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Bioceramics in Vital Pulp Therapy

Dr. Rohit Ahuja[1], Dr. Sachin Gupta[2], Dr. Vineeta Nikhil[3], Dr. Shikha Jaiswal[4]

[1]PG Student, Department of Conservative Dentistry & Endodontics, Subharti Dental College and Hospital, Swami Vivekanand Subharti University, NH-58, Delhi-Haridwar by Pass Road, Meerut-250005
[2]Professor, Department of Conservative Dentistry & Endodontics, Subharti Dental College and Hospital, Swami Vivekanand Subharti University, NH-58, Delhi-Haridwar by Pass Road, Meerut-250005
[3]Head of the Department, Professor, Department of Conservative Dentistry & Endodontics, Subharti Dental College and Hospital, Swami Vivekanand Subharti University, NH-58, Delhi-Haridwar by Pass road, Meerut-250005
[4]Professor, Department of Conservative Dentistry & Endodontics, Subharti Dental College and Hospital, Swami Vivekanand Subharti University, NH-58, Delhi-Haridwar by Pass Road, Meerut-250005

Corresponding Author: Dr. Rohit Ahuja

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ABSTRACT

The goal of vital pulp therapy (VPT) is to protect and maintain the vitality of pulp ally involved teeth that have been compromised by pulpal diseases. Due to a greater understanding of pulp physiology and bioceramic materials linked with adhesive technology, significant progress has been made in this field. The enhanced biological competence related to the high pH and long-term calcium release are the main features of bioceramics which are intended to improve the clinical outcome of pulp capping procedures. In this article, we would discuss bio ceramics and their role in improving clinical outcomes in vital pulp therapy.

Keywords: Vital pulp therapy, bioceramics

INTRODUCTION

Bioceramics are biocompatible ceramic materials or metal oxides used in the field of medicine and dentistry due to their antibacterial and antifungal activity, and good sealing properties. They include alumina and zirconia, bioactive glass, glass ceramics, calcium silicates, hydroxyapatite, resorbable calcium phosphates and radiotherapy glasses. The material's capacity to produce hydroxyapatite and create a bond with dentin is an added benefit. They are similar to hydroxyapatite and have an inherent Osteo conductive activity as well as the capacity to stimulate regenerative responses in the human body. Enhanced biocompatibility, high pH (12.9) during the setting process, which is strongly anti-bacterial, sealing ability, and convenience of use are some of the benefits of bio ceramics. The use of bio ceramics in endodontics is widespread e.g., in vital pulp therapy, obturation, perforation repair, retrograde filling, pulpotomy, resorption, specification and regenerative endodontics and has huge potential of further growth in clinical application and biomaterial. [1,2]

History of Vital Pulp Therapy

Phillip Pfaff recorded the first instance of vital pulp therapy in 1756, when he put a little piece of gold over an exposed vital pulp to facilitate healing. Rebel articulated his opinions in the statement "the exposed pulp is a doomed organ" by 1922, based on his experiences with similar antiseptic procedures. He came to the conclusion that when exposed to the oral environment, recovery of the vital undamaged pulp was always hopeless, and that it should be treated as a lost organ. Despite Rebel's widely quoted words, it was gradually realised that the dental pulp does, on occasion, exhibit definite recuperative and healing abilities. Significant progress has been achieved in the field of vital pulp therapy, with the focus shifting from the "doomed organ" paradigm of an exposed pulp to one of "predictable restoration and recovery."

Main objective of Vital Pulp Therapy

Pulp capping's main goal is to protect the underlying tissue from external stress, particularly microorganisms. As a result, the filling's quality and seal are extremely important. For a long time, this seal was assumed to be the sole indicator of the procedure's success.[3]

Direct pulp caps with bonded resin adhesives were claimed to produce good medium-term outcomes in the 1990s. However, the material's degradation, particularly at the sealing joints, had not been fully anticipated. Although the results were acceptable over a period of months, the loss of the seal and subsequent penetration of bacteria resulted in acute inflammatory responses or 'low-level' pulpal necrosis several months following treatment. The underlying biological notions underwent a paradigm change as a result of these flaws. Complete, biological wound healing with a long-term seal became seen as critical. This was initially accomplished by the use of bioactive materials, which was followed by the creation of other materials specifically designed to induce dentin bridge production.[4]

Ideal requirements for pulp capping agent [3]

Cohen and Combe suggested that a good pulp capping agent should sustain pulp vitality, promote the production of reparative dentin, should be bacteriostatic or bactericidal, and it should be able to offer bacterial seal, should adhere nicely to the dentin as well as the restorative material, must be able to withstand the stresses exerted by the restoration for the duration of the restoration, needs to be sterile and should ideally be radiopaque.

Pulp capping materials

A variety of materials have been tested as potential pulp capping agents e.g., calcium hydroxide, mineral trioxide aggregate (MTA), zinc oxide eugenol, tricalcium phosphate, tetracalcium phosphate, calcitonin, direct bonding agents, growth factors, resin-modified glass ionomer cement, IRM and dentin shavings. However, the three materials that are currently recommended on the basis of clinical research are calcium hydroxide, MTA (mineral trioxide aggregate) and calcium silicate- based cements (CSCs).

Calcium hydroxide, which has been used for pulp capping for a long time, is biocompatible, but it does not seal the wound and has inferior mechanical properties. Bioceramic cements have biocompatibility that is comparable to or better than calcium hydroxide and are superior in terms of sealing ability and mechanical properties.[5]

Bioceramic which have been commercially used in Vital Pulp Therapy are Pro- root MTA, Grey MTA, White MTA, MTA – Angelus, Biodentine and iRoot BP plus.

Biological properties and biological responses of bioceramic as pulp capping materials

In a large, randomized clinical trial, Hilton *et al*., provided confirmatory evidence for a superior performance with MTA as a direct pulp-capping agent compared to calcium hydroxide when evaluated forupto2years.[6]

Sanz *et al.* investigated the biological characteristics and mineralization potential of the novel Theracal PT, Theracal LC, and the hydraulic silicate–based cement Biodentine in vitro. They discovered that TheraCal PT had better in vitro cytocompatibility and mineralization potential on hDPSCs than TheraCal LC, as well as biological features comparable to Biodentine.[7]

MTA was employed in pulp capping in both juvenile and adult (closed apex) teeth by Bogen *et al*. The authors discovered that 97.96% of patients had favorable results based on radiographic appearance, subjective complaints, and cold tests after a 9-year study period.[8]

De Rossi *et al*., reported that Biodentine presented tissue compatibility and allowed for mineralized tissue bridge formation after pulpotomy in all specimens with similar morphology and integrity to those formed with the use of MTA.[9]

In another study, Natale *et al*., found that calcium and hydroxyl ion release from Dycal was significantly lower than Biodentine and MTA Angelus.[10]

After partial pulpotomy of sound human premolars and installation of a bioceramic paste (iRoot BP) and tooth-colored ProRoot MTA as pulp-covering biomaterials, Azimi *et al.* examined clinical signs/symptoms and histology pulp responses in terms of inflammation and mineralized bridge development. The response to partial pulpotomy treatment with both MTA and iRoot BP was positive when treating teeth with healthy pulps.[11]

Biodentine had a substantially higher strength and modulus than MTA Angelus or Dycal. Accorinte et al., compared ProRoot (Dentsply) and MTA Angelus (Angelus) in a pulp capping experiment in human teeth and found that the two materials produced similar responses in pulp after a 60-day follow-up time in the pulp, when used for pulp capping in intact, caries-free teeth.[12]

Zhu *et al*., reported that Bio Aggregate was able to promote cellular adhesion, migration, and attachment of human dental pulp cells (HDPCs) more than MTA used as a comparison, indicating its excellent cytocompatibility[13]. Similar effects on pulp cells were reported for iRoot BP Plus (RRM Putty) by Zhang et al., and for Bio dentine by Tziafa et al. Short-term studies and reports on their biological and mechanical properties indicate that the long-term performance as pulp capping agents of these materials may be comparable to that of MTA.[14]

D-MTA (dual-cure mineral trioxide aggregate) and W-MTA (white mineral trioxide aggregate) have no cytotoxic effect on the two cell lines, according to Laura Siqueira Pintado *et al*. D-MTA, on the other hand, enhanced the development of human pulp fibroblasts. For D-MTA and W-MTA, the micronucleus count was similar to that of the control group. D- MTA had a lower diametral tensile strength and was less water soluble. Despite this, water sorption was identical in both groups. They came to the conclusion that D-MTA is a promising pulp capping material. As a result, in vivo testing should be carried out to assess the material's performance.[15]

Dentinal bridge formation by various bioceramic materials

Nowicka *et al*. used tomographic imaging to assess the formation of reparative dentin bridges in human teeth after direct pulp capping with calcium hydroxide, mineral trioxide aggregate (MTA), Biodentine, and Single Bond Universal. In terms of thickness and volume, they discovered that reparative dentin generated in the calcium hydroxide, MTA, and Biodentine groups was significantly superior to that formed in the Single Bond Universal group. The Biodentine group's dentin bridges had the highest average and maximum volumes. The MTA group had the highest mean density of dentin bridges, while the Single Bond Universal group had the lowest.[16]

Muruganandhan *et al*. used CBCT and histological techniques to compare four dental pulp-capping agents. They discovered that in MTA (mineral trioxide aggregate) and ERRM (endosequence root repair material), the completeness and quality of dentinal bridge development is substantially higher than in calcium hydroxide. MTA and ERRM had lower inflammatory reactions in the pulp than calcium hydroxide and Biodentine. When compared to the other agents, MTA performed better in the production of dentinal bridges. The biocompatibility, anti-inflammatory, and inductive qualities of ERRM are most likely to blame for the positive findings. As a result, ERRM could be a viable alternative to MTA.[17]

On comparing the quality and quantity of dentin bridge formation of biodentine and propolis to mineral trioxide aggregate (MTA). Mohanty *et al* observed that both MTA and Biodentine had better quality and quantity of dentin bridge development. [18]

CONCLUSION

Bioceramic dental materials have come a long way and become an integral and vital segment of modern endodontics. Recently the full potential of these materials has been recognized and utilized. The newer generation of bioceramic dental materials is quite appreciable as it enhances the quality of dental treatment.

Most of the current bioceramic materials have rapidly gained acceptance in clinical applications for their physico-chemical and biological properties especially the ability to enhance tissue repair and regeneration (bioactivity). Bio ceramics have become de facto materials of choice for vital pulp therapy.

However, limitations still exist when compared to the criteria for an ideal vital pulp therapy. Indeed, it is expected that the presently available bioceramic materials will be further modified to overcome the few remaining challenges.

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