Merits and Demerits of Calcium Hydroxide as a Therapeutic Agent: A Review

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Abstract Calcium hydroxide, an age-old, traditional, therapeutic agent, has found profound use in the field of conservative dentistry, endodontics, and pedodontics. It is indicated for vital pulp therapies, intracanal medication, endodontic sealing, pulp revascularization, and pulpotomy. The purpose of this review is to identify the various merits and demerits with regard to each application.

Keywords: calcium hydroxide, merits, demerits, vital pulp therapy, intracanal medicament, root resorption, review

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1. Introduction

Calcium hydroxide has been used in dentistry since several decades and has become a main-stay therapeutic agent owing to its numerous advantages. It has been used in a number of applications such as vital pulp therapy, pulp revascularization, apexogenesis, apexitisification, and root canal sealers.

2. Applications of Calcium Hydroxide

2.1. Vital Pulp Therapy

This procedure includes pulp capping, partial pulpotomy, full pulpotomy, and pulpectomy. Pulp capping involves either direct or indirect (presence of a layer of intervening dentin) placement of calcium hydroxide on the pulp. Partial pulpotomy is also termed as Cvekpulpotomy. Here, inflamed coronal pulp tissue is removed but the healthy pulpal tissue is retained; the extent of pulp removal is based on a thorough knowledge of pulpal reactions post-injury. In full pulpotomy, the entire coronal pulp is removed up to the level of the orifices of the root. With regard to Pulpectomy, the entire pulp is removed, both from the coronal and the apical regions.

Calcium hydroxide as a vital pulp therapy agent:

With regard to this role, calcium hydroxide is one amongst the most preferred therapeutic agents. Since calcium hydroxide was introduced to endodontics as a pulp capping agent in 1920, it has gained popularity as a regenerative material and is widely used as on date. The following are the favourable properties that render calcium hydroxide as one amongst the most sought pulp regenerative agent.

(1) Antibacterial property

This property can be attributed to the release of the highly reactive hydroxyl ions whose mechanism of action can be ascribed to the following mechanisms: (1) destruction of the bacterial cytoplasmic membrane, (2) protein lysis, and (3) bacterial DNA damage. [1] It is effective against most endodontic pathogens [2].

(2) Mineralization property

This property can again be attributed to the hydroxyl ions, which induce an alkaline pH. The high pH of 12.5 initially induces liquefaction necrosis in the superficial portion of the pulp (1.5-2mm). This may eliminate the inflamed pulp if present. Further deeper portions of the pulp witness neutralization of the toxicity of calcium hydroxide so as to cause formation of a layer of tissue that undergoes coagulation necrosis at the junction of the necrotic and vital pulp tissue. Beyond this portion, calcium hydroxide acts as a mild irritant, which stimulates hard tissue formation. [3] The calcified material is termed osteodentine since it exhibits the characteristics of both bone and dentin. An evidence-based study concluded that calcium hydroxide based materials promoted formation of a hard tissue bridge whereas bonding agents did not. In this regard, superiority of MTA over calcium hydroxide-based products was not confirmed either. [4] CH and MTA may aid in hard tissue formation by solubilising dentinal growth factors, which in turn leads to the recruitment of pulp stem cells. [5] Numerous studies have demonstrated dentinalbridge formation in about 50–87% of cases treated with various Ca(OH)2 formulations [6].
Demerits: The barrier of osteodentine, which is produced, is often incomplete and results in the formation of the so-called tunnel defects. Formation of tunnel defects, which occur due to vascular inclusions may be observed in specimens treated with calcium hydroxide. Such defects may allow bacterial re-infection [7].

The 1.5-2mm layer of sterile pulp necrotic layer may get infected under leaking restorations thus causing pulpitis and subsequent pulp necrosis if left untreated [8].

Also, few authors have shown that MTA may be a superior material when compared to calcium hydroxide. According to Mente et al., MTA appeared to favour long-term pulp vitality after direct pulp capping when compared with calcium hydroxide [9].

After performing a histomorphometric analysis of pulp capping of human permanent premolars using calcium hydroxide and MTA, Maria et al. concluded that both the material were successful but calcium hydroxide was slower than MTA in this regard [10].

2.2. Apexogenesis

Apexogenesis is defined as a vital pulp therapy procedure performed to encourage continued physiologic development and formation of the root end [11].

The use of calcium hydroxide in traumatized immature tooth after complete chemomechanical debridement showed good results. Calcium hydroxide stimulated the epithelial cells of Hertwig's sheath and the undifferentiated progenitor cells and thus aided in continued apical root formation. [12] Its antibacterial property and inherent alkalinity are also beneficial.

Demerits:
Long-term usage of Calcium hydroxide may weaken the root.

2.3. Apexification

This procedure involves formation of a hard-tissue apical barrier and reinforcement of the thin dentinal walls of an immature non-vital tooth. It is defined as a method to induce a calcific barrier in a root with an open apex or the continued apical development of an incompletely formed root in teeth with necrotic pulp tissue. [11] Calcium hydroxide is used as a creamy mix to achieve canal disinfection. The hard tissue barrier formed with regard to long-term calcium hydroxide therapy comprises of irregularly arranged cementum-like tissue, soft tissue and calcified tissue. Islands of soft connective tissue interspersed within this barrier impart the characteristic ‘Swiss cheese’ consistency [13].

Demerits: The time taken for formation of a hard tissue-barrier with regard to calcium hydroxide, ranges from 2–3 months and 6–18 months in the case of pulp capping and apexification procedures respectively (3–5). This extended treatment time may inconveniente both the dentist and the patient. Calcium hydroxide affects the mechanical properties of dentin when used for a longer period of time rendering the tooth susceptible to fracture [14].

2.4. Pulp Revascularization

Revascularization is defined as the restoration of the vascularity to a tissue or organ. [11] Here, calcium hydroxide is primarily used to decontaminate the root canal system prior to inducing bleeding. Triple antibiotic paste has also been shown to be an effective agent in terms of eliminating root canal infection [15], but the minocycline component may induce tooth discoloration. [16] Cehreli et al. reported a case of successful revascularization with calcium hydroxide in immature necrotic molars after a follow-up of 10 months [17].

Adriana et al. proposed that the combination of calcium hydroxide and 2% chlorhexidine gel may be used for revascularization of immature necrotic teeth since superior results could be obtained using the same [18].

Demerits:
Long-term use of calcium hydroxide may cause progressive calcification of the root canal space.[19] However, this is controversial.

2.5. Root Canal Sealers

Sealers are responsible for the principal functions of root fillings, which aim to prevent reinfection. That is, sealing the root canal system by entombing remaining bacteria and filling of irregularities in the prepared canal system. [20] Calcium hydroxide based sealers such as RealSeal, Sealapex, Apexit, and Apexit Plus have the advantage of Calcium hydroxide release, which in turn contributes to their antibacterial properties owing to the release of hydroxyl ions. They may also aid in the formation of root-end hard tissue.

Demerits:
Calcium hydroxide-based sealers exhibit some disadvantages such as mild antibacterial properties, poor cohesive strength, greater solubility, and marginal leakage [21].

2.6. Intra Canal Medicaments

These are one amongst the other therapeutic agents that aid in the elimination of microorganisms, their by-products, and residual tissue from the canal system. [22] According to Weine, a medicament is an antimicrobial agent that is placed inside the root canal between treatment appointments in an attempt to destroy remaining microorganisms and prevent reinfection [23].

Demerits:
Calcium hydroxide has been shown to be less effective against Enterococcus faecalis and Candida albicans. [24] The literature on biocompatibility of calcium hydroxide especially when extruded into the periapical region is ambiguous with some reports endorsing its tolerance. [25,26,27] and some rejecting it [28,29].

2.7. Perforation Management

Calcium hydroxide was the most preferred material for the management of root perforations. In 1987, Bramante et al observed that experimentally prepared furcal root perforations in dog's maxillary and mandibular premolars showed better results when treated with calcium hydroxide. A zone of necrosis was observed immediately adjacent to the perforation site along with different degrees of cementum hyperplasia. Whereas, specimens dressed with zinc oxide and eugenol exhibited inflammatory reactions followed with abscess formation and alveolar crest resorption [30].

Demerits:
Calcium hydroxide has to be replaced on a regular basis since (1) it is displaced by tissue fluids, exhibits poor marginal integrity, and (3) lacks the required strength. [31] It is hence a temporary solution and the newer materials like MTA have gained popularity as a more permanent solution.

Root resorption

The acidic environment existing in the region of resorption is neutralized by the alkaline calcium hydroxide leading to a reversal of reaction and thus allowing hard tissue formation.[32] The hydroxyl ions released by calcium hydroxide diffuse through dentinal tubules that directly communicate with periodontal space, whose pH after the ion infusion, increases from 6.0 to 7.4-9.6.[33]. Apart from the above mentioned factor, the other important properties of calcium hydroxide that may contribute to treatment of resorption include: bactericidal, protein denaturing, and adenosine triphosphatase activating properties. Calcium hydroxide can also arrest inflammatory root resorption [34].

A study that histologically examined the healing of intentionally produced inflammatory root resorption of replanted teeth in beagle dogs concluded that long-term treatment using calcium hydroxide was more effective than the short-term treatment in cases of established inflammatory root resorption [35].

Demerits

Ironically, the use of calcium hydroxide in deciduous teeth is discouraged since it may induce chronic pulp inflammation and internal root resorption [36].

According to Ravi et al., calcium hydroxide-induced resorption in deciduous teeth may be attributed to: (1) inflammatory cytokines, which contribute to transformation of pre-odontoclasts to odontoclasts (2) pre-existing progenitor cells with a tendency to transform into odontoclasts, and loss of protective layer of predentin over mineralized dentin [37].

3. Conclusion

The applications of calcium hydroxide in the field of dentistry have been numerous. Its high alkalinity has contributed to its antibacterial and hard tissue forming properties. However, the lack of effectiveness against certain bacteria, solubility in fluids, poor coronal seal and strength are some concerns that need to be addressed. Also further research has to be undertaken in terms of improving and ascertaining the properties of calcium hydroxide.

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