# Review Article

## Calcium Hydroxide in Dentistry

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## Abstract

Calcium hydroxide has been used in dentistry for almost a century. Its mechanism of actions are achieved through the ionic dissociation of Ca(2+) and OH(-) ions and their effect on vital tissues, the induction of hard-tissue deposition and the antibacterial properties. Some of its indications include inter-appointment intracanal medicaments, endodontic sealers, pulp capping agents, apexification, pulpotomy and weeping canals. The purpose of this article is to review the properties, mechanism of action, applications, advantages, disadvantages and various indications for the use of calcium hydroxide in endodontics.

Key Words: Biomineral, Calcium hydroxide, Intracanal medicament, Weeping canal

## Introduction

Bones and teeth are biocomposites that require controlled mineral deposition during their self-assembly to form tissues with unique mechanical properties[1]. Biominerals such as calcium and phosphate synthetically produced or obtained from natural sources thus has an important function in the preventing demineralization and encouraging remineralization of hard tissues of the tooth along with the preservation and maintenance of the health of the pulp[2].

Calcium hydroxide was introduced to the dental profession in 1921, Hermann demonstrated the formation of dentinal bridge in an exposed pulpal surface and it is now considered the "gold standard" for direct pulp capping agents[3]. The use of the medication for root canal system disinfection has been supported to improve the treatment outcome[4,5] as the complexity of the root anatomy makes more difficult their cleaning and shaping[6]. Intracanal medications such as calcium hydroxide are used to reduce or eliminate bacteria located in the root canal system and prevent their proliferation between sessions[4,5,6]. Since the introduction to dentistry of calcium hydroxide by Hermann (1920, 1930), this medicament has been indicated to promote healing in many clinical situations. However, the initial reference to its use has been attributed to Nygren (1838) for the treatment of the `fistula dentalis', whilst Codman (1851) was the first to attempt to preserve the involved dental pulp[7]. According to Cvek (1989) calcium hydroxide became more widely known in the 1930s through the pioneering work of Hermann (1936) and the introduction of this material in the United States (Teuscher & Zander 1938, Zander 1939). The first reports dealing with successful pulpal healing using calcium hydroxide appeared in the literature between 1934 and 1941. Since then, and mainly after the Second World War, the clinical indications for its use were expanded and now this chemical is considered the best medicament to induce hard tissue deposition and promote healing of vital pulpal and periapical tissues (Garcia 1983)[7]. $Ca(OH)_2$ is a white odorless powder with a molecular weight of 74.08. The material is chemically classified as a strong base with a high pH (12.5) and is only slightly soluble in water with a solubility of 1.2 g/l, at a temperature of 25°C[7]. The dissociation of $Ca(OH)_2$ into calcium and hydroxyl ions results in increased pH locally. High pH of $Ca(OH)_2$ causes irritation of the pulp tissue, which stimulates repair of dentin by the release of bioactive molecules such as Bone Morphogenic Protein and Transforming Growth Factor-Beta One[3,8].

## Properties[5]

### Structure:

1. Arrangement= amorphous matrix, crystalline fillers.
2. Bonding= covalent; ionic.
3. Defects=pores, cracks.
4. Setting reaction= acid base reaction.

### Physical Properties:

1. L.C.T.E= low.
2. Thermal conductivity= insulator.
3. Electrical conductivity= insulator.
4. pH=12.5-12.8.

### Chemical Properties:

1. Solubility- 0.3-0.5

### Mechanical Properties:

1. Elastic mod=588
2. Compressive strength >24 hr=138

### Biologic Properties:

1. Biocompatible.

### Bactericidal Properties:

$Ca(OH)_2$ is bacteriocidal on contact. It must be in direct contact with the bacteria to be lethal. $Ca(OH)_2$ has been shown to be active and not active against E faecalis and Pseudomonas aeruginosa[9,10]. Asgary and Kamrani tested Ca(OH)2 against Pseudomonas aeruginosa, E faecalis, Staphylococcus aureus, and Escherichia coli and found it to inhibit growth of these bacteria[11].

## Mechanism of action

### Antimicrobial activity:

The antimicrobial activity of Ca(OH)2 is related to the release of hydroxyl ions in an aqueous environment (Siqueira 2001). Hydroxyl ions are highly oxidant free radicals that show extreme reactivity with several biomolecules. This reactivity is high and indiscriminate, so this free radical rarely diffuses away from sites of generation (Siqueira & Lopes 1999). The lethal effects of hydroxyl ions on bacterial cells are probably due to the following mechanisms (Siqueira & Lopes 1999):

- damage to the bacterial cytoplasmic membrane;
- protein denaturation; and
- damage to the DNA[5]

### Mineralization activity:

When used as a pulp-capping agent and in apexification cases, a calcified barrier may be induced by calcium hydroxide (Eda 1961). Because of the high pH of pure calcium hydroxide, a superficial layer of necrosis occurs in the pulp to a depth of up to 2 mm (Estrela & Holland 2009). Beyond this layer, only a mild inflammatory response is seen and, provided the operating field is kept free from bacteria when the material was placed, hard tissue may be formed (Estrelaet al. 1995)[5].

## Applications[12]

1. Intracanal Medicament: It is the most commonly used dressing for treatment of the vital pulp. It also plays a major role as an inter-visit dressing in the disinfection of the root canal system. Calcium hydroxide cannot be categorized as a conventional antiseptic, but it kills bacteria in root canal space. Calcium hydroxide is a slowly working antiseptic. Direct contact experiments in vitro require a 24 hour contact period for complete kill of enterococci. Calcium hydroxide not only kills bacteria, but it also reduces the effect of the remaining cell wall material lipo-polysaccharide. It has a wide range of antimicrobial activity against common endodontic pathogens, but is less effective against Enterococcus faecalis and Candida albicans. Calcium hydroxide is also an effective anti-endotoxin agent. However, its effect on microbial biofilms is controversial.

2. Endodontic Sealer: To be therapeutically effective calcium hydroxide must be dissociated into Ca++ and OH-. Therefore to be effective, an endodontic sealer based on calcium hydroxide must dissolve and the solid consequently lose content.

3. Pulp Capping Agent: 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.

4. Apexification: In apexification technique canal is cleaned and disinfected, when tooth is free of signs and symptoms of infection, the canal is dried and filled with stiff mix of calcium hydroxide and CMCP. Histologically there is formation of osteodentin after placement of calcium hydroxide paste. There appears to be a differentiation of adjacent connective tissue cells; there is also deposition of calcified tissue adjacent to the filling material.

5. Pulpotomy: It is the most recommended pulpotomy medicament for pulpally involved vital young permanent tooth with incomplete apices. It is acceptable because it promoted reparative dentin bridge formation and thus pulp vitality is maintained.

6. Weeping Canals: For such teeth dry the canals with sterile absorbent paper points and place calcium hydroxide in canal. Calcium hydroxide converts the acidic pH of periapical tissue in the weeping canal to basic pH.

## Method of preparation

The easiest method to prepare a calcium hydroxide paste is to mix calcium hydroxide powder with water until the desired consistency is achieved[7].

Leonardo et al. (1982) stated that a paste prepared with water or other hydrosoluble non-viscous vehicle does not have good physicochemical properties, because it is not radio-opaque, is permeable to tissue fluids and is rendered soluble and resorbed from the periapical area and from within the root canal. For these and the following reasons, Leonardo et al. (1982) recommended the addition of other substances to the paste:

1. To maintain the paste consistency of the material which does not harden or set;
2. To improve flow;
3. To maintain the high pH of calcium hydroxide;
4. To improve radiopacity;
5. To make clinical use easier;
6. Not to alter the excellent biological properties of calcium hydroxide itself.

## Composition of calcium hydroxide paste

Calcium hydroxide paste for use in endodontics is composed of the powder, a vehicle and a radiopacifier. Other substances may be added to improve physicochemical properties or the antibacterial action[7].

## Vehicles

According to Fava (1991), the ideal vehicle should:

1. Allow a gradual and slow $Ca^{2}$. and OH- ionic release;
2. Allow slow diffusion in the tissues with low solubility in tissue fluids;
3. Have no adverse effect on the induction of hard tissue deposition[7].

The vehicles mixed with $Ca(OH)_2$ powder play an important role in the overall dissociation process because they determine the velocity of ionic dissociation causing the paste to be solubilized and resorbed at various rates by the periapical tissues and from within the root canal. The lower the viscosity, the higher will be the ionic dissociation. The high molecular weight of common vehicles minimizes the dispersion of Ca(OH)2 into the tissues and maintains the paste in the desired area for longer periods of time (Athanassiadis et al. 2007)[5].

There are three main types of vehicles:

1. Water-soluble substances such as water, saline, anaesthetic solutions, carboxymethylcellulose, methylcellulose and Ringers solution.
2. Viscous vehicles such as glycerine, polyethylenegly col (PEG) and propylene glycol.
3. Oil-based vehicles such as olive oil, silicone oil, camphor (the oil of camphorated parachlorophe nol), some fatty acids (including oleic, linoleic, and isostearic acids), eugenol and metacresylacetate (Fava & Saunders 1999)[5].

Staehle et al. (1995) reported that an aqueous suspension allows a more efficient release of hydroxyl ions. According to Simon et al. (1995), distilled water or camphorated paramonochlorophenol result in better diffusion than phosphate buffered saline or propylene glycol[13].

Radiopacifier : Calcium hydroxide mixed with any of the quoted vehicles lacks radiopacity and is not easily seen radiographically. This is the main reason radiopaque materials are added to the paste, thereby allowing identification of lateral and accessory canals, resorptive defects, fractures and other structures (Smith & Woods 1983, AlacË am et al. 1990). A radiopacifier should have an atomic weight higher than calcium for radiopacity purposes (Tavano et al. 1978). Some examples of such substances are barium sulphate and bismuth, and other compounds containing iodine and bromine (AlacË am et al. 1990)[7].

| Clinical application of biomaterials | Enamel reminera -lization | Dentino -genesis | Cemento -genesis | Apexifi -cation | Perforat-ion repair | Repair of resorption defects | Repair of bony defects |
|---|---|---|---|---|---|---|---|
| Calcium phosphate Cement | + | - | + | - | + | - | + |
| Β-tricalcium phosphate | + | - | + | - | + | - | + |
| Bioactive glass | + | - | + | - | - | - | - |
| Synthetic hydroxyapatite | + | - | - | - | - | - | + |
| Calcium hydroxide | - | + | + | + | + | + | - |
| Portland Cement | - | + | - | + | + | + | - |
| Mineral trioxide aggregate | - | + | + | + | + | + | + |
| Biodentine | + | + | + | + | + | + | - |

**Table1** : Clinical restorative application of biomineral based biomaterials

## Characteristic of calcium hydroxide paste

When calcium hydroxide powder is mixed with a suitable vehicle, a paste is formed and, because the main component is calcium hydroxide, Maisto (1975) classified these formulations as alkaline pastes because of their high pH. According to some authors (Maisto 1975, Goldberg 1982, Leonardo et al. 1982), these pastes should have the following characteristics:

1. Composed mainly of calcium hydroxide which may be used in association with other substances to improve some of the physicochemical properties such as radiopacity, flow and consistency;
2. Non-setting;
3. Can be rendered soluble or resorbed within vital tissues either slowly or rapidly depending on the vehicle and other components;
4. May be prepared for use at the chairside or available as a proprietary paste;
5. Within the root canal system they are used only as a temporary dressing and not as a definitive filling material[7]

## Advantages of Calcium hydroxide[14]

- Initially bactericidal then bacteriostatic.
- Promotes healing and repair.
- High pH stimulates fibroblasts.

- Neutralizes low pH of acids.
- Stops internal resorption.
- Inexpensive and easy to use.

## Disadvantages of Calcium hydroxide[15]

- Does not exclusively stimulate dentinogenesis.
- Does exclusively stimulate reparativedentin.
- Associated with primary tooth resorption.
- May dissolve after one year with cavosur face dissolution.
- May degrade during acid etching.
- Degrades upon tooth flexure.
- Marginal failure with amalgam condensation.
- Does not adhere to dentin or resin restoration.

## Conclusion

Calcium hydroxide is widely used material in endodontic treatment due to its high alkalinity and bactericidal properties. It is a material which is readily available, simple to prepare and restorable. Calcium hydroxide is still a material of choice which is widely being used for various reasons in Endodontics.

## References

1) He G, Dahl T, Veis A, George A. Nucleation of apatite crystals in vitro by self- assembled dentin matrix protein. Nat Mater 2003;2(8):552-558.

2) Shetty N, Kundabala M. Review article Biominerals in restorative dentistry Journal of Interdisciplinary Dentistry 2013;3(2):64-70.

3) Hilton TJ. Keys to clinical success with pulp capping: A review of the literature. Oper Dent 2009;34(5):615-625.

4) Kontakiotis EG, Tsatsoulis IN, Papanakou SI, Tzanetakis GN. Effect of 2% Chlorhexidine Gel Mixed with Calcium Hydroxide as an Intracanal Medication on Sealing Ability of Permanent Root Canal Filling: A 6-month Follow-up. J Endod 2008;34(7):866-870.

5) Mohammadi Z, Dummer PMH. Properties and applications of calcium hydroxide in endodontics and dental traumatology. Int Endod J 2011;44(8):697-730.

6) Kim SK, Kim YO. Influence of calcium hydroxide intracanal medication on apical seal. Int Endod J 2002;35(7):623-628.

7) Fava LR ,Saunders WP. Review Calcium hydroxide pastes: classification and clinical indications. International Endodontic Journal 1999;32(4):257-282.

8) Graham L, Cooper PR, Cassidy N, Nor JE, Sloan AJ, Smith AJ. The effect of calcium hydroxide on solubilisation of bio-active dentine matrix components. Biomaterials 2006;27(14):2865-73.

9) Ballal V, Kundabala M, Acharya S, Ballal M. Antimicrobial action of calcium hydroxide, chlorhexidine and their combination on endodontic pathogens. Aust Dent J. 2007;52(2):118–121.

10) Pallotta RC, Ribeiro MS, de Lima Machado ME. Determination of the minimum inhibitory concentration of four medicaments used as intracanal medication. Aust Endod J. 2007;33(3):107–111.

11) Asgary S, Kamrani FA. Antibacterial effects of five differentroot canal sealing materials. J Oral Sci. 2008;50(4):469–474.

12) Mustafa M, Saujanya KP, Jain D, Shetty S, Arun A, Uppin L, Kadri M. Role of Calcium Hydroxide in Endodontics : A Review. GJMEDPH 2012;1(1):66-67.

13) Pérez F, Franchi M, Péli JF. Effect of calcium hydroxide form and placement on root dentine pH. International Endodontic Journal 2001;34(6):417–423.

14) Arendorf TM, Walker DM. The prevalence and intraoral distribution of Candida albicans in man. Archives of Oral Biology 1980;25(1):1–10.

15) Ashkenaz P. One-visit endodontics: a preliminary report. Dental Survey 1979 ;55(1):62–9.