10.5005/jp-journals-10024-2025

REVIEW ARTICLE

Additive and reducing Effects between Calcium Hydroxide and Current Irrigation Solutions

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ABSTRACT

Introduction: Microorganisms should be considered to have the major role in starting and perpetuation of pulpo-periapical diseases. Using intracanal medicaments is necessary to gain a bacteria-free environment in the canal system. Calcium hydroxide (abbreviated as $Ca(OH)_2$), which is the most commonly used medicament in endodontic therapy, has been shown to be effective against primary sources of infection; however, its effectiveness against some microorganisms, such as *Candida albicans* and *Enterococcus faecalis* has not been proved. On the other hand, sodium hypochlorite (NaOCl), chlorhexidine (CHX), and iodine potassium iodide (IKI) have been shown to be the potent medicaments against these microorganisms. Because of this fact, combination of $Ca(OH)_2$ and some irrigants of the root canal has been suggested as potential intracanal medicaments. The aim of this literature review is to identify and address the efficacy of $Ca(OH)_2$ in combined with some of these irrigating solutions.

Keywords: Calcium hydroxide, Chlorhexidine, Endodontics, Irrigation, Sodium hypochlorite.

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How to cite this article: Mohammadi Z, Jafarzadeh H, Shalavi S, Sahebalam R, Kinoshita JI. Additive and reducing Effects between Calcium Hydroxide and Current Irrigation Solutions. J Contemp Dent Pract 2017;18(3):246-249.

Source of support: Nil

Conflict of interest: None

INTRODUCTION

Hermann[1] in 1920 introduced an important material to the endodontics. It was calcium hydroxide ($Ca(OH)_2$) proposed to be used as a suitable agent for pulp capping. This material is an odorless powder with suitable water solubility and the ability to decrease as temperature rises.[2] Dissociation coefficient of this combination permits slow release of hydroxyl ions and calcium. Low solubility of this material is considered as a good characteristic as a long period is necessary before it becomes soluble in tissue fluids when in direct contact with vital tissues.[3,4] The thixotropic behavior of $Ca(OH)_2$ in water causes it to be very fluid during agitation.[3] After exposure of $Ca(OH)_2$ to carbonate ions or carbon dioxide inside the tissues, the chemical dissociation may lead to creation of calcium carbonate. However, one research published in 2002 concluded that after exposure to carbon dioxide for 1 month, $Ca(OH)_2$, intracanal bactericidal pH of the material was maintained.[2]

RETRIEVAL OF LITERATURE

An English-limited MEDLINE search strategy was arranged and performed through the articles published between 2002 and 2015. The searched keywords included "sodium hypochlorite (NaOCl) and calcium hydroxide," "chlorhexidine (CHX) and calcium hydroxide," "calcium hydroxide and antimicrobial," "iodine potassium iodide and calcium hydroxide," "calcium hydroxide and endodontic bacteria." After this stage, a hand search was performed in the references of the collected articles to find more matching relevant articles.

Resultantly, a total of 1,106 articles were found, which in order of their related keywords are "calcium hydroxide and chlorhexidine-296", "calcium hydroxide and iodine potassium iodide-28", "calcium hydroxide and sodium hypochlorite-331", "calcium hydroxide and antimicrobial-243," "calcium hydroxide and endodontic bacteria-208."

Mechanism of Antimicrobial Activity

Regarding the antimicrobial effect of $Ca(OH)_2$ in aqueous environments, Siqueira[5] showed the dependency to hydroxyl ion release. Another study concluded that hydroxyl ions should be considered as free radicals with the ability of high reaction with some of the biomolecules. This reaction is indiscriminate, so free radicals may rarely diffuse away from the generation site. The bactericidal effects of these ions may be due to the denaturation of some proteins, damages to cytoplasmic membrane of the bacteria, and also damage to the DNA structure. However, it is not obvious that which of these three mechanisms has the main role in the bacterial cell death.[6] Cytoplasmic membrane is the main enzymatic site, so the hydroxyl ions exert their action in this area.[7] Extracellular enzymes can act on some products, such as lipids, carbohydrates, and proteins through hydrolysis. The pH gradient of cytoplasmic membrane may be changed by the increased concentration of hydroxyl ions acting on membrane proteins. This kind of injury to the organic components may be seen in phase of peroxidation.[8]

Some cellular processes like some changes in mobility, cellular metabolism, conductivity and transport through isosmotic cellular volume and membrane, activation of cellular proliferation may influence on intracellular pH. So, some functions of the cells may be influenced by changes in pH (such as some essential enzymes for metabolism).[9] In an important study, it has been shown that irreversible inactivation of bacterial enzymes may be seen under extreme conditions of pH for a long time.[10]

IKI and $Ca(OH)_2$

Peciuliene et al[11] indicated that 2% IKI 4%-saturated $Ca(OH)_2$ combination shows weaker effect than 2% IKI 4%. In another research, Haenni et al[12] showed that the increase effect of $Ca(OH)_2$ on the pH may be maintained in combination of IKI and $Ca(OH)_2$. Sirén et al[13] also concluded that some additive benefits may be achieved by combination of IKI and $Ca(OH)_2$. Fuss et al[14] stated that combination of IKI and $Ca(OH)_2$ may be a suitable product against *Enterococcus faecalis* in bovine tooth. In human teeth infected with *E. faecalis*, it has been shown that $Ca(OH)_2$/iodoform/silicone oil is the most effective combination followed by $Ca(OH)_2$/2% IKI, and the least effect showed to be achieved by $Ca(OH)_2$.[15]

CHX and $Ca(OH)_2$

For CHX, the best antimicrobial activity can be achieved in pH between 5.5 and 7,[16,17] so alkalinizing pH by combining some $Ca(OH)_2$ to the CHX may precipitate CHX molecules and so decreases its effectiveness. However, $Ca(OH)_2$ alkalinity in the combination form showed no change, so the suitability of mixing CHX with $Ca(OH)_2$ has not been proved yet.[17]

As a medicament, $Ca(OH)_2$ is less effective than CHX in decreasing intratubular amount of *E. faecalis*.[17,18] Almyroudi et al[19] showed that $Ca(OH)_2$/CHX 1:1 mixture is efficient in decreasing intratubular enterococcus. However, some researchers in bovine dentin[20] or in human dentin[21] concluded that CHX had better effect against *E. faecalis*, followed by CHX/$Ca(OH)_2$ combination and also $Ca(OH)_2$ alone.

Haenni et al,[12] using agar diffusion, showed no additive antimicrobial effect by mixing 0.5% CHX with $Ca(OH)_2$ powder. Although CHX has decreased antimicrobial effect, $Ca(OH)_2$ do not lose its antibacterial properties in this combination. One study on extracted human teeth concluded that 2% CHX was the most effective against *E. faecalis* inside the tubules, followed by 2% CHX/$Ca(OH)_2$ mixture, whilst $Ca(OH)_2$ alone was completely ineffective in 1 month period of study.[22] 2% CHX has more effectiveness against *C. albicans* than $Ca(OH)_2$/2% CHX mixture at 1 week, although no difference at 30 days was observed. $Ca(OH)_2$ alone had no effect this kind of *Candida*.

In two separate studies on *E. faecalis*, Schäfer et al[21] and Lin et al[23] showed that 2% CHX has more effects comparing $Ca(OH)_2$ alone or their combination. However, Evans et al[24] showed that $Ca(OH)_2$ in water may be less effective than 2% CHX/$Ca(OH)_2$. Lindskog et al[25] in an animal research showed that teeth medicated with CHX for 30 days had reduced inflammatory signs in periodontium. Waltimo et al[26] also concluded that saturated $Ca(OH)_2$ has less effect against *C. albicans* than 0.5% CHX acetate. $Ca(OH)_2$/CHX mixture had more effects than $Ca(OH)_2$ alone.

Synergism of NaOCl and $Ca(OH)_2$

Complete debridement of the canal system by using hand and/or rotary instruments alone seems to be impossible, so the irrigation with NaOCl and intracanal placement of a medicament, such as $Ca(OH)_2$ may be utilized as an attempt to achieve this aim.[27]

Synergistic effects of NaOCl and $Ca(OH)_2$ is controversial. Hasselgren et al[28] showed that after 12 days of

exposure, $Ca(OH)_2$ paste (mixed with water) has the ability of tissue dissolving. They also reported that pretreatment of the tissue with $Ca(OH)_2$ can increase the tissue dissolving effect of NaOCl. In another research, Metzler and Montgomery[29] showed that 1 week pretreatment with $Ca(OH)_2$ followed by irrigation with NaOCl can clean isthmuses better than hand preparation of the canal alone. Yang et al[27] also demonstrated that NaOCl and $Ca(OH)_2$ partially dissolved pulp in bovine samples. Both of these chemicals had more effects than water alone. Wadachi et al[30] in another study on bovine samples reported that debris was decreased in cases treated with NaOCl for 30 seconds or $Ca(OH)_2$ for 1 week. However, $Ca(OH)_2$/NaOCl mixture was better than single treatment. Morgan et al[31] concluded that irrigation with $Ca(OH)_2$ shows only 10% weight loss of tissue comparing saline.

Although $Ca(OH)_2$ is useful as an endodontic antibacterial medicament and as an endodontic irrigant, its potential risks as a combined material is better to be assessed.[32-34]

CONCLUSION

- For increasing the antimicrobial activity of $Ca(OH)_2$, mixing the powder with NaOCl, CHX, and IKI has been proposed.
- Adding $Ca(OH)_2$ to CHX for pH alkalinizing may lead to decreasing the effectiveness.
- All studies regarding combining $Ca(OH)_2$ and IKI showed synergistic effect between them without reducing the pH.
- Although the ability of NaOCl to dissolve the tissues may increase after pretreatment of tissues with $Ca(OH)_2$, synergistic effects of NaOCl and $Ca(OH)_2$ is still controversial.

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