Journal of Medical and oral biosciences
ISSN (Online): 3007-9551
ISSN (Print): 3007-9543
JMOB
Open Access DOAJ

Type: Review article
Published: 27/ 11/2024

Vital Pulp Capping: Historical Review and Update

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OPEN ACCESS

ARTICLE INFO
Received: 03/ 11/2024
Revised: 22 /11/ 2024
Accepted: 24/ 11/2024
Publish online: 27/11/2024

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CITATION

Mohammad Munthir Abdulrazzaq. (2024). Vital Pulp Capping: Historical Review and Update. JMOB. 1;(4): 71-80.
https://doi.org/10.58564/jmob.73

Abstract

The vital pulp capping aims to keep the exposed pulp alive by treating it. Secondary dentin, peritubular dentin (sclerosis), and reparative dentin are all products of living pulp tissue, which responds to biological and pathologic factors during a tooth's lifetime. Vital Pulp Capping revealed numerous research and published articles. Subsequently, this historical review intended to focus on the historical application of different materials used for preserving the vitality of the tooth pulp and indirect pulp capping, including Calcium phosphate, Calcium hydroxide, Zinc oxide eugenol cement, Corticosteroids and antibiotics, and others in published articles. A comprehensive electronic search was done using selected terms including Pulp capping agent, Stimulate reparative dentin formation, Maintain pulpal vitality, Release fluoride to prevent secondary caries, and Bactericidal or bacteriostatic, Adhere to dentin in different databases for relevant published literature. The results showed various published articles over centuries on the development of different materials used to preserve the vitality of the tooth pulp. In conclusion, this review article revealed numerous published articles that displayed the development and application of materials used for tooth pulp capping. The author recommends addressing the limitation factors faced during this study to improve the reliability and contribution of Vital Pulp Capping in clinical applications.

Keywords: Calcium phosphate, Calcium hydroxide, Zinc oxide, eugenol cement, Corticosteroids ,antibiotics, pulp capping materials.

Introduction

After tooth perforation and to secure the pulp tissue recovery, maintaining its vitality and functionality, pulp capping is required with specific pulp capping material. The direct or indirect application of protective materials on the pulp after pulp eliminating local irritants is aimed to keep the vital pulp (1,2). These procedures techniques are to place a curative over the exposed pulp surface and enhance reparative dentin formation and healing by producing odontoblast -like cells (3). The vital pulp successful treatments requires several elements including:

A. Eliminating of infection and discard the harmful rudiments from the environment.
B. Applying suitable biomaterials that stimulate the pulp odontogenic response.
C. Blocking bacterial microleakages formation by making a good plug / closure (3).

The vital pulp capping is used for teeth with traumatized injuries such as malocclusion, attrition, abrasion, erosion and mechanical trauma. In addition, deep caries lesion is also treated by pulp capping to maintain their pulp vitality. Dentin retains its resilience and toughness because the pulp tissue, by its circulation that extends into the tubular dentin, keeps the dentin wet. The teeth's ability to withstand the stresses of chewing depends on these features (1). The first pulp capping technique in the history was in 1756. It was done by Phillip, where he placed a little piece of gold over an exposed essential pulp to facilitate healing. Researcher found that the pulp capping procedure's success was very conditional on the operating conditions, and the prognosis was conditional on the age, kind, location, and extent of pulp exposure. On top of that, the perfect pulp capping material would also include qualities like: Stimulation of reparative dentin formation, Maintain pulpal vitality, Release fluoride to prevent secondary caries, Bactericidal or bacteriostatic, Adhere to dentin, Adhere to restorative material, Resist forces during restoration placement and during the life of restoration, Sterile, Radiopaque, and Provide bacterial seal (2). Review of literatures revealed scarce published review on pulp capping in Iraq. Consequently, this review articles intends to focus on the pulp capping and the historical development of materials that used in treatment.

Methods

Literature search strategy

In this study, a search was done for relevant literature published on pulp capping using different keywords. The search strategy was based on a comprehensive electronic search in databases such as PubMed, Medline, and Cochrane to retrieve relevant published articles. Search terms included a combination of Pulp capping agent, Stimulating reparative dentin formation, Maintaining pulpal vitality, Releasing fluoride to prevent secondary caries, and Bactericidal or bacteriostatic, and Adhering to dentin. No restrictions on data or language were applied.

Results

The electronic search gave (505) published articles comprising 84, 205, and 206 in PubMed, Cochrane, and Medline, respectively. Subsequently, 469 articles were excluded after screening the titles and abstracts. The retrieved articles were displayed in the table. 1 to show the historical application of material in pulp capping and their advantages and disadvantages. The exclusion was either for irreverent or duplicate articles. Ultimately, 36 articles were retrieved and included in writing this historical review. Due to the appropriate outcomes, only 36 studies from various countries were included in this review literature (Figure 1).

Table.1: Shows the summary of advantages and disadvantages of various pulp capping agents.

Pulp capping agent	**Advantages**	**Disadvantages**
Calcium phosphate (1900's). (4)	• Helps in bridge formation with no superficial tissue necrosis • significant absence of pulp inflammation compared to	Clinical trials are necessary to evaluate this material

	Ca(OH)2 Good physical properties	
Calcium hydroxide (Ca (OH)2 (1960's). (5)	Gold standard of direct pulp capping material Excellent antibacterial properties Induction of mineralization Low cytotoxicity	Highly soluble in oral fluids Subject to dissolution over time Extensive dentin formation obliterating the pulp chamber Lack of adhesion Degradation after acid etching Presence of tunnels in reparative dentin
Zinc oxide eugenol cement (1960-70's). (6)	Reduces inflammation	Lack of calcific bridge formation Releases eugenol in high concentration which is cytotoxic Demonstrate interfacial leakage
Corticosteroids and antibiotics (1970's). (7)	Reduces pulp inflammation Vanocmycin + Ca(OH)2 stimulated a more regular reparative dentin bridge.	Should not be used in patients at risk from bacteremia.
Polycarboxylate cement (1970's). (8)	Chemically bond to the tooth structure	• Lack of antibacterial effect Fail to stimulate calcific bridge formation
Inert materials (1970's) (Isobutyl cyanoacrylate and Tri calcium phosphate ceramic). (9)	• Reduces pulp inflammation Stimulate dentin bridge formation	None of these materials havebeen promoted to the dental profession as a viabletechnique
Collagen (1980). (10)	• Less irritating than Ca $(OH)_2$ and promotes mineralization	Does not help in thick dentin bridge formation
Bonding agents (1995) 4-META-MMA-TBB adhesives and hybridizing dentin bonding agents. (11)	• Superior adhesion to hard tissues Effective seal against microleakage.	• Have cytotoxic effect • Absence of calcific bridge formation *In vivo* studies have demonstrated that the application of an adhesive resin directly onto a site of pulp exposure, or to a thin layer of dentin (less than 0.5 mm), causes dilatation and congestion of blood vessels as well as chronic inflammatory pulpal response
Hydroxyapatite (1995). (12)	• Biocompatible • Act as scaffold for the newly formed mineralized tissue	Mild inflammation with superficial necrosis of pulp
Lasers (1995-2010) CO2 Nd: YAG. (13)	• Formation of secondary dentin • sterilization of targeted tissue Bactericidal effects	• Sensitivity of the Technique. • Causes thermal damage to pulp in high doses • Technique sensitive Causes thermal damage to pulp in high doses
Glass ionomer/Resin	• Excellent bacterial seal • Fluoride release, coefficient of	• Causes chronic inflammation • Lack of dentin bridge formation

modified glass ionomer (1995). (14)	thermal expansion and modulus of elasticity similar to dentin • Bond to both enamel and dentin Good biocompatibility	• Cytotoxic when in direct cell contact • Poor physical properties, high solubility and slow setting rate RMGIC is more cytotoxic than conventional GIC, so it should not be applied directly to the pulp tissue
Mineral trioxide aggregate (1996-2008). (15)	• Good biocompatibility • Less pulpal inflammation • More predictable hard tissue barrier formation in comparison to calcium hydroxide • Antibacterial property • Radiopacity • Releases bioactive dentin matrix proteins	• More expensive • Poor handling characterstics • Long setting time • Grey MTA causes tooth discoloration • Two step procedure • High solubility
MTYA1-Ca (1999). (16)	• Helps in dentine bridge formation without formation of a necrotic layer • Shear bond strength is higher than conventional GIC and similar to RMGIC • Dentin bridge formation without reduction of pulp space in MTYA1-Ca, but there is reduction of pulp space is seen in dycal. • Better adhesion to dentine	Presence of 10% $Ca(OH)_2$ interferes with complete curing of material, residual monomers causes cytotoxicity
Growth factors (1900-2007). (17)	• Formation of osteodentin and tubular dentin • Formation of more homogeneous reparative dentin • Superior to Ca(OH)2 in the mineralization inducing properties • Dentin bridge formation was equal to dycal after 28 days • Only TGF-β1 induced reparative dentin formation	• Possibility of unexpected side effects and the production • cost can be obstacles for their clinical application • Fail to stimulate reparative dentin in inflamed pulp • Half-life is less • High concentration is required • Delivery vechicles used for the molecules show potent effects at the pictogram level and appropriate carriers will be required to facilitate their handling in the clinical situation • Appropriate dose response is required to avoid uncontrolled obliteration of pulp chamber • Possibility of immunological problems due to repeated implantation of active molecules • Other factors does not induced reparative dentin formation
Bonesialoprotein (2000). (18)	• Induced homogeneous and well mineralized reparative dentin. • Superior to Ca(OH)2 in the mineralization inducing properties	Further clinical studies are needed

Biodentin (2000). (19)	• Biocompatible • Good antimicrobial activity. • Stimulate tertiary dentin formation • Stronger mechanically, less soluble and produces tighter seals compared to Ca(OH)2 • Less setting time, good handling characteristics than MTA	• More long-term clinical studies are needed for a definitive evaluation of Biodentine
ENZYMES Heme-Oxygenase-1 (2008) Simvastatin (2009). (20)	• Play a cytoprotective role against pro inflammatory cytokines and nitric oxide in human pulp cells • Prevent H_2O_2 induced cytotoxicity and oxidative stress in human dental pulp cells. • Anti inflammatory action • Induction of angiogenesis • Improve the function of odontoblasts, thus leading to improved dentin formation	• Further in vitro and in vivo studies are required • In high concentration causes pulp tissue damage. • Careful evaluation is required before clinical application to determine the suitable concentration when applied indirectly to a cavity or directly to pulp tissue.
STEM CELLS (2009). (21)	• Regeneration of dentin-pulp complex • SHED is superior to DPSCs	• Less economic Technique sensitive
Propolis (2005-2010). (22)	• Antioxidant, antibacterial, antifungal, antiviral and anti-inflammatory properties • Superior bridge formation compared to Dycal, similar results to MTA • Forms dental pulp collagen, reduces both pulp inflammation and degeneration. • Stimulate reparative dentin formation	Showed mild / moderate inflammation after 2,4 weeks with partial dentinal bridge formation.
Novel endodontic cement (2010). (23)	• Biocompatible • Shorter setting time • Do not cause tooth staining • Good handling characteristics compared to MTA • Induced a thicker dentinal bridge with less pulp inflammation than MTA	Further assessment is required for evaluation of pulp response to this material in inflamed pulp.
Emdogain (2001-2011). (24)	• Promote odontoblast differentiation and reparative dentin formation • Suppresses the inflammatory cytokine production and create a favourable environment for promoting wound healing in the injured pulp tissues • Amount of hard tissue formed in EMD treated teeth was twice that	• EMD gel (EMD dissolved in propylene glycol alginate gel) when applied on exposed pulps without the adjunctive use of a pulp-capping material was proven to be ineffective in producing a hard tissue barrier because of its poor sealing qualities. • Clinical advantages of using EMD are unproven

	of the calcium hydroxide • Post operative symptoms were less MTA produced a better quality reparative hard tissue response with the adjunctive use of Emdogain compared with calcium hydroxide	
Odontogenic ameloblast associated protein (2010). (25)	• Biocompatible • Accelerates reactionary dentin formation • Normal pulp tissue appearance withoutexcessive tertiary dentin formation and obliteration of the pulp cavity compared to MTA	• Till now only in vitro study was conducted. • Further studies containing a larger number of samples and longer follow-up assessments with various studies with higher primates should be followed
Endo sequence root repair material (2010-11). (26)	• Antibacterial property Less cytotoxic than MTA, Dycal and light cure Ca(OH)2	Bioactivity of the cells as well as ALP activity were decreased gradually when exposed to ERRM
Castor oil bean cement (2010-11). (27)	• Good antibacterial property • Less cytotoxic • It showed less inflammatory response in subcutaneous tissue of rats when compared with calcium hydroxide cement. • Facilitates tissue healing • Better sealing ability than MTA & GIC • Good mechanical properties • Low cost	• Bio inert rather than bioactive • Further clinical trials are required
Theracal (2012). (28)	• Act as protectant of the dental pulpal complex • Bond to deep moist dentin • Used as a replacement for Ca(OH)2, glass ionomer, RMGI, IRM/ZOE and other restorative materials • Have strong physical properties,no solubility, high radiopacity • TheraCal displayed higher calcium releasing ability and lower solubility than either ProRoot MTA or Dycal	It is opaque and "whitish" in color, it should be kept thin so as not to show through composite materials that are very translucent affecting final restoration shading

Placental Collagen

Medical applications of collagen include promoting cell proliferation, speeding wound healing, and diminishing the size of burn scars, among others (29). Collagen is primarily utilized in dentistry for socket wound healing because of its efficient action (30,31). The collagen group showed more evident osteoid tissue development, and wound closure was quicker. The histological, biochemical, radiological, and electron microscopical effects of pulp capping materials made from human placental collagens have been the subject of

several in vivo research (on dogs). In comparison to decal (calcium hydroxide), which induces reparative dentin production more consistently and later, and with a less inflammatory reaction, collagen from the human placenta is the more biologically friendly material for pulp capping, according to previously published research (32,33,34).

Biodentin and Mineral trioxide aggregate

The pulp exposure was successfully restored in both the experimental and control groups. Most teeth that underwent reparative dentinogenesis had dentin bridges formed, while the pulp's functional and morphological integrity were preserved. Histological examination of pulp from Vietnamese pigs showed that Biodentine, comparable to MTA, had positive therapeutic benefits following direct pulp capping (35).

Expectation

Focusing on creating the perfect scaffold is necessary because of the growing need for regenerative dentistry. The literature has presented many materials to seal and encourage tertiary dentine regeneration. To improve the success rates of vital pulp treatment, newer materials are being developed to seal the exposed site while inducing odontogenesis. Bioceramics and other synthetic materials are newer, while biological scaffolds are another example. The amount of pulp infection and the accuracy of diagnosing the reversibility of pulpal inflammation are the most critical factors determining the success rate of vital pulp treatment. Using novel approaches, it is possible to increase the success rate of caries extraction for vital pulp therapy patients. Biological scaffolds made entirely of natural materials are about to be the subject of increased investigation, with encouraging preliminary findings. Additionally, other avenues for investigating more straightforward and validated methods of pulpal disease identification should be pursued (35).

Discussion

Outcomes from this historical review displayed the application of various materials in tooth vital pulp capping (4-25). Most of the results of the reviewed articles were compatible with various historical stages for developing different tooth pulp capping materials. However, electronic research has only been shown in numerous publications worldwide that have revealed implications for the development of various tooth pulp capping materials used in treatment and for future development compared to other dentistry disciplines. In conclusion**,** this review article focused on numerous previously published articles that showed the application of agents used for tooth pulp capping. The author recommends to address the limitation factors faced during this study to improve the reliability and contribution of Vital Pulp Capping in clinical application that fasten tooth pulp healing.

DECLARATIONS

Acknowledgments

We would like to thank College Of Dentistry/ Al-iraqi University

Funding

There is no source of funding to support this article.

Competing interests statement

No conflict of interest related with the publishing of this article.

Ethics statement

The author approved that this research follows the journal's Attach Ethic Approval guidelines as appeared on the journal's author guidelines page.

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