+	-	+	+	+	+
Damle *et al.*, (2016) [6]	+	-	+	+	-	+	+

Bonte *et al*., (2012) [7]	+	-	+	+	+	_	+
Beslot-Neveu *et al*., (2011) [8]	+	+	+	+	+	+	-
Gawthaman *et al*., (2013) [9]	+	-	+	+	-	+	+
Lee *et al*., (2015) [10]	+	+	+	-	+	+	+
Shaik *et al*., (2021) [11]	+	-	+	+	+	_	+

Results and Discussion

The goal of this study by Damle *et al.* (2012) [5] was to assess the clinical and radiographic effectiveness of calcium hydroxylate and mineral trioxide aggregate (MTA) in the apexification of injured juvenile permanent incisors. Thirty permanent incisors were apexified, with half going to the MTA group and the other half to the calcium hydroxide group. Both groups had necrotic pulps and open apices. In addition, the formation of the apical barrier time was studied. After 24 hours, obturation with gutta-percha points was performed in the MTA group. Between the two groups, it was established that this difference was statistically significant. A statistically significant difference in how long it takes to complete the lamina dura was also found. Group, I had a mean survival of 4.07 1.49 months, but Group II had a mean survival of 6.43 2.59 months (p= 0.0067). Apexification with MTA is successful, and the procedure offers many benefits, including a shorter treatment time, improved sealing ability, biocompatibility, and a barrier to fast obturation.

The purpose of this study by Damle *et al*., (2016) [6] was to compare the results obtained with the more conventional application of calcium hydroxide (Ca (OH)2) to those obtained by investigating the effects of mineral trioxide aggregate (MTA) on inducing root end creation of immature roots of injured infant permanent anterior teeth. All in all, 22 of the front teeth were fixed. Children in Group I (the MTA group) had a mean age of 101.41 years, whereas those in Group II (the comparison group) averaged 1010.801.32 years. In both sets of patients, the central incisor was the most often affected tooth, whereas the lateral incisor was affected in just two youngsters. At the 3, 6, and 9-month follow-ups, clinical and radiographic evaluation took place. Data were then analyzed using SPSS version 15.0. (Fisher exact test and Chi-square test). Barrier formation was found in 81.81% of individuals in the Ca (OH)2 group and 90.90% of patients in the MTA group after nine months. The median time needed for a barrier to development in the MTA group was 4.90 months, whereas in the Ca (OH)2 group, it was 5.33 months. It may be concluded that MTA and Ca (OH)2 are equally effective as apexification medicines. But MTA helped with the early obturation of immature roots with broad open apices.

The efficiency of calcium hydroxide (CH) and mineral trioxide aggregate (MTA) in promoting root apex closure in immature necrotic permanent incisors was compared in this prospective randomized clinical experiment by Bonte *et al.* (2012) [7]. The same authors previously reported the methodological framework for this investigation. Thirty kids were helped if they had a non-vital permanent incisor. One-half of the study participants were given MTA, while the other half were given CH. A calcified apical barrier was evaluated clinically and radiographically at follow-up visits at 6 and 12 months to determine whether it had formed. The mineralized barrier was present in 43.8% of the CH group and 64.7% of the MTA group at the 6-month checkup. 50 and 82.4% (p0.07) were the results after a year. At the three-month checkup, neither group reported any discomfort or soreness to percussion. The 6-month follow-up on neither substance revealed any discernible differences. Results for apical closure were superior in the MTA group at the 12-month checkup. After 12 months, four out of fifteen teeth in the CH group showed signs of coronal or radicular fractures. Indications in Clinical Practice to accomplish the coronoradicular filling sooner and reduce the risk of root fracture, apexification with MTA is preferred to CH.

The primary purpose of the research by Beslot-Neveu *et al*., (2011) [8] is to evaluate how well MTA, a root-end filling material, performs over 6 months in inducing a strong calcific barrier to cover hermetically non-essential immature permanent anterior teeth with open apices. Thirty-four children and adolescents (ranging in age from 6 to 18) with pulp necrosis of a permanently underdeveloped incisor were included in the analysis. Several investigations have revealed MTA's biocompatibility in vitro and in vivo, shown to have no negative effects in an in-living investigation. By comparing the toxicity of six different dental biomaterials, Beslot-Neveu *et al*., (2011) found that MTA was the safest option. There is no potential for major adverse consequences from following this treatment.

Gawthaman *et al*., (2013) [9] presented two cases in which open-apex teeth were effectively specified using a combination of calcium hydroxide and MTA in a single treatment phase. The first case is the female patient, aged 9, who had been experiencing discomfort in her top front tooth for three days. Similar damage to the same tooth occurred around four days ago due to a fall. The second case is the boy patient, age 11, who presented with the main complaint of a discolored right maxillary central incisor and a one-year history of trauma. The available literature and our current instances suggest that MTA and calcium hydroxide may be utilized effectively for apexification. Compared to calcium hydroxide, MTA offers better qualities regarding the speed with which the apex closes. More research and clinical trials over a longer period are needed.

This study looked at the clinical results of Lee *et al*., (2015) [10] for 40 necrotic immature permanent incisors treated with calcium hydroxide [$Ca(OH)_2$] or mineral trioxide aggregate (MTA) apexification/apexogenesis. Forty necrotic open-apex incisors from children ages 6.5 to ten were randomly divided into four groups, each with teeth of the same type and root apex width in patients of the same age. Incisors in Group 1 received ultrasonic filing and MTA placement; incisors in Group

2 received ultrasonic filing and Ca (OH) 2 medication; hand filing and MTA placement in Group 3; and hand filing and Ca (OH) 2 medication in Group 4. Twenty incisors subjected to MTA apexification/apexogenesis ended up with a rounded root apex. Sixteen of the twenty incisors that were apexified/apex genetically formed with calcium hydroxide showed a conical or nearly conical root apex, whereas the other four showed a flat root apex. We checked up on the teeth once every three weeks for the first nine weeks and then once a week after that.

This meta-analysis was done by Shaik *et al*., (2021) [11] and examined the efficacy of three treatments for the apexification option of necrotic immature permanent teeth: Bioceramic root repair material (BCRRM), mineral trioxide aggregate (MTA), and calcium hydroxide are examples of endosequence materials. We chose 150 studies for further examination after analyzing the titles and abstracts of all 410 found. Following an examination of the whole texts, nine papers matched the inclusion and exclusion criteria and were chosen for the final systematic review. There was no statistically significant difference between the bioceramic and MTA success rates, which were 93.3% and 90%, respectively. In conclusion, both MTA and the bioceramic sealer operate admirably.

Table 3. Summary of the findings from the included studies

Author's name	Sample	Age	Duration	Results
Damle *et al*., (2012) [5]			**4 to 6 months**	MTA demonstrated success and is an effective option for apexification due to its short treatment time, good sealing ability, biocompatibility, and provision of a barrier for immediate obturation.
Damle *et al*., (2016) [6]	**22**	**10 years**	3, 6, and 9 month	MTA was beneficial in terms of immediate obturation of immature roots with wide open apices.
Bonte *et al*., (2012) [7]	**30**	6 to 18 years	6 and 12 months	Clinical relevance Apexification using MTA seems preferable to CH in order to early achieve the coronoradicular filling and to limit the risk of root fracture.
Beslot-Neveu *et al*., (2011) [8]	**34**	6 to 18 years	6 months	The authors studied the toxicity of 6 dental biomaterials and proved MTA was the least harmful of all
Gawthaman *et al*., (2013) [9]	**2**	9 to 11 years old	**3 days**	Considering the time duration for the apex closure MTA has superior properties when compared with calcium hydroxide
Lee *et al*., (2015) [10]	40 children	6.5–10 years		All of the 20 incisors treated with MTA apexification/apexogenesis showed a blunt root apex. Of the 20 incisors treated with calcium hydroxide apexification/apexogenesis, 16 exhibited a conical or nearly conical root apex and four a blunt root apex.
Shaik *et al*., (2021) [11]				The success rate in both bioceramic and MTA was 93.3% and 90%, respectively, with no statistically significant difference

The clinical evaluation of teeth treated with MTA revealed that one tooth extruded about 1 mm due to irritation in the periapical region, causing pain. This soreness disappeared after six months. One of the lateral incisors had an intraoral abscess during the one-month follow-up, which was assumed to be an acute exacerbation of chronic pulpitis. When the intra-canal dressing was replaced after one week, the abscess disappeared.

In Group I, seven teeth were painful at the start, but only five teeth were painful after therapy. At the 3-month checkup after surgery, one patient had mild pain and tenderness that came and went. This was produced by the inadvertent protrusion of MTA into the periapical area. Six participants in Group II were asked how much pain they were in before to surgery. Four of the children reported slight pain and reacted to percussion at their 3-month post-surgery appointment. Ca (OH) 2 had been pushed past the apical barrier in all of these cases. At the 6-month visit, none of the children were in discomfort or felt sore.

The clinical symptoms disappeared rapidly, including pain and touch sensitivity, within three months. At the 3-month checkup, all instances of MTA and 80% of cases of CH were free of periodontal indications. Hence CH was chosen as the initial treatment.

Calcium hydroxide was effective for apical barrier formation in 74% to 100% of cases, and the average time for apical barrier formation was between 5 and 20 months. In the current case, apical barrier development was visible after three months. MTA has made progress in the apexification method. As apexification material, MTA is a primary monoblock. During the maturity of MTA, appetite-like interfacial de posits emerge, filling the gap left by the material during the shrinkage phase and increasing the MTA's resistance to root canal wall friction.

Both calcium hydroxide and MTA apexification/apexogenesis were found to be efficacious in treating 40 necrotic immature open-apex incisors in this investigation. Three positive clinical outcomes were observed: First, all symptoms and signs associated with diseased teeth subsided after treatment; second, all periapical lesions associated with diseased teeth showed complete or nearly complete regression after treatment; and third, root apex elongation with hard tissue barrier formation or continued root development occurred after treatment. When compared to calcium hydroxide, MTA had superior clinical and radiographic results, and the apical barrier established in a shorter period of time. Although MTA proven to be a promising material for apexification, it has several drawbacks, including discolouration and dentine wall weakness.

Even though the study has some flaws, CHPP shows promise as a treatment for apexification, and it works well when Ca (OH)2 apexification is needed. But researcher only looked at one study in which CHPP tips were used on a tooth for 24 months, and the tooth's apex closed. Due to this, the two authors cited below, Tirmazi and Darak reported that clinical studies are needed with a larger sample size and a longer follow-up time [12, 13].

Ulusoy explored whether bone repair and reabsorption of MTA could occur after MTA was released from periradicular tissues, or if MTA could remain inactive and obstruct the healing process. Another possibility when endodontic material is placed between the bone and the mucosa is physical pain of the oral mucosa during MTA extrusion. As a result, the outcome of the treatment after MTA extrusion into the periradicular tissues is unpredictable and cannot be predicted [3].

Calcium hydroxide and mineral trioxide aggregate (MTA) is used for inducing a calcific barrier at an open tooth root (apexification). Of the 216 studies identified, four studies were included. There were no differences in the clinical success rate [pooled odds ratio (OR) = 3.03, 95% confidence interval (CI): 0.42–21.72, p = 0.271], radiographic success rate (pooled OR = 4.30, 95% CI: 0.45–41.36, *p* = 0.206), or apical barrier formation rate (pooled OR = 1.71, 95% CI: 0.59–4.96, p = 0.322) between calcium hydroxide and MTA groups. The time required for apical barrier formation was significantly less in the MTA group (pooled difference in means = −3.58, 95% CI: from −4.91 to −2.25, p < 0.001). While both materials provide similar success rates, the shorter treatment time with MTA may translate into higher overall success rates because of better patient compliance [14].

Using MTA for apexification several clinical trials 5,6 have shown that MTA is a good way to close the root of immature teeth or teeth with root fractures, even if the apex is open. When teeth are treated with MTA, the barrier forms much faster than when teeth are treated with Ca (OH2). Nicoloso *et al.*, 16 are currently conducting a study with the greatest number of apexification-treated samples (252) and the longest follow-up time (10 years) [15]. The success rates of teeth with open apices demonstrate that inserting apical plugs with MTA is an effective method for treating teeth with open apices. Before surgery, apical periodontitis was determined to be the most significant predictor of prognosis. Even after more than four years of follow-up, success rates continue to be rather high [16].

Conclusion

MTA was found to be superior to conduct the procedure of apexification successfully as compared to calcium hydroxide. Therefore, it can be used as a material of choice by endodontists in their practice.

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