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USES OF CALCIUM HYDROXIDE IN DENTISTRY- A CONCISE REVIEW

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ABSTRACT

Calcium hydroxide is a powder which is commonly mixed with a physiological saline to form a paste (pH 12.5) and it has a hard tissue inducing effect. When applied to the pulp, it shows no or minimal inflammatory reaction. Calcium hydroxide has anti-bacterial properties and has a limited shelf life as they eventually turn into calcium oxide. This can be used as liners or bases, for indirect and direct pulp cupping, root canal dressing, root canal sealant, apical closure. Calcium hydroxide induces the deposition of mineralized tissue which is essentially significant because it establishes biological compatibility of the product. The present paper presents a concise overview of the different applications of calcium hydroxide and provides a brief review of previous literature works.

Key words:- Direct and Indirect pulp capping, Pulpotomy, Pulpectomy, Zinc Oxide Eugenol

INTRODUCTION

Hermann in 1920 introduced calcium hydroxide to dentistry. However, initial reference to its use has been attributed to Nygren (1838) for the treatment of *"fistula dentalis"*, whilst Codman (1851) was the first to attempt to preserve the involved dental pulp.[1] First, clinical success of pulpal healing by calcium hydroxide was reported between 1934 and 1941. After the II World War, clinical indications for its use were expanded and now this chemical is considered the best medication to induce hard tissue deposition and promote healing or vital pulp and periapical tissue (García, 1983).[1] Mechanism of action of calcium hydroxide is not yet fully understood. It is believed that it acts by the dissociation of calcium hydroxide into Ca^{2+}& OH^- ions. The free hydroxyl ions may initiate or favour mineralisation (Tronstrad *et al*.).[2]

The use of calcium hydroxide in dentistry has been varied. It is used for Direct & Indirect pulp capping, as a root canal medicament, lining of cavities, in pulpotomy and pulpectomy procedures, routine dressings of root canals, treatment of infected root canals & also long-term dressings, for prevention of root resorption, for repair of iatrogenic perforations and treatment of horizontal root fractures.[3,4]

REVIEW OF LITERATURE

The uses of calcium hydroxide in dentistry have been under the following headings.

1) ***Liner and base of cavities:*** The setting type of calcium hydroxide (Dycal; Dentsply) is used as cavity liners and bases. The advantage lies in the fact that
   - They have a rapid initial set in the cavity in the presence of moisture in the oral cavity and within the dentinal tubules.
   - They are lining material of choice under composite resin as they do not interfere with Bis-GMA resins.
   - Lim and McCabe (1982) showed that the initial set of the material in thin sections is sufficient to bear the condensation pressure developed during amalgam restorations even for lathe cut amalgam alloys.
   - Cox *et al*. (1987) showed that light cured resins are biocompatible and will not cause pulpal damage. However, it may be detrimental to the pulp in deeper cavities due to the heat generated during heating.[5,6]

2) Indirect pulp capping: King *et al.* in 1965 and Fischer in 1972 showed that calcium hydroxide has bactericidal properties. To this Fischer (1977), added that it helps to control. but not eliminate (Watts

Paterson.1987) the few viable organisms that remain. Eidelman *et al.* (1966). Mjor (1967), in their study showed that calcium hydroxide stimulated an increase in mineralisation within the dentine that remains at the base of the cavity.[7]

3) ***Direct pulp capping:***Calcium Hydroxide is still the most widely used material for pulp capping. If calcium hydroxide is used necrosis of pulp can occur due to the presence of bacterial infection. Under these conditions, Tronstad and Major (1972), found ZnO Eugenol to be more effective. Cox *et al*. (1987), reported that ZnO Eugenol would be the wrong material of choice. Massler (1967) found young permanent teeth to be more successfully treated than older permanent teeth because of the open apical foramen and increased blood supply to the pulp. Cvek (1978) reported that pulp capping procedures on traumatically exposed teeth in which low bacterial contamination has occurred, success percentage was 96 percent.[6,8]

4) ***Pulpotomy:*** Cvek (1978), showed that on traumatically exposed, non-carious pulps only the inflamed tissue, a few millimetres needed to be removed regardless of the size of the exposure or length of time that it had been left untreated. Camp (1978) noted that in case of a carious exposure, area of inflammation extended further into the pulp and more pulp tissue had to be removed.[8]

5) ***Dressing of root canals:*** Root canal when heavily infected prior to instrumentation, a dressing of calcium hydroxide up to the full length of the canal is the treatment of choice. Sonat *et al.* (1990) observed an inflammatory cell response when extrusion of calcium hydroxide occurred in periapical tissues of dogs through the apical foramen: in addition to the periodontal fibre organization, formation of new cementum and alveolar bone was also seen.[9] For long term dressing calcium hydroxide is the material of choice because of its prolonged antimicrobial effect which may last for weeks (Bystrom *et al.* 1985).[1]

6) ***Treatment of infected root canals and periapical lesions:*** Heithersay (1975), in his study recommended that calcium Hydroxide be used as a root canal dressing in teeth with large periapical lesions. and in cases where it was necessary to control the passage of periapical exudates into the canal.[10] Matsumiya and Kitamura (1960) considered that Calcium hydroxide accelerated the natural healing of periapical lesions, regardless of the bacterial status of the root canal at the time of placement of the material. However, doubt has been expressed by Pitt Fort (1982), in his study.[10]

7) ***Apical closure:*** Granath in 1959 and Frank in 1966 had reported the use of calcium hydroxide for apical closure. Calcium hydroxide was mixed with CMCP (Frank 1966) and with Ringer's solution (Cvek *et al*. 1976). They reported successful closure of the apex.[1] Koening *et al*. (1975), reported similar success with tricalcium phosphate and (Cooke and Rowbotham 1960) zinc oxide pastes. England and Best (1977), reported apical closure even without the presence of a root filling material.[11]

8) ***Prevention of root resorption:*** Andreasen (1971) reported arresting external inflammatory root resorption following replantation, in nine cases out of ten, using calcium hydroxide However, Cvek (1973), reported the same with early obturation with gutta percha.[12]

9) ***Following the replacement of an avulsed tooth, or transplantation of a tooth:*** Andreasen, (1981) warned that immediate placement of calcium hydroxide can stimulate early resorption in treating an avulsed tooth. Probably, calcium hydroxide diffuses through the apical foramen, injuring the cementum and initiating resorption.[12]

10) ***Repair of iatrogenic perforations:*** Heithersay (1975), Zeigler and Serene (1987), reported the successful use of calcium hydroxide in repairing of perforations. The size of the perforation as reported by Stock (1985), and the avoidance of extrusion excess material through the perforation as noted by Bergenholtz *et al.* (1979), is important in the success of such treatment.[9] Beavers *et a1.* (1986), reported necrosis of the periodontal membrane coronal to perforated areas after the placement of calcium hydroxide. They added that early dressing prevented ingrowth of granulation tissue.[6] Kvinnsland *et al.* (1989), reported that success rate for non-surgical treatment of perforated root canals with calcium hydroxide which was also included in the study, was poorest in cervical region, probably due to the proximity of epithelial attachment leading to a periodontal defect.[13] Beavers *et. al*. (1986), used Sealapex to treat root canal perforations. They observed bone healing and ingrowth of trabeculae into the perforation after 42 days. Also, reparative cementum formation and ankylosis occurred.[9] Himel *et al.* (1985), found tricalcium phosphate superior to calcium hydroxide as it provided an effective barrier because of a better matrix formation against which the canal could be obturated.[14] Sinal *et al.* (1989), found no significant difference between tricalcium

phosphate and calcium hydroxide in the repair of perforations. They observed no bone perforations over a 1-month period.[14]

11) ***Treatment of horizontal root fractures:*** Cvek (1974), and (1981) suggested preliminary dressing of calcium hydroxide left in place for 3-6 months may encourage soft tissue healing and possibly mineralization at the fracture site. This provides a barrier for further condensation.[12]

12) ***Constituent of root canal sealers:*** Holland and de Souza (1985), reported their use, the rationality being that they further induced mineralization. Pitt Ford and Rowe (1988) reported similar success with that of Zinc oxide Eugenol cement.[14] Tagger *et al.* (1988), investigated the release of calcium and hydroxyl ions from Sealapex and CRCS (Calcibiotic Root Canal Sealer). They found that Sealapex released ions and disintegrated more rapidly than CRCS. CRCS continued to alkalize its environment, possibly due to free eugenol combining with calcium ions as they were released.[14] Gordon and Alexander (1986), investigated the rise in pH caused by two calcium-hydroxide containing sealers and concluded that it was insufficient to bring about any biological changes.[14] Zmener and Cabrini (1987), observed adverse effects when blood monocytes and lymphocytes were maintained in contact with these materials.[10] Sonat *et al.*(1990), reported that hard tissue formation was more pronounced after root filling with Sealapex than with calcium hydroxide or gutta percha, in dog's teeth.[9] Cohen *et al*. (1985), suggested slight leakage both in Sealapex and CRCS. Zmener (1987), compared these sealers with Tubli Seal and found leakage to be same for all sealers. Hovland and Dumsha (1985), reported no difference in apical seals done with Sealapex, CRCS and Tubli-Seal.[9]

DISCUSSION

The high pH of calcium hydroxide, which is above 11 is responsible for its beneficial effects. Its property to initiate mineralization is widely accepted now. It is believed that an epitactic mechanism operates following the initial seeding of a collagenous tissue. The process is probably the result of the juxtaposition of charged groups on adjacent macromolecules which give rise to the epitactic centres. These centres require a nucleation site from which hydroxyl apatite crystal growth can proceed.[9]

Calcium ions present in the applied calcium hydroxide do not get incorporated in the mineralized repair which derives its mineral content solely from dental pulp via blood supply of pulp (Sciaky and Pisanti1960, Pisanti and Sciaky (1964).[15] So, it is an initiator and not a substitute for repair. Mitchell and Shank Walker (1956), argued the concept that the free hydroxyl ions may initiate or favour mineralization. Highly alkaline compounds such as barium hydroxide and calcium phosphate failed to initiate mineralization.[16] However, calcium hydroxide may act as a local buffer against the acidic reactions produced by the inflammatory process. (Heithersay,1975). An alkaline pH may also neutralize the Lactic acid secreted by osteoclasts, and this may help to prevent further destruction of mineralized tissue.[17] During lining of cavities early versions of calcium hydroxide disappeared due to the effects of bacteria and microleakage.[5] In indirect pulp capping procedures, calcium hydroxide might have stimulated the healing of a minute pulpal exposure which might have been overlooked.[5] Pashley *et al.* (1986), reported reduction in the permeability of dentine and smear layer when calcium hydroxide was applied.[18] In direct pulp capping procedures larger exposure had poorer prognosis because of increased contamination of microorganisms as established (Seltzer and Bender, 1984).[8] When traumatic exposure with no contamination occurs then the size of the exposure is immaterial (Cvek 1978).[2] However, Cox *etal*. (1982), established that traumatic exposure when exposed to saliva up to 7 days still healed as the bacteria did not penetrate deep within pulpal tissue.[2] In deciduous teeth pulpotomy was more successful than pulp capping in carious involvement of pulp (Massler, 1967). However, pulps with mineralized deposits within the canal are not recommended for pulp capping procedures because their repair potential is considered to be reduced (1981).[9,19] In pulp capping procedures, setting type of calcium hydroxide is recommended. These are of two basic setting mechanisms

- The two-paste system which is based on the reaction between calcium and zinc ions and a salicyclate chelating agent and is accelerated by the presence of water (Lim and Mc Cabe,1982).[20]
- The single-paste system, which utilizes the polymerization of a dimethacrylate by means of light, and is represented by Prisma VLC Dycal. The disadvantage is that they adhere to the composite restoration when they are used as a base, resulting in withdrawal from the base of the cavity during polymerization (Papadakou,1989).[20]
- Calcium hydroxide for pulpotomy may be in the form of hard setting, non-setting or a slurry of freshly mixed powder and saline. Medicaments mixed with calcium hydroxide is not recommended as it does not improve the properties of the material (Magnusson,1980).

- Calcium hydroxide reduces the seepage of apical fluids into the canal by forming a fibrous layer that is formed when calcium hydroxide is placed in direct contact with host tissues (Rasmussen and Mjor, 1971), or may be due to capillary constriction as suggested by Heithersay (1975).[4] Also, mechanical blockage physically could restrict apical seepage.
- The property of calcium hydroxide to dissolve necrotic tissue is useful when irrigating solutions cannot reach inaccessible areas of root canal (Metzler and Montgomery,1989).[21] The closure of the apex of a non-vital tooth following dressing of calcium hydroxide occurs due to continued root development if Hertwig's sheath (formative element) remains.[11] Also, by a calcific barrier of mineralized scar tissue across apical foramen. This barrier is formed by cementum like tissue with loose connective tissue elements (Heithersay,1975). The barrier may be considerably short of the radiographic apex.[11,22]
- The lateral canals form, usually at the junction of original root and the newly formed tissue (Heithersay,1975).[11]
- England and Best (1977), reported apical closure even without the presence of a root filling material.[11] The success might therefore depend upon the thorough cleaning of the canal than on the type of dressing inserted. Calcium hydroxide materials are inherently soluble. Therefore, they must be replaced at 3 months interval until closure occurs, usually after 6 to 24 months (Yates,1988).[1]
- The beneficial effect of calcium hydroxide in the treatment of external and internal resorption is doubtful. This is now considered to be sustained by infection within dentinal tubules coronal to the resorptive process (Tronstad, 1988).[9]
  It was earlier believed that osteoclasts could divide into osteoblasts under the influence of calcium hydroxide. However, this is not true as it is a well-known fact that both the cells have different origins. Calcium ions cannot diffuse through dentinal tubules (Fuss *et al.* 1989). Wang and Hume (1988) demonstrated that hydroxyl ions would not pass through dentine.[16]

Thus, the action of calcium hydroxide in the treatment of cervical inflammatory resorption is doubtful as there is no direct communication with the surface of the root so that calcium hydroxide can pass through. The elimination of the source of infection within root canal and obturation with gutta percha is of importance.[13] Two weeks following the replantation of an avulsed tooth, the root canal should be thoroughly cleansed and calcium hydroxide dressing should be given for a period of 3 to 6 months prior to the placement of a conventional root filling.[12] Calcium hydroxide, though not diffusible through dentine, but still may permeate through lateral canals. In the treatment of perforations, calcium hydroxide preliminary dressing is important as the fibroblasts from the periodontal membrane lack the capacity of pulpal fibroblasts to differentiate into odontoblasts.[16]

CONCLUSION

Calcium hydroxide is the wonder material in the field of dentistry. Since its introduction in the early part of the twentieth century it has been widely used in dental treatment. Its antibacterial property and the property to induce mineralization is the basis of its varied used. Its high pH in its pure state has done wonders in the dental treatment of patients. However, a less empirical and a more scientific evaluation of its mechanism of action and its efficacy must be found. Then its further use in the future can be established.

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