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Recent Advances in Pulp Capping Materials

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ABSTRACT

Pulp capping is a dental restoration procedure that protects the dental pulp from death of tissue after it has been exposed, or almost exposed during cavity preparation, from a severe injury, causing the pulp to die. Calcium hydroxide and Mineral Trioxide Aggregates (MTA) are the most often utilised pulp capping materials in dentistry, and they have had significant clinical success. In recent years various other materials like Bone morph genic protein, Bio dentin, Lasers are also introduced clinically. Therefore this review article will summarize recent pulp capping materials and their advantages.

Key words: Pulp capping, Pulp capping materials, Calcium hydroxide, MTA, Growth hormones, Enzymes

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INTRODUCTION

It is a dental restoration procedure that protects the dental pulp from death of tissue due to soft tissue injury [1]. There are two methods of pulp capping. Direct method is a treatment for exposed vital pulp that entails placing a dental substance over the exposed area to help form a preventive barrier [2-4]. As well as the preservation of vital pulp [5-6]. Indirect method is a treatment that involves placing a substance on a tiny portion of residual dentin that prevents essential exposure of pulp. Pulpotomy varies from pulp-capping in that it removes a part of the existing pulp prior to application of capping substance. Caries exposure occurs when pulp is exposed before caries is totally eradicated. Mechanical exposure occurs when pulp is exposed during cavity preparation with no caries. Mechanical exposures usually occur as a result of a failure during tooth preparation. A various dental substances used in direct pulp capping although they typically have poor effects because it shows toxic effect to the dental pulp [7]. Calcium hydroxide is the one of the best material materials, with a significant track record of clinical success. Mineral Trioxide Aggregates (MTA), have gained a lot of attention as direct pulp capping materials in recent years. Apart from calcium hydroxide, MTA is also used as material [8]. Despite the fact that both these materials have an excellent track record in clinical trials, they both have some drawbacks, such as slow (or no) setting times, difficult handling, low physical strength, high solubility, and/or progressive resorption. They can be light cured, giving them a favourable condition it enhances the ability to withstand the stress of physical forces, it is easy to manipulate, and more accurate for placement [9].

Furthermore, the pulp-capping material should possess the desirable characteristics such as:

- Stimulate irritation dentin development.
- Maintain normal condition of pulp.
- Fluoride is released to inhibit the formation of a layer of dentin after the tooth's root has fully-developed.
- Bacteriostatic or bactericidal.
- Bind to the dentin
- Bind to restorative materials.
- Withstand the pressures when the restoration is placed.
- It is free from bacteria or microorganisms.
- Gives bacterial seal [10].

LITERATURE REVIEW

Following are the recent pulp capping materials

Calcium hydroxide: Hermann introduced in the year 1921 Calcium Hydroxide (Ca $(OH)_2$) as a best capping materials [11-13]. He also found that calcium hydroxide may be used to heal an exposure site in 1930 [14-15]. Since in the form of powder, paste, and cement has been utilised successfully in the clinic to aid in the creation of reparative dentin as well as the preservation of essential pulp, mineralization, and bacterial growth inhibition [16-17].

Advantages

- It is gold standard of direct pulp capping material.
- Initially bactericidal than bacteriostatic.
- Promote healing and repair.
- Balances low pH of acids.
- Stops destruction of dentinal tubules.
- Induction of mineralization.
- Poor cytotoxicity.
- Low cost and simple to use [18].

Disadvantages

- After one year, cavo surface disintegration may occur.
- Marginal failure with amalgam condensation
- Over time, it will disintegrate.
- The pulp chamber is completely obliterated due to extensive dentin development.
- Adhesion problems
- After acid etching, the material degrades [18].

Glass ionomer or resin modified glass ionomer

When utilised in close proximity but not direct contact with the pulp, glass ionomer provides an effective resistance against bacteria and it has good biocompatibility [18-19].

Advantages

- Amazing bacterial seal.
- Fluoride release, expansion coefficient, and elastic modulus are similar to dentin.
- Affiliate with both enamel and dentin.
- Excellent compatibility with pulp tissue [18].

Disadvantages

- Causes long-term inflammation.
- Formation of dentinal bridges is absent.
- It is cytotoxic when it comes into contact with cells.
- Physical characteristics are poor, solubility is high, and the setting rate is slow.
- Resin Modified Glass Ionomer Cement is more toxic than traditional GIC; administration to the pulp tissue should not be done directly [18].

Calcium phosphate: Because of its good compatibility with pulp tissue, it has better compressive strength, and ability to change into hydroxyapatite over time, calcium phosphate cement has been considered as a possible replacement [18]. In contrast to calcium hydroxide, Yoshimine found that tetra calcium phosphate cement caused bridge development with no superficial death of tissue and no substantial pulp inflammation [20].

Advantages

- With no superficial tissue necrosis, it aids in the creation of bridges.
- Compared to Ca $(OH)_2$, there is a considerable lack of pulp inflammation.
- Good physical properties [18].

Disadvantages

Clinical trials are required to assess this item [18].

Lasers: Between 1985 and 1987, Melcer suggested applying a carbon dioxide (CO_2) (1W) laser for "direct pulp capping [21-24].

Advantages

- Following the use of a laser for pulpectomy in primary teeth, better clinical, radiographic, and histological results were obtained.
- In diode laser pulpotomies, the patient did not experience any pain or discomfort, and no painkiller was required.
- Secondary dentin formation.
- Targeted tissue sterilization.
- Bactericidal properties [18].

Disadvantages

- Techniques that is sensitive.
- In large doses, causes thermal damage to pulp.
- High price [18].

Mineral Trioxide Aggregates (MTA): Torabinejad in year 1990s discovered Mineral Trioxide Aggregates (MTA). Has become available as various types of dental materials. During the setting process initial PH 10.2 which increases up to 12.5 during first few hours [25].

Advantages

- Cell adhere and growth.
- Nontoxic and non-mutagenic.
- Promote formation of original tissue when it gets contact with cementum, alveolar bone, and periodontal ligament.
- It has the capacity to trigger cytokine release from bone cells, which aids in the creation of hard tissue.
- There is less pulpal irritation.
- In compared to calcium hydroxide, the creation of a hard tissue barrier is more predictable.
- Property of antibacterial.
- Radio sensitivity.
- Bioactive dentin matrix proteins are released [18].

Disadvantages

- It is a technique sensitive material, hard to manipulate

- Long time to set
- Tooth discolouration is caused by grey MTA.
- A two-step approach is followed.
- Solubility is high [18].

Zinc Oxide Eugenol (ZOE) Cement: ZOE cement is more effective for irritated and exposed pulp. When it comes in contact with soft tissues it causes inflammation [26]. Eugenol has anti-inflammatory response which reduces sensitivity in the dental pulp at low doses [18].

Advantages

- Zinc oxide eugenol cement destroys or inactivates pathogens.
- Kills bacteria present in carious lesions, so arrest its process this gives pulp chance for healing and regeneration.
- Excellent initial seal [18].

Disadvantages

- Formation of calcific bridges is not possible due to a lack of calcium.
- Releases a high concentration of eugenol, which is toxic to living cells or tissue.
- Demonstrate the presence of interfacial leakage [18].

Corticosteroids and antibiotics: For pulp capping, corticosteroids such as Cleocin, penicillin, neomycin, and Keflin were used with calcium hydroxide in the hopes of minimising or protecting pulp inflammation [18]. Gardner discovered that a combination of vancomycin and calcium hydroxide was somewhat more effective in inducing a more regular reparative dentin bridge than calcium hydroxide. According to Watts and Paterson, anti-inflammatory medicines should not be given to anyone who is at risk of bacteraemia [27-28].

Advantages

- Reduces the inflammation of the pulp
- Promoteda more regular reparative dentin with vancomycin+Ca $(OH)_2$ [18].

Disadvantages

- Should not be used in patients who are susceptible to bacteraemia [18].

Inert materials: Isobutyl cyanoacrylate and tri calcium phosphate ceramic are the Inert materials. Although there was less pulpal inflammation and unanticipated space between one or more teeth, none of these materials has been recommended to the dentistry as a viable approach [29-30]. Cyanoacrylate is an adhesive that result from chemical reaction between formaldehyde and esters of cyanoacrylate [18].

Advantages

- It is an excellent agent which shortens the clotting of blood and prevents the growth of bacteria.
- It triggers the formation of morphologically abnormal dentin [18].

Disadvantages

- It does not produce continues barrier of morphologically irregular dentin following application of not covered pulp tissue.
- None of these materials have been promoted in dentistry as a viable technique [18].

MTYA1-Ca filler: Atsuko Niinuma developed resin based agent containing calcium hydroxide. Dentine bridge construction occurred in $MTYA_1$-Ca and necrotic layer was not formed, despite the fact that it was not histopathological inferior to Dycal. Hence it promises to be a good material [31].

Advantages

- Aids in the production of morphologically irregular dentin formed in response to an irritant or other substance that reseals exposed tooth pulp tissue without forming a necrotic layer.
- Shear bond strength is comparable to RMGIC and higher than ordinary GIC.
- Dentin bridge formation occurs in $MTYA_1$-Ca without a reduction in pulp space.
- Dentin bonding is improved [18].

Disadvantages

- The presence of 10% Ca $(OH)_2$ prevents the material from fully curing, and leftover monomers cause toxicity in pulp tissue [18].

Bonding agents: Dentin bonding agents, according to miyakoshi. Give greater adherence to peripheral hard tissues. However, because of the cytotoxic effect and the lack of calcific bridge development, they have a poor prognosis [32].

Advantages

- Effective barrier against germs, oral fluids, ions, and chemicals getting into the contact between the teeth and filling material.
- The tendency of disparate objects or surfaces to adhere to each other due to physical forces in hard tissues [18].

Disadvantages

- Toxic to living tissue.
- The production of calcific bridges is not present.
- In vivo investigations have shown that placing an adhesive resin directly on the point of exposure of pulp or dentin thickness of less than 0.5 mm promotes blood vessel dilation and congestion, as well as a chronic inflammatory pulp response [18].

Growth factors: Growth factors promote wound healing and tissue regeneration as well as regulating growth and development.

Bone morphogenic protein: Bone Morphogenic proteins are the group of molecules work by producing adult stem cells to replicate into bone forming cells lines that form new bone. They are involved in many physiological and pathological processes such as-

- Inflammatory response.

- Bone forming and resorption.
- Growth signalling pathways.
- Oncogenesis and immune response.
- They are also referred to as osteogenic proteins.

Advantages

- It play important role in cell growth, apoptosis in variety of cell development including osteoblast and chondrocytes.
- Rapidly formed tertiary dentin and tubular dentin formation.
- Dentin formation that is more homogenous.
- In terms of mineralization inducing properties, Ca $(OH)_2$ is superior.
- After 28 days, the dentin bridge development was equal to dycal [18].

Disadvantages

- Increased infection rates
- Increased postoperative swellings
- The expense of their clinical application can be an impediment.
- In the case of an inflammatory pulp, failure to activate reparative dentin
- The half-life is shorter.
- A high level of concentration is needed.
- Immunological issues may arise as a result of the frequent implantation of active substances [18].

Bio Dentin: Bio dentine is novel bioactive cement that has mechanical qualities similar to dentin and can be used to replace dentin. It enhances the production of tertiary dentin and has a beneficial effect on vital pulp cells [33].

Advantages

- Biocompatible.
- Antimicrobial activity is good.
- Enhance the development of tertiary dentin.
- It is mechanically stronger, less soluble, and creates tighter seals than calcium hydroxide.
- Compared to MTA, it takes less time to set up and has better handling capabilities [18].

Disadvantages

- For a clear assessment of Bio dentine, more long-term clinical investigations are required [18].

Bone Sialoprotein: According to Goldberg M bone sialoprotein was the most beneficial bioactive molecule in producing uniform and well mineralized secondary dentin (BSP). In terms of mineralization inducing characteristics, both BSP and BMP-7 outperformed calcium hydroxide [34].

Advantages

- Induced reparative dentin that is homogeneous and well mineralized
- In terms of mineralization inducing properties, Ca $(OH)_2$ is superior [18].

Disadvantages

- Further clinical studies are needed [18].

Enzymes

Heme-Oxygenase-1: Hypoxic stress and nitric oxide-mediated cytotoxicity are both protected by HO-1 induction. Furthermore, HO-1 expression in dental pulp cells produced by Bismuth oxide-containing Portland Cement (BPC) protects against BPC's cytotoxic effects [35].

Advantages

- They act as a barrier against cytokines and nitric oxide in human pulp cells.
- Prevent toxicity in pulp cells caused by H_2O_2 [18].

Disadvantages

- Damage to pulp tissue occurs at high concentrations.

Thera Cal: It is a light-cured, resin-modified liner for both pulp capping methods, as well as a protective base/ liner beneath composites, amalgams, and other base materials. It acts as a dental pulpal complex insulator, barrier, and protectant.

Advantages

- Protect the tooth pulpal complex by acting as a protectant. Dentin that is deep and wet
- Physical properties are strong, there is no solubility, and the radiopacity is high.
- Pro Root MTA and Dycal both have stronger calcium releasing ability but lesser solubility than Thera Cal [18].

Disadvantages

- It's opaque and "whitish" in colour, and must be thin to avoid showing through translucent composite materials and influencing final restoration shading [18].

Other enzymes

- Oil Bean (COB) Cement.
- Novel Endodontic Cement (NEC).
- Emdogain (EMD).
- Propolis (Russian penicillin) [36-40].
- Stem Cells.
- Simvastatin.

CONCLUSION

Mineral trioxide aggregate, calcium hydroxide, zinc oxide eugenol, zinc phosphate etc. are the materials used in direct pulp capping as well as indirect pulp capping. Materials are biocompatible to the patients and hence widely used in dental field. Pulp capping materials are easy to manipulate for dentist and clinicians. Various growth factors such as bio dentin, bone morphogenic protein and enzymes like heme-oxygenase-1 are also introduced clinically which enhance the growth and development of pulp capping.

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