

Calcium Hydroxide : a miracle munition

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ABSTRACT

Calcium hydroxide is considered as a miracle in dentistry because of its versatile properties. Its uses today are widespread. It is a basic compound with an appropriate pH > 11. As such it is mildly irritating to vital pulp tissue. The characteristics of calcium hydroxide come from its dissociation into calcium and hydroxyl ions. The action of these ions on tissues and bacteria explains the biological and antimicrobial properties of this substance. It is supplied in several types. It is available in powder form. It is sold as a liquid containing calcium hydroxide suspended in a solvent. Also it is handy to use in a single-paste mode, two-paste catalyst and base system and a calcium hydroxide paste formulation that contains a polymer resin that can be hardened by illumination from a handheld blue light.

Introduction

Calcium hydroxide has been studied for many years. Herman in 1920 suggested calcium hydroxide for the treatment of dental pulp.[1,2] The formula was considered to be the pioneer in the use of calcium hydroxide, with addition of others substances. For Stanley, a new era had begun. Calcium hydroxide encourages the deposition of a hard tissue bridge that usually protects the dental pulp.[3] The ability to stimulate mineralization associated to the antimicrobial effectiveness confers on it the current success as an endodontic medication.

However, well-conducted researches about the properties of calcium hydroxide, such as histocompatibility, antimicrobial potential, physical-chemical aspects, give credibility to the choice of this medication in several clinical situations. Calcium hydroxide is an excellent therapeutic option when the clinical situation requires the use of pulp capping agent and intracanal medication.

Two effects of this medication need to be considered, biological and antimicrobial effects.[2-5] The chemical dynamics of calcium hydroxide as demonstrated by ionic dissociation, characterizes its properties. The activation of tissue enzymes such as alkaline phosphatase shows mineralizing effects and inhibiting effect on bacterial enzymes, which leads to its antimicrobial property, illustrating the biological qualities of hydroxyl and calcium ions on both tissue and microorganisms. This study discusses its main functions, with special attention to maintain endodontic biological principles.

Properties of calcium hydroxide

STRUCTURE-

- Arrangement = amorphous matrix, crystalline fillers.
- Bonding = covalent; ionic
- Composition = multiphase

PHYSICAL PROPERTIES-

- LCTE = low
- Thermal conductivity = insulator
- Electrical conductivity = insulator

CHEMICAL PROPERTIES

- Solubility = 0.3 - 0.5
- pH = 12.6

MECHANICAL PROPERTIES

- Elastic mod = 588
- Compressive strength >24 hr = 138 [1,2,8]

Mechanism of Action (MOA)

MOA of Hydroxyl Ions bacteria

The greatest concern in the selection of any dressing is the knowledge of its mechanism of action on the predominant bacterial flora. Antibiotics provoke two types of effects on bacteria. They either inhibit growth or reproduction or they lead to its death. These actions are exercised essentially by interfering in the synthesis of the cell wall, altering the permeability of the cytoplasmic membrane and interfering in protein synthesis.[2,4,5] Calcium hydroxide is an antibacterial agent due to its elevated pH. pH influences the specific activity of the proteins of the membrane with a combination with specific chemical groups & can lead to alterations in the ionization state of organic components, depending on pH, there will be an intense transfer of available nutrients through membrane, inducing inhibition and toxic effect on cell. Thus, the influence of elevated pH (12.6) of OH⁻ ions, transfer capacity and permeability of cytoplasmic membrane explains the action of Calcium Hydroxide on bacteria, this is known as Lipidic peroxidation. OH⁻ ions remove hydrogen atoms from fatty acids of cell membrane giving rise to a lipidic radical, which on reacting with oxygen is transformed into lipidic peroxidase radical. The peroxidase radical itself acts as a new inductor and forms

a new lipidic radical. Thus, the chain reaction continues resulting in loss of integrity of membrane, thereby acting as bacteriostatic or bactericidal.[6]

MOA on Tissues

Elevated pH of calcium hydroxide activates alkaline phosphatase from the tissue. This is hydrolytic enzyme that liberates phosphate from esters of phosphates. This phosphate ion, once free, reacts with calcium ion from the blood stream to form a precipitate, calcium phosphate, in the organic matrix. This precipitate is the molecular unit of hydroxyapatite(Seltzer and Bender, 1979). [4,5,7]Calcium hydroxide when in direct contact with adjacent tissue gives origin to a zone of necrosis through rupture of glycoproteins resulting in protein degeneration within 7-10 days.

Using different methodology, electronic sweep microscope and micro-analyzer of dispersion of x-ray have confirmed the above action. OH- of calcium hydroxide activates enzyme alkaline phosphatase favoring mineralization whereas the calcium ions cause reduction of permeability of new capillaries of adjacent tissue. Mechanism of calcium hydroxide can be altered by presence of carbon dioxide due to formation of calcium carbonate, which is devoid of any biological or bacteriological properties.

Advantages of calcium hydroxide

- 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.
- Particles may obturate open tubules.[5]

Disadvantages of calcium hydroxide

- does not exclusively stimulate dentinogenesis
- does exclusively stimulate reparative dentin.
- Associated with primary tooth resorption
- May dissolve after one year with cavosurface dissolution.
- May degrade during acid etching
- Degrades upon tooth flexure
- Marginal failure with amalgam condensation
- Does not adhere to dentin or resin restoration.[8]

Uses

Calcium hydroxide- as intracanal medicament-

It is the most commonly used dressing for treatment of the vital pulp. The value of calcium hydroxide in endodontic treatment of necrotic infected teeth is now well documented. It is most advantageous to use water as a vehicle for the Calcium hydroxide paste. Calcium hydroxide not only kills bacteria, but it also reduces the effect of the remaining cell wall material lipopolysaccharide.[4,6] Saturated Calcium hydroxide solution mixed with a detergent is an effective antimicrobial agent suitable for irrigation.

Calcium hydroxide- as endodontic sealer

In the root canal filling sealer plays an important role.

Sealer fills all the space the gutta-percha is unable to fill because of gutta-percha's physical limitations. To be effective, an endodontic sealer based on calcium hydroxide must dissolve and the solid consequently lose content. Thus one major concern is that the calcium hydroxide content dissolve, leaving obturation voids.[5,7] This would ruin the function of the sealer, because it would disintegrate in the tissue.

Calcium hydroxide as pulp capping agent

Calcium hydroxide is generally accepted as the material of choice for pulp capping.

Histologically there is 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.[3]

Commercially available compounds of calcium hydroxide in a modified form are known to be less alkaline and thus less caustic on the pulp.

Calcium hydroxide in 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. Histologically the formation of osteodentin after placement of calcium hydroxide paste immediately on conclusion of a vital pulpectomy has been reported.[9,10] There appears to be a differentiation of adjacent connective tissue cells; there is also deposition of calcified tissue adjacent to the filling material. The calcified material is continuous with lateral root surfaces. The closure of apex may be partial or complete but consistently has minute communications with the periapical tissue.

Calcium hydroxide in pulpotomy

It is the most recommended pulpotomy medicament for pulpally involved vital young permanent tooth with incomplete apices.

It is acceptable because it promotes reparative dentin bridge formation and thus pulp vitality is maintained.

Histologically pulp tissue adjacent to calcium hydroxide is first necrotised by the high pH of calcium hydroxide. This necrosis, accompanied by the acute inflammatory changes in the underlying tissue, after 4 weeks a new odontoblastic layer and eventually a bridge of dentin developed.

Three histologic zones under calcium hydroxide in 4-9 days:

1. Coagulation necrosis
2. Deep staining areas with varied osteodentin
3. Relatively normal pulp tissue, slightly hyperemic, underlying an odontoblastic layer.[9,10]

Internal resorption may result from overstimulation of the primary pulp by the highly alkaline calcium hydroxide. This alkaline induced overstimulation could cause metaplasia within the pulp tissue, leading to formation of odontoclasts. Also undetected microleakage could allow large numbers of bacteria to overwhelm the pulp and nullify the beneficial effects of calcium hydroxide.

Calcium hydroxide in weeping canals

Sometimes a tooth undergoing root canal treatment shows constant

clear or reddish exudate associated with periapical radiolucency. Tooth can be asymptomatic or tender on percussion. When opened in next appointment, exudates stops but it again reappear in next appointment. This is known as "weeping canal".

In these cases tooth with exudates is not ready for filling, since culture reports normally show negative bacterial growth so, antibiotics are of no help.[6,7] For such teeth dry the canals with sterile absorbant paper points and place calcium hydroxide in canal. It happens because pH of periapical tissues is acidic in weeping stage which gets converted into basic pH by calcium hydroxide.

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