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Review Article

**THE EFFECTIVENESS OF CALCIUM HYDROXIDE AND  
MINERAL TRIOXIDE AGGREGATE (MTA) IN DIRECT  
PULP CAPPING: A REVIEW STUDY**<sup>1</sup>Dr Osama Zakir, <sup>2</sup>Dr Saad Hussain, <sup>3</sup>Dr Zahira Nawaz<sup>1,2</sup>BDS, Karachi Medical and Dental College, Karachi<sup>3</sup>Army Medical College, Rawalpindi

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**Abstract:**

Calcium hydroxide is generally accepted as the material of choice for pulp capping. Histologically there is a complete dentinal bridging with healthy radicular pulp under calcium hydroxide dressings. When calcium hydroxide is applied directly to pulp tissue there is necrosis of adjacent pulp tissue and an inflammation of contiguous tissue. Dentinal bridge formation occurs at the junction of necrotic tissue and vital inflamed tissue. Beneath the region of necrosis, cells of underlying pulp tissue differentiate into odontoblasts and elaborate dentin matrix.

The aim of the study is to get a brief review about the properties and clinical applications of calcium hydroxide and Mineral Trioxide Aggregate in conservative dentistry including its antibacterial effect activity for protection of the dental pulp. Therefore, in latest years, the use of calcium hydroxide or mineral trioxide aggregate in indirect and direct pulp capping was one of the most popular lining materials for protection of the pulp in dentistry. Both materials showed a high success rate for reparative dentin when used as pulp capping. In general, the priority the procedure of placement material for pulp protection as pulp capping, indirect or direct must be clinically no pain, no radiographic exchange in pre-apical area and vital tissue of the pulp.

**Keywords:** Dentinal Bridge, Calcium Hydroxide, Mineral Trioxide Aggregate, Pulp Capping

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**INTRODUCTION:**

Calcium hydroxide has been used extensively in dentistry since by Hermann in 1920, and since that time calcium hydroxide has been a very popular cavity liner as a pulp capping agent for 60-70 years back and it is used to elicit a regenerative response of the dentine-complex component tissues [1]. Calcium hydroxide has been used in dentistry for almost a century; it is still the most commonly used endodontic treatment throughout the world [2]. Mineral trioxide aggregate was developed and introduced to dentistry by Mahmoud Torabi Nejad in 1999, and it was mainly used as a cement in root canal therapy, it's composed of tricalcium silicate, di-calcium silicate and tricalcium aluminate, and some manufactures add bismuth oxide to enhance radio-opacity of the material [3]

Pulp protection from restorative material toxicity after cavity preparation, use of cavity liner if deep, as a cavity liner, with a thickening agent with mineral trioxide aggregate, according to several studies, has proven to have good biocompatibility in direct contact with the pulp. Also MTA prevents micro-leakage, and promotes regeneration of the tissue and provides better seal than calcium hydroxide [4]. Traditionally, standard material for pulp capping of normal vital pulp tissue is calcium hydroxide has been the most common indirect and direct pulp capping agent, as cavity liner, is placed to a thickness of typically less than 0.5 mm. Additionally, calcium hydroxide when used in pulp capping can reduce bacterial count in the cavity which also promotes reparative dentin formation [3].

Preservation of pulp vitality continues to be a major challenge for restorative dentistry in view of the numbers of new and replacement restorations performed each year.

Pure calcium hydroxide paste has a high pH (approximately 12.5–12.8) and is classified chemically as a strong base, however the effects of calcium hydroxide on bacterial cells are probably due to protein denaturation and damage to DNA and cytoplasmic membranes [5]

MTA powder contains particles that require moisture in order to set. Several liquids have been suggested to be mixed with MTA, the main cardinal components of an MTA are silica, calcium and bismuth oxide. MTA is marketed in two forms, grey MTA and white MTA. Grey MTA basically consists of di-calcium and tricalcium silicate and bismuth oxide, whereas white MTA is primarily composed of tricalcium silicate and bismuth oxide. Calcium hydroxide and calcium silicate hydrates are formed when

MTA is mixed with water which transforms into crystallized and porous solid gel [6].

**Applications of Calcium Hydroxide:**

Calcium hydroxide dissociates into calcium and hydroxyl ions, these calcium ions reduce capillary permeability thus in turn reducing the serum flow and reducing the levels of inhibitory pyrophosphates that cause the mineralization [7]. The hydroxyl ions neutralize acid produced by osteoclasts maintaining optimum pH for pyro phosphatase activity, leading to increase level of calcium dependent pyro phosphatase which reduced the levels of inhibitory pyrophosphate and causing mineralization [8].

It is generally believed that calcium hydroxide is ideal for direct pulp capping since it accelerates the formation of reparative dentin. There are 2 reasons for this: first, since the material is basic (pH of 11 to 12), it serves as an irritant, stimulating the formation of reparative dentin; and second, the therapeutic effect of calcium hydroxide may be due to its ability to extract growth factors from the dentin matrix [3].

Direct pulp capping is the treatment of the exposed vital pulp by sealing the pulpal wound with a dental material to induce a reparative dentin genic response, and is one of the most important endodontic modalities for maintaining dental pulp vitality.

The material must act as a barrier, protecting the pulp while inducing the formation of new dentine bridge between the pulp and restorative material [9].

The indirect pulp cap when caries is thought to extend close to, or into the pulp, excavation of the pulpal caries can be stopped at stained but firm dentine [10]. The underlying pulp becomes inflamed to a varying and unknown degree, depending on the extent of the dental caries.

Calcium hydroxide lining is applied over the pulpal dentine prior to placement of the definitive restoration, this is classically referred to as the indirect pulp cap. The difficulty with this technique is knowing how rapid the carious process has been, how much tertiary dentine has been formed and knowing exactly when to stop excavating to avoid pulp exposure [11].

Calcium hydroxide is an ideal lining material for the very deep cavity preparation and also continues to represent an option for both the indirect and direct pulp cap. Calcium hydroxide is a multipurpose agent and there are several indications for its clinical application. Some of its indications include direct and indirect pulp capping, apexogenesis, apexification and treatment of root resorption, iatrogenic root perforations, root fractures, replanted teeth and interappointment intracanal dressing [12].

It is the material of choice for all pulp conservative treatment because of its biological and therapeutic potential.

The dry powder of calcium hydroxide, a suspension or cement form, has been recommended for the treatment of exposed pulp due to its beneficial properties, such as induction of mineralization and inhibition of bacterial growth.

#### **Applications of MTA:**

MTA has been proposed as the material of choice for pulp capping. It is believed that MTA effect differs on different tissues. In study there were normal and irregular odontoblasts, that might be attributed to the action of trioxides and oxides on pulpal cells. MTA also induced bone-like cells that are responsible for the formation of hard tissue. Pulp capping procedure is indicated in teeth with immature root to preserve pulpal vitality. MTA has been extensively studied as a pulp capping material in comparison to calcium hydroxide which has been shown to be superior to calcium hydroxide if not similar [13]

MTA also has been used in pulpotomy techniques where part or all of the pulp chamber is removed while maintaining the radicular pulp, in an attempt to preserve its vitality, so the root can continue maturation.

It was reported that MTA use in pediatric dentistry is prohibited, due to the high cost of an MTA, as the material also can't be kept after the envelop has been opened.

#### **Indirect Pulp Treatment**

The indication for indirect pulp treatment is limited to teeth that have no signs of irreversible pulp pathologies based on a thorough clinical and radiographic examination and a direct evaluation of the cavity preparation.

Even today, the subject of vital pulp therapy remains controversial; especially regarding which type of pulp dressing provides the most predictable healing. Calcium hydroxide has been the standard, but newer alternatives are being studied [5].

(a) Calcium hydroxide widely used for pulp capping procedures: [14]

- (1) Is nowadays widely used as an intra-canal medicament in endodontic therapy
- (2) Clinically, calcium hydroxide appears to control infection
- (3) To reduce the incidence of symptoms between appointments
- (4) This antibacterial effect is believed to be dependent on its strongly alkaline pH (12.4)
- (5),

Pure calcium hydroxide paste has a high pH (approximately 12.5-12.8)

(b) Factors of successful pulp capping:

Direct pulp capping is the most conservative restorative procedure for protecting the pulp from further insult, permitting healing and repair, a calcium hydroxide is the most commonly used materials for direct pulp capping [15].

Direct pulp capping is a treatment for exposed vital pulp due to several causes: caries, trauma or mechanical reasons, the latter typically due to a misadventure during tooth preparation, which uses a dental material to facilitate both the formation of reparative dentin from odontoblasts, and the maintenance of vital pulp [16,17]. Selection of pulp capping materials is important to ensure dental pulp cell vitality. Historically, Hermann discovered that calcium hydroxide is effective in repairing a pulp exposure site and the calcium hydroxide possesses antibacterial properties and promotes pulp tissue repair, therefore direct pulp capping is one of the most common dental practices in restorative dentistry [18-19].

Direct pulp capping is a vital pulp therapy technique which aims at maintaining pulpal tissues viability by protecting the pulpal system from bacterial ingress and hence enhancing its reparative capacity. Bridging off the communication site with new dentine is a prerequisite for the long term success of direct pulp capping treatment [20, 21].

Successful direct pulp capping prevents the need for more complex or invasive treatment options such as root canal therapy or extraction [22]

There are several factors that can increase the success rate of direct pulp capping, such as the following:[23]

1. Asymptomatic tooth with no history of spontaneous or lingering pain.
2. Less than 0.5mm pulp exposure.
3. Controlled pulpal bleeding after exposure.
4. Proper isolation of the tooth during the procedure.
5. Minimal blood contamination of adjacent dentin

#### **Properties of Calcium Hydroxide and Mineral Trioxide Aggregate:**

Elastic modulus and compressive strength of MTA is higher than that of calcium hydroxide which made it a more suitable option when the final restoration is placed with condensation forces. The high bond strength of mineral trioxide aggregate is important due to the fact that the material can suffer displacement under occlusal forces which might result in sealing failure, MTA

is biocompatible with the pulp and its biocompatibility is enhanced over time when the material is completely set.

Calcium hydroxide is not acutely toxic via the oral, dermal, or inhalation route. It's used as dressing for treatment of the vital pulp, the ability to encourage hard tissue healing around infected dentin and have an antibacterial effect.

The calcium hydroxide is relatively soluble in water, its solubility drastically decreases, but hardened MTA contains calcium hydroxide in a silicate matrix which contribute to its high pH, this composition may differ according to the solution that was used to mix the MTA powder [8]. Also some antibacterial properties and activities, depending on its powder to liquid ratio and related to the release of highly reactive hydroxyl ions in a fluids environment, which mainly affects cytoplasmic membranes proteins and DNA.

#### **Outcome of Pulp Capping Using Either Calcium Hydroxide or MTA**

In a new multi-center, parallel-group randomized controlled trial that compare the effectiveness of MTA and CH as a direct pulp capping material in adult molars with carious pulpal exposure. tooth survival was set as a primary outcome which was defined as asymptomatic tooth that responds normally to vitality testing and periapical radiographs don't show any bone rarefaction, the survival rate in MTA group was 53% while in the

Calcium hydroxide group was 52%. in their study reported that calcium hydroxide was found not to have any beneficial effect on the healing of the exposed inflamed pulp. The results with zinc oxide and eugenol were more favorable. In an observational study of the direct pulp capping with mineral trioxide aggregate, observed 49 of 53 teeth in 37 patient between one and nine years with a mean age being 16.6 years and a recall rate of 92.5%. they found that the survival rate was 97.96% that has been based on cold testing, sings & symptoms and radiographs at recall appointment.

In their systematic review and meta-analysis stated that MTA performs better than calcium hydroxide in direct pulp capping therapy, with 100% success rate for the MTA after six months follow up in comparison to 79.4% success rate for the calcium hydroxide group with the same follow up duration.

#### **CONCLUSION:**

In conclusion, can be suggested as the materials of best choice for pulp capping and no significant

difference was found between them in terms of calcified bridge formation and thickness with a well-structured dentin is formed when using MTA, as well as pulpal inflammatory response. MTA is a bioactive material that influences its surrounding environment required to promote wound healing, provides immediate bond and sealing properties, and stimulates hydroxyl-apatite and secondary dentin formation within affected tissues.

The handling characteristics of calcium hydroxide and its lower price render the material the first choice to be clinically used in comparison to the high cost of MTA and the difficulties of it is mixing and handling characteristics.

Calcium hydroxide is classified as a strong base with a high pH approximately 12.5–12.8. Its main properties come from the ionic dissociation of Ca<sup>2+</sup> and OH ions and their effect on vital tissues, generating the induction of hard tissue deposition and being antibacterial. Calcium hydroxide is a suitable material for pulp capping. Calcium hydroxide is a necessary material which has a number of applications especially in conservative dentistry. Because of the extreme importance of these materials has become without competition serves as a bread every day for practitioner dentist.

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