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Revive and Restore: The Art of Indirect Pulp Capping

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ABSTRACT: Vital pulp therapy is a conservative approach for teeth with compromised pulp tissue due to deep dental caries, trauma to teeth or failed restoration. Nowadays, more selective caries removal is advisable to be used in current era than nonselective caries removal. For teeth without irreversible pulpitis and lesions that are getting close to the dental pulp, pulp capping should always be the first treatment of choice. With the advent of more recent bioceramic materials, vital pulp therapy is gaining more popularity. In order to line the cavity floor with appropriate protective material and to completely seal against microleakage by an intact restoration, indirect pulp capping is an essential pulp therapy procedure. Calcium hydroxide (CH), resins, calcium phosphate, zinc phosphate cement, glass-ionomer cement, bioglass, mineral trioxide aggregate (MTA) and Biodentine are among the several materials that have been studied for pulp capping. The several indirect pulp capping materials utilized in restorative dentistry are highlighted in this review.

KEYWORDS: Biodentine, calcium hydroxide, indirect pulp capping, mineral trioxide aggregate.

I. INTRODUCTION

The dental pulp is a highly specialized mesenchymal tissue that is encased in hard mineralized tissue and has odontoblasts as its defining feature [1]. In order to prevent harm to the pulp-dentin complex, minimally invasive dentistry encourages the preservation of important tooth structure [2].The primary goal of the contemporary restorative dentistry technique is to maintain the pulp health of teeth with cavities, which lowers the need for root canal therapy and prolongs the teeth's presence on the dental arch [3].The process of indirect pulp capping involves sealing the pulp with a biocompatible substance and protecting the carious dentin that borders the pulp to prevent pulp exposure [4].

Depending on the clinical need and case selection, indirect pulp capping can be done in one or two steps [5].Various materials have been employed and evaluated as pulp capping agents. For many years, the "gold standard" of direct and indirect pulp capping has been Calcium hydroxide, which was proposed by Hermann in 1921 [6,7]. Filled resins, cements, liners, aqueous suspensions, and visible light-cured liner with calcium hydroxide are some of its many forms. Poor marginal seal toward dentin, disintegration, and gradual degradation are drawbacks of CH. Tunnel-like flaws can also be found in dentin that forms next to CH In cell cultures, CH demonstrated cytotoxicity and resulted in cell death histologically. CH resorbs over time due to its dimensional instability [8].

In 1993, Portland cement was modified to introduce MTA. Bismuth oxide, silicate oxide, tricalcium silicate, tricalcium oxide, and tricalcium aluminate make up MTA [9].MTA stimulates growth factors and cytokines to start the production of reparative dentin along with superior dentin marginal sealing [10] This material's prolonged setting time, potential for tooth discoloration, and handling issues limit its usage as a superior pulp capping material [11].

Introduced in 2009, Biodentine is a silicate-based cement with exceptional qualities. Zirconium oxide, calcium carbonate, and tricalcium silicate are combined to form powder. Calcium chloride is an ingredient that reduces water and speeds up settling in liquid. At first, it takes 12 minutes to set and doesn't discolor teeth. Biodentine promoted the formation of reparative dentin without causing pulp inflammation.The clinical results of indirect pulp capping using Biodentine, CH, and MTA have been the subject of investigations all these years.

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II. EVOLUTION OF PULP CAPPING MATERIALS

A) Calcium hydroxide

For many years, the most common method of pulp capping, both directly and indirectly, was calcium hydroxide. It is the most extensively studied pulp capping material due to its extensive application. Commercially available calcium hydroxide material is Dycal (Dentsply) as shown in Fig 1.

Fig1.Calcium hydroxide (Dycal; Dentsply Sirona)

Mechanism of action

Calcium hydroxide works by disinfecting the superficial pulp. About 1.5 mm of pulp tissue necrotizes when exposed to pure calcium hydroxide, removing any surface layers of inflammatory pulp that may be present [13]. The high pH of calcium hydroxide (12.5) causes liquefaction necrosis in the outermost layers [14].

As the deeper pulp layers are impacted, the toxicity of calcium hydroxide seems to be offset, leading to a coagulative necrosis at the interface between the necrotic and vital pulp that only slightly irritates the surrounding tissue. The pulp recovers with a strong tissue barrier if there are no bacteria present since this minor irritation triggers an inflammatory response [15,16]. Hard-setting calcium hydroxide has been demonstrated to start healing with a hard tissue barrier and does not cause necrosis of the pulp's outer layers [17,18].

Advantages

The major advantage of Ca $(OH)_2$ is that it is antibacterial and disinfects superficial pulp. It has high alkaline pH which primarily stimulates enzymes and fibroblasts [12]

Limitations

High solubility, poor physical qualities, lack of adhesion to the dentin and tunnel like flaws created in dentin bridge are some of its drawbacks. Many of us have seen the material irritably dissolve off the tooth right after finishing the subsequent stage of the clinical workflow.

B) Mineral trioxide aggregate (MTA)

Currently, bioceramic materials are thought to be the best pulp capping agents [19].One first-generation bioceramic material that has demonstrated efficacy as a pulp capping agent is mineral trioxide aggregate (MTA). [20,21,22,23](Fig 2).

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Fig 2. Mineral trioxide aggregate (MTA)

Advantages

When unset, it has a high pH, comparable to that of calcium hydroxide, and when set, it forms a solid barrier against microorganisms [24].Also, for a final restoration, it acts hard enough to be used as a base [24].

Limitations

In contrast to other medications that require a one-step process, MTA requires a wet environment for at least six hours to set correctly, making the therapy a two-step process. Therefore, in order to use MTA as a pulp capping agent, a wet cotton pellet must be placed over the pulp until it sets. After that, the permanent restoration can be made.
Another limitation is when grey MTA was applied as a capping material to anterior teeth, it caused discoloration of the tooth crown [26]. A few years later, a new white version of MTA was introduced to address this discoloration issue. It has
been observed that the white MTA also causes discoloration, which is probably due to the bismuth oxide filler that is present in the material.
Recently, more contemporary bioceramic materials with the same advantageous qualities as MTA but without the previously mentioned drawbacks have entered the market. They don't discolor the tooth and set fast enough for a single visit. These substances are currently thought to be better capping agents for traumatic pulp exposures than calcium hydroxide or traditional MTA.

C) BIODENTINE

Introduced in 2009, Biodentine is a tricalcium silicate–based cement that exhibits remarkable bioactive qualities and has the potential to be used as a pulp capping agent. Tricalcium silicate is added to calcium silicate to give the material improved physicomechanical qualities [27]. Before being placed, the material needs to be prepared in a triturator.

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Fig 3. Biodentine (Septodont)

Advantages

Biodentine has shown promising outcomes in pulp capping treatments and can be utilized as a dentin substitute beneath composite restorations [28]. It has faster setting time of 10-15minutes as compared to MTA.

Limitations

This material's primary flaw can alternatively be seen as its moderate strength as evaluated by several researchers. The requirement of triturator for its preparation can be seen as another limitation due to cost and availability.

Recent advances in pulp capping materials

A) Resin-modified calcium silicate

One of the commercially available resin modified calcium silicate material is TheraCal LC by Bisco Inc as shown in Fig 4. Many of the benefits of MTA have been included into the resin-based composition, which also incorporates light curing technology, resulting in a setting time measured in seconds as opposed to hours or minutes like the pulp capping materials that were previously available. TheraCal LC is a calcium silicate product, just like Biodentine, but its powder composition and particle size have changed. It belongs to fourth generation of calcium silicate materials [29]. Furthermore, it has been demonstrated that TheraCal LC releases calcium ions in amounts that can encourage the pulp and odontoblasts to regenerate healthy tissue [30]. Studies comparing the effectiveness of capping the pulp with TheraCal LC, Biodentine, and MTA have revealed comparable outcomes, despite the fact that these materials' qualities have improved [31]. To identify a certain winner, further extensive long-term research on the newest materials will be required.

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Fig 4.Resin-modified calcium silicate (TheraCal LC; Bisco Inc)

B) Resin-modified bioceramic

One of the commercially available resin modified bioceramic material is Ceramir Protect LC by Directa Dental Group as shown in Fig 5. Like other bioactive goods, it dissolves and recrystallizes into nanocrystalline hydrates and creates a unique interaction between the material and the tooth. The product releases calcium, which encourages the formation of hydroxyapatite and tertiary dentin. It has a highly alkaline pH which makes it hostile to microorganisms and repels them, fostering a healing environment. Its thixotropy and superior moisture tolerance lessen the likelihood that materials may dissolve when they come into contact with saliva and bonding chemicals. It has twice as much calcium release as rival products, light curing properties for effective placement, and radiopacity for better visibility on radiographs.

Fig 5. Resin-modified bioceramic (Ceramir Protect LC; Directa Dental Group)

III. CONCLUSION

Preserving pulp vitality and its normal functioning is the goal of conservative treatment. By encouraging the creation of reparative dentin and reducing inflammation, a healthy and functional pulp can mend itself.

For several years, Calcium hydroxide has been material of choice for pulp protection. However, with several advancements and research, newer materials like MTA and Biodentine have been introduced with better efficacy that have led to increased success rate of indirect pulp capping. The research for newer bioactive materials for pulp capping with improved inductive properties is still in progress so as to ensure maximum chances of maintaining pulp vitality in deep carious lesions.

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