Calcium Hydroxide – A Great Calcific Wall

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Abstract:

Calcium hydroxide is a material which has been used for a variety of purposes. The precise mechanism by which it acts is still not clearly understood. This paper gives a brief review on different applications of Calcium Hydroxide and its mechanism of action.

Key Words: Calcific wall, Calcium hydroxide.

Introduction:

During the last 200 years there have been many changes in the rationale governing the treatment of the exposed dental pulp as it was long ago observed that an exposed pulp healed with great difficulty, if at all. The earliest account of pulp therapy was way back in 1756, when Phillip Pfaff packed a piece of gold (leaf?) over an exposed vital pulp to promote healing.[1] Until Hermann's (1920) introduction of a material so eminent, which marked a new era in pulp therapy, when he demonstrated that a ***Calcium hydroxide*** formula called Calxyl induced dentinal bridging of the exposed pulpal surface. Since then the emphasis has shifted from the "doomed organ" concept of an exposed pulp to one of hope and recovery.[1]

What makes calcium hydroxide so special to dentistry? Probably the answer to this question could be that it is one of those few materials which has both an antibacterial property and an august property of inducing a hard tissue barrier, an elixir of life for the dying teeth! What makes calcium hydroxide to have an upper hand over the rest of the materials is that calcium hydroxide is easy to manipulate. Its cost compared to that of the currently available materials is less.

Definition:[2]

Calcium hydroxide is a strong alkali, which can be formed by the reaction of calcium oxide with watera process called as slaking. If the oxide is treated with only sufficient water to make it crumble to a fine,white,dry powder slaked lime is produced.

Synonyms: Calcium Hydrate, Caustic Lime, Hydrated Lime, Lime, Lime Hydrate, Slaked Lime.
Chemical formula: $Ca(OH)_2$ '! $CaO + H_2O$
Formula weight: 74.09
Density: 2.24
Melting point: 580 degree Celsius.

Calcium Hydroxide, How Does it Work?

Since the introduction of Calxyl by Hermann, it has become the standard clinical agent for promoting the formation of reparative dentin. The precise mechanism by which this occurs is still not clearly understood; however the antimicrobial activity of calcium hydroxide is believed to enhance this formation. It is proposed that the elimination of the bulk of the bacteria in the dentin, the "balance of power" is shifted from a gradually dying pulp to one with the potential for complete resolution. The antimicrobial activity has been attributed to calcium hydroxide's high pH.[3]

Mechanism of antimicrobial activity:[4]

Calcium hydroxide is a strong alkaline substance with a pH of approximately 12.5. Most of the endopathogens are unable to survive in this high alkaline environment. When in direct contact several bacterial species found in infected root canals are eliminated in only a short period of time. Antimicrobial activity of calcium hydroxide is related to the release of hydroxyl ions in aqueous environment. Hydroxyl ions are highly oxidant, free radicals that show extreme reactivity, with several biomolecules. Their lethal effects on the bacterial cells are probably due to the following mechanisms:

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Damage to the bacterial cytoplasmic membrane:

Hydroxyl ions induce lipid per oxidation, resulting in the destruction if phospholipids, structural components of the cellular membrane. Hydroxyl ions remove hydrogen atoms from the unsaturated fatty acids, generating a free lipid radical. This free radical reacts with oxygen, resulting in the formation of a lipidic peroxidase radical, which removes another hydrogen atom from a second fatty acid, generating another lipidic peroxidase. Thus, peroxidases act as free radicals, initiating an autocatalytic chain reaction and resulting in further loss of unsaturated fatty acids and extensive tissue damage.

Protein denaturation:

The alkalinization provided by calcium hydroxide induces the breakdown of the ionic bonds that maintain the tertiary structures of proteins. As a consequence the enzyme maintains its covalent structure but the polypeptide chain is randomly unraveled in variable and irregular special conformation. These changes frequently result in the loss of biological activity of the enzyme and disruption of the cellular metabolism. Structure may also be damaged by hydroxyl ions.

Damage to the DNA

Hydroxyl ions react with the bacterial DNA and induce the splitting of the strands. Genes are then lost. Consequently DNA replication is inhibited and the cellular activity is disarranged.

Destruction of bacteria when calcium hydroxide is used as a pulp dressing:[5]

Some of the healing properties of calcium hydroxide may be attributed to its antibacterial effects. Under normal conditions healing is due to the antibacterial activity of calcium hydroxide, rather than any effect it may exert on mineralization.

As a root canal medicament:

There is some uncertainty as to the efficacy of calcium hydroxide compared with the other medicaments when used as an intra canal dressing. Thus in contrast to its mode of action in mineralization, calcium hydroxide has a non-specific bactericidal action within the confines of the root canal. Alkalis in general have a pronounced destructive effect on cell membranes and protein structures.[4] Although most microorganisms are destroyed at pH 9.5 a few survive at pH 11 or higher. The main issue is not “how bacteria are killed” but how the vital tissues can be protected from the toxicity of calcium hydroxide. This is brought about by the separation of the material from the vital tissues by a zone of necrosis. Bacteria may survive after intra canal medication for several reasons. First, bacterial strains present in the root canal infection may be intrinsically resistant to the medicament. Secondly bacterial cells may be enclosed with an anatomical variation inaccessible to the medicament. Thirdly, the medicament may be neutralized by the tissue components and by the bacterial cells or products, losing its antibacterial effects. Fourthly, the medicaments may remain in the root canals for insufficient time to reach and kill the bacterial cells. Finally, bacteria may alter their pattern of gene expression after changes in the environmental conditions. This alteration may allow them to survive in unfavorable environments. Good clinical results have been attributed to the use of calcium hydroxide as an intra canal medicament. Nonetheless, the antibacterial activity of calcium hydroxide is still controversial and it is not clear whether the benefits of this substance are based upon the superior antibacterial activity.[4]

The Great Calcific Wall:

The mode of therapeutic activity of calcium hydroxide for calcific bridge formation is not clear despite extensive literature. Calcific bridge formation is the generic term describing repair by osteodentin bridge formation in pulpal exposure and cementum like material or cementoid formation in periapical or periodontal tissues.

The magic mantra of calcium hydroxide:

It seems that calcium hydroxide has the unique potential to induce mineralization, even in tissues which have not been programmed to mineralize. Calcium ions and the alkaline pH have been proposed to act separately or synergistically in promoting calcification. It has been speculated that the material exerts a mitogenic and osteogenic effect, the high pH combined with the availability of calcium ions and hydroxyl ions has an effect on the enzymatic pathways and hence mineralization.

The dentin bridge:

A mineralized barrier or “dentin bridge” is usually produced following the application of calcium hydroxide to a vital pulp (pulpotomy). This repair material appears to be the product of odontoblasts and connective tissue cells. There appears to be some variation in the way the dentin bridge is formed, depending on the pH of the material that is used to dress the tooth. In the case of a necrotic zone is formed adjacent to the material and the dentin bridge then forms between this necrotic layer and the underlying vital pulp. The necrotic tissue eventually degenerates and disappears, leaving a void between the capping material and the bridge.

Applications of calcium hydroxide in pedodontics

Operative dentistry[6]

As a liner:

The calcium hydroxide pastes are now in general use as lining materials. Their perceived advantages, in addition to their therapeutic effects are as follows:

- They have a rapid initial set in the cavity under the accelerating effect of moisture in the ambient air of the oral cavity and from within the tubules.
- They do not interfere with the setting reaction of the Bis-GMA resins and are therefore the lining material of choice under the composite resins.
- It is generally considered that the initial set of the material in thin sections is sufficiently hard to resist the applied condensation pressures that are required even for the lathe cut amalgam alloys.

As a base and a sub base:

Calcium hydroxide can be used both as a sub base and as a base. When as a sub base it provides therapeutic properties. It should be placed deep in deep portions of the cavity preparation subsequently covered by a definitive supporting base.

Calcium hydroxide for pulp protection:[7]

Indirect pulp treatment

The demineralization and staining precedes bacterial invasion of dentin. This presents the basis for the indirect pulp treatment. Carious dentin actually consists of two layers having different ultramicroscopic and chemical structures. The outer carious layer is irreversibly denatured, infected and incapable of being remineralized and hence should be removed. The inner carious layer is reversibly denatured but not infected and is capable of being remineralized and hence should be preserved.

Direct pulp treatment:

Direct pulp treatment involves the placement of a biocompatible agent on the healthy pulp tissue that has been inadvertently exposed by caries excavation or traumatic injury. The treatment objective is to seal the pulp against bacterial leakage and encourage the pulp to wall off the exposure site by initiating a dentin bridge and maintain the vitality of the underlying pulp tissue organ. Success with direct pulp treatment is dependant on the coronal and radicular pulp being healthy and free from bacterial invasion.

Calcium hydroxide in pediatric endodontics:[8]

Pulpotomy:

Pulpotomy is the most widely used technique in vital pulp therapy for primary and young permanent teeth with carious pulp exposures.

Calcium hydroxide in primary teeth:

Historically, calcium hydroxide was the first medicament used in the “regenerative” capacity because of its ability to stimulate hard tissue barrier formation. The calcium hydroxide pulpotomy is predicted on the healing of pulp tissue beneath the overlying dentin bridge. Internal resorption may result from the over stimulation of the primary pulp by the highly alkaline calcium hydroxide. This alkaline-induced over stimulation could cause metaplasia within the pulp tissue, leading to the formation of odontoclasts. Contradicting to this, it is seen that some low pH commercial preparations of calcium hydroxide, showed earlier and more consistent bridging.

Calcium hydroxide for the pulpotomy of young permanent teeth:

The improved clinical outcomes with the use of calcium hydroxide in young permanent teeth make it the most recommended pulpotomy agent for carious and traumatically exposed teeth. Its use is of particular importance in incompletely formed apex **(Apexogenesis).**

Apexification:

The upper central incisors are the teeth most commonly traumatized in children. Immature roots with open apices may be managed with calcium hydroxide in either a pulpotomy procedure with calcium hydroxide placement over the vital radicular pulp (apexogenesis) or as temporary root canal filling material in cases of nonvital immature teeth (apexification).

Calcium hydroxide as a root canal filling material for primary teeth:

The best treatment of a primary pulp is the prevention of pulpal disease which is, through preventive and therapeutic measures. A healthy primary tooth is the ideal space maintainer. Pulpectomy is always just a compromise, but with taking proper indication into account, preferred to an extraction. The therapeutic goals are to eliminate the necrotic pulp and the microorganisms and to ensure the hermetic seal of the root canals, so that the primary tooth can complete its function until the exfoliation, the most commonly used materials as root canal filling are zinc oxide eugenol, iodoform based pastes and calcium hydroxide.

Apical plug[9]:

In situations where there is an open apex or indeed normal apical anatomy the dentin chip plug in the periapical tissue has been advocated as an artificial but biological apical stop against which gutta-percha can be condensed. The intentional extrusion of calcium hydroxide powder to act as an apical stop enabling condensing of gutta-percha has been advocated with good clinical success rates.

Dressing of the root canal[9] :

It is doubtful whether a routine calcium hydroxide dressing is necessary for the root canal therapy in the canals that contain vital pulp tissue as these are not infected prior to the instrumentation, or in contaminated canals which have been cleaned and shaped with modern instrumentation techniques. However, if a root canal is heavily infected prior to instrumentation, it is highly probable that a few bacteria will remain. In these circumstances, a dressing with calcium hydroxide which can be placed the full length of the canal is the treatment of choice.

Treatment of weeping canals[9]:

Calcium hydroxide is now widely used to reduce the seepage of apical fluids into the canal so as to allow the placement of a satisfactory root filling.

Calcium hydroxide in the repair of iatrogenic perforations[9]:

It has been reported that perforations of the root canal wall, by the instruments or by posts, may be treated in a similar way to the apical closure, in an attempt to hard tissue formation. The early preliminary dressing of the perforation with calcium hydroxide is very important to prevent the in growth of granulation tissue.

Calcium hydroxide as a root canal ealer[9]:

Calcium hydroxide has had such a long association with endodontics but it is surprising that the commercially available calcium hydroxide root canal sealers were not developed till recently. Calcium hydroxide –based root canal sealers which have introduced as an alternative to the conventional zinc oxide eugenol –based sealers are Sealapex and Calcioboitic Root Canal Sealer (CRCS).

Conclusion:

Calcium hydroxide has been around the century and the research surround it’s properties and use, has increased dramatically in the recent years. Lado et al[3] conducted a study to evaluate the antimicrobial activity, the agents were Dycal and Advanced Dycal, Renew, Pulpdent, Life, Healthco, IRM, Zinc oxy phosphate and reagent Calcium hydroxide, they concluded that calcium hydroxide compounds are the agents of choice since they not only directly stimulated the formation of reparative dentin but also were more bactericidal than reagent Calcium hydroxide. Many newer materials are now available in the market, which claim to be superior to calcium hydroxide. But how possible is the use of these materials in the Indian scenario?

When compared to the prices of the newer materials calcium hydroxide is more cost effective. Some preparations of calcium hydroxide are still, expensive but a simple calcium hydroxide powder and sterile water can serve many purposes and works out to be reasonable and affordable to many patients who visit the Indian dental clinics. One must also consider the ease in manipulation and the time factor associated with the calcium hydroxide preparations. Though calcium hydroxide has limited use in the primary teeth, it has innumerable applications in permanent teeth, especially the young. Hence calcium hydroxide has become one of the most widely accepted materials in the dental office.

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