Calcium Hydroxide in Dentistry: A Review

*Mohamed S Zeglam, and Asma S Arara

1Lecturer in Conservative Dentistry, Department of Conservative Dentistry & Endodontics, University of Tripoli, Libya
2International Resident in Comprehensive Program, New York University

Introduction

Endodontics is a branch of dentistry that deals with diseases of dental pulp, roots and periradicular tissues as well as associated inflammatory sequelae[1]. One of the main goals of the root canal therapy is to eliminate bacteria and their products from the root canal system [2]. In order to reach the optimal result of endodontic treatment, this is significantly dependent on elimination of bacteria or at least decrease their counts to levels that cannot be detected by culturing methods [3].

Intracanal medications are used in endodontic therapy to eradicate remaining viable bacteria in the root canal system following instrumentation and irrigation, reduce pain and periapical inflammation, eliminate any exudates which might present apically, and act as a chemical and physical barrier which may prevent re-infection of the root canal system from any potential coronal leakage [4,5]. However, it has been argued that there is no ideal medicament that can completely eliminate residual bacteria from the root canals [6-8].

Along the history of endodontics, various intracanal medicaments have been used as temporary dressings to disinfect root canals between visits. Generally, they fall into different categories based on their chemical basis; these are: aldehydes, phenolic compounds, halides, calcium hydroxide, antibiotics, and other combinations [9]. For an intracanal medicament to be effective and suitable for the clinical application, it must be kept in contact with the tissues inside the canal, introduced easily into the canal, and easy to remove afterwards [10]. Currently, it is acknowledged that calcium hydroxide is one of the most popular intracanal dressing used in endodontics [11,12].

History and presentation of calcium hydroxide:

Using calcium hydroxide as an intracanal medicament has been widely accepted in endodontics since its introduction by a German dentist called Hermannin 1920[10]. It is a white odourless powder with the chemical formula of Ca (OH)₂. It is classified as a strong base with a high PH (12.5 – 12.8) with low solubility in water [10,13]. The latter characteristic has a clinical value of which the material needs to be in contact with vital tissues for a long period before it becomes soluble in tissue fluids and starts its effect [10].

Calcium hydroxide is commercially available in different forms. It can be presented as a ready-made paste, as a hard setting cement or as a powder/liquid (vehicle) mixture [14]. Three kinds of vehicle are used: aqueous, viscous or oily [10]. Different substances have been added to calcium hydroxide powder in order to improve flowability and consistency of the paste, its antimicrobial effect and radiopacity [10].

Clinical application and uses of calcium hydroxide

There are several indications of calcium hydroxide in restorative dentistry (table 1)(15). However, this article will focus on its main uses in endodontics.

The use of calcium hydroxide in the field of endodontics has several advantages such as:

- Bactericidal and bacteriostatic effect.
- Highly alkaline that can neutralizes acids.

<table>
<thead>
<tr>
<th>Table 1: Uses of calcium hydroxide in restorativedentistry(15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Lining the cavities</td>
</tr>
<tr>
<td>2- Indirect pulp capping</td>
</tr>
<tr>
<td>3- Direct pulp capping</td>
</tr>
<tr>
<td>4- Pulpotomy</td>
</tr>
<tr>
<td>5- Dressing of root canal</td>
</tr>
<tr>
<td>6- Long-term temporary dressing</td>
</tr>
<tr>
<td>7- Treatment of infected root canals and periapical lesions</td>
</tr>
<tr>
<td>8- Apical closure</td>
</tr>
<tr>
<td>9- Prevention of root resorption</td>
</tr>
<tr>
<td>10- Repair of iatrogenic perforations</td>
</tr>
<tr>
<td>11- Treatment of horizontal root fracture</td>
</tr>
<tr>
<td>12- Root canal sealer</td>
</tr>
</tbody>
</table>

*Corresponding author: Mohamed S Zeglam, Lecturer In Conservative Dentistry, Specialist In Restorative Dentistry Saint James Hospital – Tripoli, Libya, E Mail: mszeglam_dent@yahoo.co.uk


Citation: Mohamed S Zeglam, and Asma S Arara (2017) Calcium Hydroxide in Dentistry: A Review. BAOJ Dentistry 3: 024.

Copyright: © 2017 Mohamed S Zeglam, and Asma S Arara. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
ultimately antibacterial activity is reduced [12]. This results in decreasing the hydroxyl ions concentration and radicals [12]. Once calcium hydroxide diffuses through the tissues, extreme reactivity in which they are inherently highly oxidant free related to the liberation of hydroxyl ions, and these ions show pH is retained high [12]. Since its antimicrobial activity is mainly calcium hydroxide possesses antimicrobial effects as long as its contact with the root canal walls in order to be effective [21]. Furthermore, calcium hydroxide possesses antimicrobial effects as long as its pH is retained high [12]. Since its antimicrobial activity is mainly related to the liberation of hydroxyl ions, and these ions show extreme reactivity in which they are inherently highly oxidant free radicals [12]. Once calcium hydroxide diffuses through the tissues, this results in decreasing the hydroxyl ions concentration and ultimately antibacterial activity is reduced [12].

There are several suggested mechanisms which may explain the antibacterial effect of calcium hydroxide [4,12,22]. Firstly, it damages bacterial cytoplasmic membrane by the action of hydroxyl ions. These ions are responsible for destroying phospholipids, the main components of bacterial cell membrane. Secondly, hydroxyl ions dissociated from calcium hydroxide denature and damage structural proteins in the bacterial cell. Consequently, this results in loss of biological activity of the enzymes and interruption of the cellular membrane which lead to death of bacteria. Finally, calcium hydroxide damage the DNA by inhibiting DNA replication and, consequently, disrupting cellular activity [23]. Calcium ions have a major role in cell stimulation, proliferation, migration and mineralization [47]. These ions are available at the site of action and reported to be important for exerting therapeutic effect which is mediated through ion channels [47]. Calcium hydroxide has also a physical role by which it acts as a space filler for the root canal; this aids in preventing the ingress of micro-organisms and limiting the space for bacterial growth and multiplication [4,11]. Moreover, calcium hydroxide has other biological properties such as its ability to promote periapical hard tissue healing by inactivating lipopolysaccharide (LPS), inhibiting root resorption and stimulating periapical healing especially after trauma [11,15].

An in vitro study showed that pre-treatment of the root canal with calcium hydroxide solution increased the tissue dissolving and cleansing properties of 0.5% sodium hypochlorite to the same degree reached by 5% sodium hypochlorite alone [24]. Therefore, this method may be an alternative to the use of 5% sodium hypochlorite which is proven to be highly cytotoxic. This study has confirmed a similar work done by Hasselgren et al which explained that when the tissue is pretreated by calcium hydroxide solution for 30 minutes, it swells and thus enhances the accessibility and the tissue dissolving effect of the 0.5% sodium hypochlorite [24,25].

Calcium hydroxide is also considered to be valuable in controlling the inflammatory exudates from the periapical tissues, and the reason behind this may be related to the antimicrobial properties of this material, contraction of small blood vessels periapically, and formation of an apical plug [26,27]. Similar to sodium hypochlorite, calcium hydroxide has the ability to dissolve necrotic materials, although it is less effective [25].

Short-term dressing with calcium hydroxide is effective on bacteria found in direct contact with this material [4]. Bacteria located in ramifications and irregularities are protected from the action of the alkaline paste due to the presence of necrotic tissues, which act as a buffer, and also because of the arrangement of the bacterial biofilm which allows the deeply seated colonies to be protected by the peripheral ones [20]. In addition, due to low diffusibility and solubility of calcium hydroxide, it is difficult to reach a rapid and high pH needed to eliminate bacteria found within dentinal tubules [4]. Therefore, long-term use of calcium hydroxide may be required to render the root canal system bacteria-free. This is, however, still controversial with modern and current endodontic concepts of the one-visit root canal treatment [4, 12].

Therapeutic effects of calcium hydroxide:

Antimicrobial activity of calcium hydroxide

Studies have shown that calcium hydroxide has lethal effects on bacterial cells [2,16,17]. It has been found that most endodontopathogens are unable to survive in [2]. However, calcium ions are needed for the growth of candida. It has been found that C. albicans are resistant to calcium hydroxide than E. faecalis. This could explain why calcium hydroxide has no effect on C.albicans [45]. Several studies demonstrated that instrumentation and irrigation with sodium hypochlorite are not adequate to render root canals free of bacteria; this is due to the fact that 40% - 60% of the canals still enclose cultivable bacteria even after using different sodium hypochlorite concentration [2,3,18,19]. Therefore, adjunctive inter-appointment antimicrobial dressing can be used for infected root canals [20]. Unlike vapour-forming intracanal medications, calcium hydroxide must be applied in direct contact with the root canal walls in order to be effective [21]. Furthermore, calcium hydroxide possesses antimicrobial effects as long as its pH is retained high [12]. Since its antimicrobial activity is mainly related to the liberation of hydroxyl ions, and these ions show extreme reactivity in which they are inherently highly oxidant free radicals [12]. Once calcium hydroxide diffuses through the tissues, this results in decreasing the hydroxyl ions concentration and ultimately antibacterial activity is reduced [12].

It can stops internal resorption.
• Promotes healing and repair.
• High pH stimulates fibroblasts.
• Inexpensive and easy to use [46].

However, calcium hydroxide has some disadvantages such as:
• Does exclusively stimulate reparative dentine.
• Associated with resorption of primary teeth.
• Highly soluble.
• Degrades upon tooth flexure.
• Weak compressive strength that leads to marginal failure with amalgam condensation.
• Does not adhere to dentine [46].

Although various proprietary brands are available, ordinary calcium hydroxide powder can be used simply by mixing it with purified water until reaching the desired consistency, then spiral root canal filler can be used for application [14]. During application, it is recommended that care should be taken to avoid extrusion of paste to the tissues beyond the apex. However, if this does happen, healing process will not be jeopardized [14]. After applying calcium hydroxide into the canal system, it is extremely important that temporary coronal seal must prevent any leakage and recontamination of the root canals between visits [14]. This can be achieved by using intermediate restorative material (IRM) or glass ionomer cement (GIC) especially for periods of over 10 days [14].

Although various proprietary brands are available, ordinary calcium hydroxide powder can be used simply by mixing it with purified water until reaching the desired consistency, then spiral root canal filler can be used for application [14]. During application, it is recommended that care should be taken to avoid extrusion of paste to the tissues beyond the apex. However, if this does happen, healing process will not be jeopardized [14]. After applying calcium hydroxide into the canal system, it is extremely important that temporary coronal seal must prevent any leakage and recontamination of the root canals between visits [14]. This can be achieved by using intermediate restorative material (IRM) or glass ionomer cement (GIC) especially for periods of over 10 days [14].

Citation: Mohamed S Zeglam, and Asma S Arara (2017) Calcium Hydroxide in Dentistry: A Review. BAOJ Dentistry 3: 024.
the mechanism is still unclear, Calcium hydroxide plays a unique role in inducing mineralisation and hard tissue formation by affecting the activities of the cells responsible in bone formation and resorption [15,28]. It has been suggested that high pH may initiate mineralisation by neutralising the lactic acid secreted by osteoclasts and also buffering the acidic reactions of the inflammatory process [15]. Hence, calcium hydroxide has been used as a root canal dressing to induce apical closure of pulpless immature teeth (apexification) and immature teeth with vital radiucal pulp (pulpotomy), repair of iatrogenic perforations, treatment of external and internal resorption, and horizontal root fracture [13-15]. In pulpotomy and direct pulp capping, and due to the high pH, coagulation necrosis is induced by contact with calcium hydroxide and tissues become saturated with calcium ions. Cells from the under laying pulp tissues differentiate into odontoblast-like cells, which then begin to form the calcific bridge[44]. However, mineral trioxide aggregate (MTA) has recently taken over many of the calcium hydroxide functions since its introduction at the end of last century [29,30].

Paradoxically, some authors argue that the regular use of calcium hydroxide in re-treatment of infected teeth associated with apical periodontitis is question able [31,32]. An in vivo study, for example, found that inclusion of calcium hydroxide in saline in the root canal for 4 weeks was not effective to prevent re-growth of bacteria [8]. On the other hand, It has been found that the remaining calcium hydroxide in the root canal has a negative effect on the penetration of the sealer into dentinal tubules as well as the dentine bond strength [33]. Therefore, the quality of the seal of the root filling would be compromised [34]. The residues have a potential to react with the sealer which might decrease its working time and flow ability [35].

Furthermore, a recent study shows that there is no effective method for removing inter-appointment calcium hydroxide, as remnants of the material were found in all experimental groups even though different types of vehicles were used [36]. The same result has been obtained by other studies in which, regardless of the removal technique used, the total removal of calcium hydroxide paste from the root canal was impossible and up to one third of the root canal surface remained covered with calcium hydroxide residues [37-39].

**Combination of calcium hydroxide with other substances:**

Along the history of calcium hydroxide in dentistry, various active components have been added to this substance in order to improve its antimicrobial properties; for example, camphorated parachlorophenol and antibiotics [10]. Schroeder advocated the use of a combination of Ledermix, a proprietary paste of corticosteroid-antibiotic compound, with calcium hydroxide for the treatment of infected teeth with open apex [40]. It has been also advocated that a 50:50 mixture of Ledermix and calcium hydroxide is reliable for the treatment of infected root canals, perforation, large periradicular radiolucent lesions and inflammatory root resorption [5]. However, Taylor et al expected that this mixture act in a similar way if calcium hydroxide is used alone, since no considerable alteration of the pH was noticed [41]. Hence, studies suggested that combination of two antimicrobial medicaments may not add synergistic effects against some microorganisms [42].

**Calcium hydroxide and single-visit endodontics:**

The aim of immediate or one-visit root filling is to prevent potential bacterial growth between visits. It has been reported that one-visit endodontics works effectively in most infected cases [21,26,43]. Accordingly, in such cases, placement of intracanal medicaments is not required. Despite that, calcium hydroxide still can be utilised if it is used as a sealer. An in vivo study, for instance, done by Weiger et al to explore the influence of calcium hydroxide as an intracanal dressing on the healing of periapical lesions of pulp less teeth showed that, from a microbiological view, one-visit root canal treatment using calcium hydroxide-based sealer created suitable environment for the healing of periapical tissues; therefore, they considered one-visit treatment is an alternative to two-visit with calcium hydroxide as an inter-appointment dressing [7].

**Conclusion**

Calcium hydroxide has a significant role in endodontics as well as several clinical indications. It has long track record as one of the most effective antimicrobial medicaments used during root canal therapy. Further, the ability of calcium hydroxide to induce mineralisation appears to be of particular value in dentistry. However, it should not be considered as a substitute for ordinary irrigation and mechanical shaping of the root canals. Even though great clinical outcomes have been achieved with the use of calcium hydroxide, considering calcium hydroxide as a superior intracanal medicament is still controversial.

**References**


