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Research Article

Advances in Pulp Capping Agents

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ABSTRACT

The procedure of pulp capping relies primarily on the ability of the pulpal health. Various factors affect this process namely: age, health of periodontium, root formation, size of exposure, nature of injury and microbial contamination all these only can decide the success of pulp capping. A wide range of materials has been tried to achieve the success. In this review recent advances of the pulp capping materials are been emphasized.

Keywords: pulp capping materials, recent advances in pulp capping, autogenous cells, enzymes.

INTRODUCTION

Pulp capping is a technique used in dental restorations to prevent the dental pulp from dying, after being exposed, or nearly exposed during a cavity preparation. When dental caries are removed from a tooth, the affected and softened enamel and dentin are removed. In this case, direct pulp capping is carried out in order to maintain pulp vitality. Pulp capping is classified as 1) Direct Pulp Capping and 2) Indirect Pulp Capping. Indirect pulp capping is during excavation of deep caries and there is remaining dentin above the pulp chamber. Then, pulp-capping materials are used in order to induce formation of reparative dentin. Therefore, recently there are various pulp capping materials with it's own properties. The main goal of pulp capping materials is to induce formation of hard tissue by the pulp cells (1).

Conventional Pulp Capping Materials

Calcium Hydroxide: Calcium hydroxide is capable of stimulating the formation of tertiary dentin by the pulp cells because it release hydroxyl (OH) and calcium (CA) ions upon dissolution (2),(3). It also has antibacterial properties (4).Therefore, it is known as the "gold standard" material for direct pulp capping (5). It is causes dentin demineralization by activating the enzyme ATPase. It stimulates reparative dentin formation. Moreover, it acts as a mechanical barrier when applied to dentin. High pH neutralizes acidity of silicate and zinc phosphate cements.

Zinc Phosphate Cement: It is acidic in nature, but well tolerated by the pulp if placed on intact dentin, presumably because of buffering of the unreacted acid by hydroxyapatite. The consistency should be very thick like putty. Cavity varnish serves as adherent to hold cement securely against dentin, as a barrier against irritation from unset cement. The pH of zinc phosphate cement is 3 – 4 first hour, 48 hours it becomes neutralize. At an effective depth of 2.5 mm and more, zinc phosphate cement will usually create a healthy reparative reaction.

Zinc Oxide Eugenol: It has anti – inflammatory, anti – bacterial and mildly anesthetic. It provides good seal to cavity wall. Furthermore, it is used as a short-term temporary indirect pulp capping.Anti bacterial seal property is also established probably because any gap between the cement and dentin will contain a high concentration of eugenol, which is strongly bactericidal. Anodyne effect, which relieves tooth, aches in deep preparations by its sedative action.

Polycarboxylate Cements: It has pH of setting cement in range of 1.5 for first day. Acid has low diffusion mobility into underlying dentin due to its immediate complexing with dentinal fluoride, calcium, proteinacious components; complexed product will prevent further penetration of the acid.

Propolis: It is a natural extract of honey bees from different kinds of plants which has high concentration of phenolic acids(antioxidant).Furthermore it has antimicrobial and anti-inflammatory properties (6). In Direct pulp capping propolis is used to induce formation of reparative dentin by decreasing the permeability of the dentin (7).

Bio dentine (Bioactive Molecules): Bio dentine is a biocompatible material, which can influence healing by promoting the proliferation, migration and adhesion of human dental pulp stem cells when it is used as pulp capping material in direct pulp capping. (8)In the few in vitro studies, Bio dentine induced the differentiation of cultured pulp cells into odontoblast-like cells (9) and mineralized foci formation, which is similar to Mineral trioxide aggregates and calcium hydroxide (10).

Bio aggregates: Pulp cells in a tooth repairs and regenerates during pulp capping. Firstly, recruitment of HDPCs (altered adhesion and migration), and subsequent cell attachment occurs. Then, it progresses into odontoblastic differentiation and mineralization of HDPCs (11). A novel bio ceramic nanoparticle cement Bio Aggregate was recently recommended for dental pulp capping procedures (12). According to (13) Lingxin Zhu et al study Bio Aggregate is able to promote the adhesion,

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migration, and attachment of HDPCs as well as optimize focal adhesion formation and stress fiber assembly for the first time.

White Mineral Trioxide Aggregate (MTA): White mineral trioxide aggregate (WMTA) used as a pulp capping material because of its ability induce proliferation and migration of Stem cells from the apical papilla (SCAP).It has osteoinductive properties. Based on study of (14) Robert Schneider et al white mineral trioxide aggregate became popular as pulp capping material.

Mineral Trioxide Aggregate (MTA): In a condition where pulp is inflamed, restoration of mineral trioxide aggregate (MTA) forms hard tissue bridge by mesenchymal cells of pulpal cells. Its appearance was detected from the study of Azimi et al (15). In their study, when a teeth is treated with MTA it had less sensitivity to cold.

Mineral Trioxide Aggregates (MTA) derived Pozzolan Cement: An MTA-derived pozzolan cement (Endocem; Maruchi, Wonju, Korea) sets faster has recently compared to Mineral Trioxide Aggregate (MTA). (16) Choi et al reported that Endocem has a much shorter setting time (around 4 minutes) and higher washout resistance than the previously marketed MTA brand (ProRoot; Dentsply, Tulsa, OK). It is biocompatible and it's mineralization potential as ProRoot in MG63 cells. In vitro and in vivo studies of (17) Sue-Jung park et al Concludes that ProRoot and Endocem induce odontoblastic differentiation of hDPCs to a similar extent and both of the materials help in the formation of tertiary dentin.

Alpha-Tricalcium Phosphate: Recent study shows that α-TCP has a similar osteoinductive properties as mineral trioxide aggregate (MTA) both in vitro and in vivo, however, disadvantage of α-TCP is that it has compromised physical properties, which is solubility and compressive strength. Moreover it also has fast setting time which is an largest advantage. Based on their study, (18) Jun-Bong Lee et al α-TCP is potentially suitable to be used as an pulp capping material.

Bonding agents: Cox et al demonstrated dentine-bonding agents as pulp capping agent. Dentine bonding agents interacts with plasma proteins, tissue proteins connective tissue cells, which help to differentiate pulp cells to fully differentiated odontoblasts hybrid layer formed, surrounding odontoblastic processes, which increases bond strength and biological seal. Mijakoshi et al study states the effectiveness of 4-META adhesives. 4-META-MMA-TBB adhesives and hybridizing dentin bonding agent's major drawbacks are cytotoxicity, which causes injury to the pulpal cells. (19) However it prevents micro leakage due to its tight seal.

Laser: Pulp capping therapy using lasers results in good prognosis for the tooth. Laser of different wavelengths is used. For Example, Er, Cr: YSGG lasers (2780 nm) and laser assisted technique using Erbium: YAG lasers (2940 nm). (20) The erbium laser in this study produces minimal temperature increase because the tooth is air/water-cooled, while being bactericidal and productive of hemostasis (21). Neodymium-doped yttrium-aluminum-garnet laser (1064nm) which is infrared beam can be of therapeutic benefit for direct pulp capping (22). Moritz et al states that favorable results in direct pulp capping achieved using continuous wave CO_2 laser in addition to the conventional calcium hydroxide dressing technique.

Glass ionomers cement: It produces dentinal bridging, but irritates when it is placed directly onto sensitive pulpal tissue. This will eventually lead to chronic inflammation and also direct pulp cap failure, as the sensitive tissue is unable to deal with continuous inflammation. The glass ionomer is secondary, yet important procedure for a successful pulp capping to prevent bacterial invasion from compromised dentinal tubules (23).

Enzymes

Heme-Oxygenase-1: In heme catabolism, Heme oxygenase-1 (HO) is the rate-limiting enzyme. Odontoblasts and oxidatively stressed dental pulp cells express HO-1. HO-1 also plays a cytoprotective role against pro inflammatory cytokines and nitric oxide in human pulp cells (24).

Simvastatin: It is a 3-hydroxy-3-methylglutaryl coenzyme. Statin improves the osteoblast function via the BMP-2 pathway and improves the formation of odontoblasts. Moreover, it has possible effectiveness of statin in pulp regeneration along with dentin regeneration due to angiogenesis. It also has anti-inflammatory property. Thus, it is considered as an ideal pulp capping material for reparative dentin formation (25).

Growth Factors: Growth factors regulate growth and development and induce wound healing and tissue regeneration. Bone Morphogenic Protein (BMP) Bone morphogenetic protein-2 (BMP-2) is a multi-functional growth factor belonging to the transforming growth factor β superfamily that has a broad range of activities that affect many different cell types. BMP-2 induces odontoblastic differentiation of human dental pulp cells (DPCs) during pulpal healing. BMP 7 and 4 also expresses same function (26).

Platelet-Rich Plasma: It is obtained from human blood, which is rich in growth factors. According to M.Maden et al platelet rich plasma promotes inflammatory responses in infected rat's dental pulp. Thus, it is promotes wound healing of the pulp cells and also prevents the necrosis of pulpal cells (27).

Plasma-rich Fibrin: Platelet rich fibrin (PRF) is a fibrin matrix in which platelet cytokines, growth factors, and cells are trapped and may be released after a certain time and that can serve as a resorbable membrane. PRF is on of the new generation of platelet concentrates, which is popular among fibrin technology. The slow polymerization mode PRF membrane serves in the healing process (28).

Emdogain (EMD): EMD is enamel matrix derivative of Hertwig's epithelial root sheath during tooth development. It plays important role in enamel mineralization and periodontal tissue formation. EMD osteogenic induction medium enhanced the proliferation of HDPCs (human dental pulp cells). EMD contains BMP like molecules, which promote odontoblast differentiation and reparative dentin formation. It also has repair and regenerative property (29).

Theracal: It is a light cured, resin modified calcium silicate filled liner design used in direct and indirect pulp capping after oozing of blood from the pulp canal is arrested. It acts as a base under composites, amalgams, cements, and other base materials. Theracal LC serves as an barrier and protects of the pulp. Composition of Theracal LC is tricalcium silicate particles in a hydrophilic monomer, which releases calcium and acts as a strong base. This is because Calcium release stimulates hydroxyapatite and secondary dentin bridge formation (30).

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