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# Bioceramics in Dentistry: Applications and Insights

*Urvashi Saggar [a], Harpreet Singh [b], Parvinder Singh Baweja [c], Bhuvanesh Tandon [d], Srishti Bhatia[e], Navneet Kaur [f]*

[a,e,f] *Post Graduate Student, Conservative Dentistry & Endodontics, Baba Jaswant Singh Dental College, Ludhiana.*

[b] *Dean Research, Professor and Head, Conservative Dentistry & Endodontics, Baba Jaswant Singh Dental College, Ludhiana*

[c] *Professor, Conservative Dentistry & Endodontics, Baba Jaswant Singh Dental College, Ludhiana*

[d] *Reader, Conservative Dentistry & Endodontics, Baba Jaswant Singh Dental College, Ludhiana.*

**A B S T R A C T**

The systematic progression of dentistry has been remarkable, especially with the interdisciplinary approach taken in biomaterials research since the turn of the millennium. The collaboration across fields like chemistry, physics, and bioengineering has led to significant advancements in the development of bioceramics and other biomaterials. These innovations are particularly impactful in conservative dentistry and endodontics, where the need for materials that can effectively mimic the properties of natural hard tissues is paramount. This review on bioceramics effectively highlights their diverse applications in dentistry with the commercially available products.

Keywords: Bioceramics, biodentine, conservative dentistry, endodontics, mineral trioxide aggregate.

## Introduction

Bioceramics have emerged as a crucial class of biomaterials, particularly for repairing and replacing damaged musculoskeletal structures. Bioceramics have gained wide acceptance in medical applications, particularly in orthopedics, maxillofacial surgery, and dental implants. [1]

Bioceramics have also been employed in the manufacturing of heart valve prostheses due to their durability, resistance to wear, and biocompatibility. Bioceramics are also utilized in cochlear implants to provide a stable and biocompatible platform for stimulating auditory nerves. [2]

Bioceramic materials for bone, teeth, pulp-capping materials, and skin grafting are being developed using tissue engineering, stem cell technologies, nanotechnology, and 3D bioprinting techniques.[3] Bioceramic scaffolds combined with stem cells are used to regenerate bone and dental tissues. These scaffolds provide a conducive environment for cell growth and tissue formation, facilitating natural regeneration processes. Bioceramics are used in dental pulp capping procedures to stimulate dentin formation and promote pulp tissue repair. Bioceramic materials hold tremendous potential to address biomedical needs and advance human health.[4]

## BIOCERAMICS IN DENTISTRY

Bioceramics, a promising class of biomaterials, have emerged as a result of significant advances in materials science in dentistry. [5] Bioceramics, composed of calcium phosphates, sulfates, and bioactive glasses are advantageous in dental applications due to their distinct physical, chemical, and biological features.[6] Bioceramics have revolutionized various aspects of dentistry, including restorative, endodontic, periodontal and implantology. [7]

Bioceramics are synthetic, inorganic materials that interact with living systems. These materials have high biocompatibility, bioactivity, osteoconductivity, and can promote tissue repair and regeneration. [8] Various examples of bioceramics utilized in dentistry include hydroxyapatite, tricalcium phosphate, and bioactive glasses. Bioceramic materials come in a variety of forms, including powders, granules, cements, and scaffolds, making them adaptable for dental applications. [9]

The rationale for using bioceramics in dentistry lies in their unique properties, which closely resemble the natural mineral components found in the human body. Because of their exceptional bioactivity, bioceramics can develop a strong link with surrounding tissues, which promotes osseointegration and reduces the possibility of negative reactions. Additionally, because of their porous texture, which promotes bone ingrowth, they are perfect for bone grafting and dental implants. Because bioceramics can produce bioactive ions, which further increases their potential for regeneration, they can be utilized for periodontal, vital pulp therapy, and root-end filling procedures. [10] Bioceramics continue to evolve, offering promising solutions across various dental specialties, from endodontics to oral medicine, and contributing significantly to advancements in dental care and treatment outcomes.

## APPLICATIONS OF BIOCERAMICS IN DENTISTRY

1. **Endodontics**:

   - Bioactive bioceramics like MTA (Mineral Trioxide Aggregate) (Figure 1), Biodentine (Figure 2) and Bioceramic sealers (Figure 3) are commonly used in vital pulp therapy, root canal treatment, perforation repair, apexification, and root end filling.[4]
   - Bioceramics such as BIO-C TEMP (Figure 4) are utilized as intracanal medicaments, showing positive effects on collagen content and immune expression, particularly in tissue repair. BIO-C TEMP offers a significant advantage over calcium hydroxide pastes due to its low solubility, enabling prolonged contact with the canal walls. [11]

2. **Restorative Dentistry**:

   - Glass ceramics serve as temporary enamel substitutes in Class II restorations and even permanent dentin substitutes in large carious lesions, particularly in cases of dentin hypersensitivity.


Figure 1: Various commercially available Mineral Trioxide Aggregate


Figure 2: Biodentine


Figure 3: Commercially available BIOCERAMIC ROOT CANAL SEALERS


Figure 4: Bio C Temp (Angelus)

3. **Prosthodontics**:

- Bioceramic materials, such as lithium disilicate and zirconia, are commonly used in creating dental restorations, including crowns, bridges (Figure 5), inlays, onlays and dental implants (Figure 6). These materials offer exceptional strength, durability, and aesthetic qualities, making them ideal for producing long-lasting dental solutions with improved esthetics.[12]

Figure 5: Fixed prosthesis containing Bioinert ceramics

Figure 6: Dental implants containing Bioinert ceramics

4. **Orthodontics**:

- Bioglass particulates protect enamel surfaces around orthodontic brackets, reducing the risk of enamel erosion in acidic environments, especially in high caries-risk patients.
- Fluoride and bioactive glass paste (Figure 7) further reduce enamel erosion when used in combination.


Figure 7: FluoroDip (Bioactive Glass Paste)

- Bioceramic brackets and orthodontic appliances have gained popularity in orthodontic treatments.[12] These materials provide biocompatibility, low friction, and outstanding mechanical properties, ensuring a comfortable and effective orthodontic experience for patients. Bioceramic brackets reduce friction during tooth movement, leading to faster and more predictable orthodontic outcomes.

5. **Periodontics**:

- Bioceramics are utilized as periodontal regenerative materials, with Calcium Phosphate Ceramics (CPCs) serving as bone defect fillers and scaffolds for bone formation, aiding in the healing of periodontal tissues.

- Bioceramic scaffolds (Figure 8), membranes and bone graft (Figure 9) promote the regeneration of periodontal tissues, aiding in the repair of periodontal defects and the restoration of periodontal health. (Figure 9) [13]

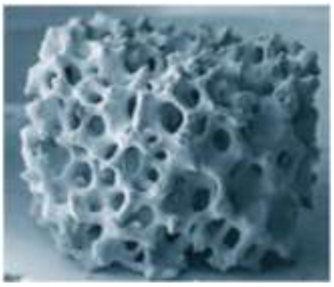

Figure 8: Calcium Phosphate based scaffolds


Figure 9: Ostofom Bone Graft

6. **Oral and Maxillofacial Surgery**:

- Bioceramics are employed as substitutes or additions to autogenous bone in surgical procedures such as filling bone defects, joint replacements, alveolar bone augmentation, orbital floor fractures, and sinus obliteration.
- Porous Hydroxyapatite (HAP) granules are popular bone defect fillers, promoting natural bone formation and rapid gap filling.
- Bi-Ostetic Bioactive Glass Foam (Figure 10) is a sterile bone graft composed of highly purified fibrillar Type I bovine collagen, 45S5 bioactive glass granules, Bi-Ostetic resorbable 60% hydroxyapatite and 40% tricalcium phosphate granules. Bi-Ostetic Bioactive Glass Foam is safe and has **excellent biocompatibility**. Once implanted, it is gradually resorbed and subsequently replaced by natural bone.

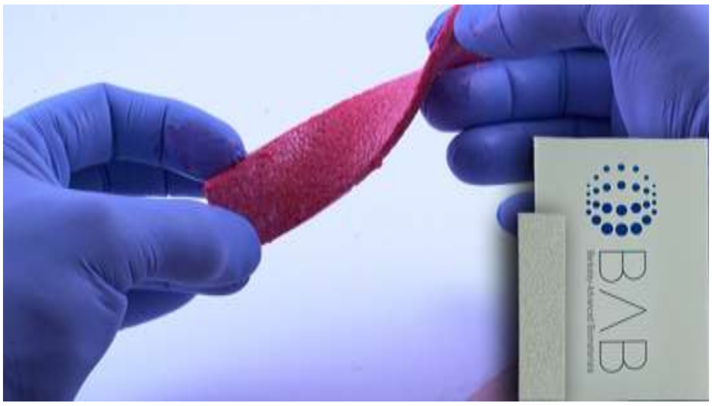


Figure 10: Bi-Ostetic Bioactive Glass Foam

7. **Drug Delivery in Oral Medicine**:

- Bioceramics serve as drug carriers, particularly in oral medicine, enabling targeted delivery of antitumor drugs through CPC-based carriers encapsulating drugs and improving their distribution and pharmacokinetic properties.

8. **Innovations**:

- Advanced techniques like 3D printing facilitate the creation of bioceramic scaffolds with interconnected porous structures for efficient bone reconstruction in maxillofacial and craniofacial conditions, promoting bone regeneration without osteogenic factors. [13]
- Metal implants can be coated with bioresorbable and bioactive bioceramics (Figure 11) using wet chemical process (Figure 12), enhancing biocompatibility and serving as temporary frameworks that dissolve over time and are replaced by body tissues, improving implant fixation.

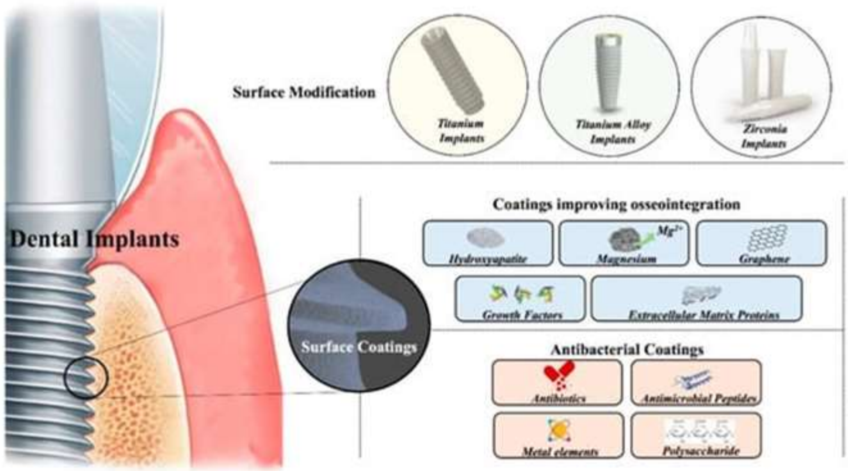


Figure 11: A schematic illustration of Surface Modifications and Functional Coating of Dental Implants.

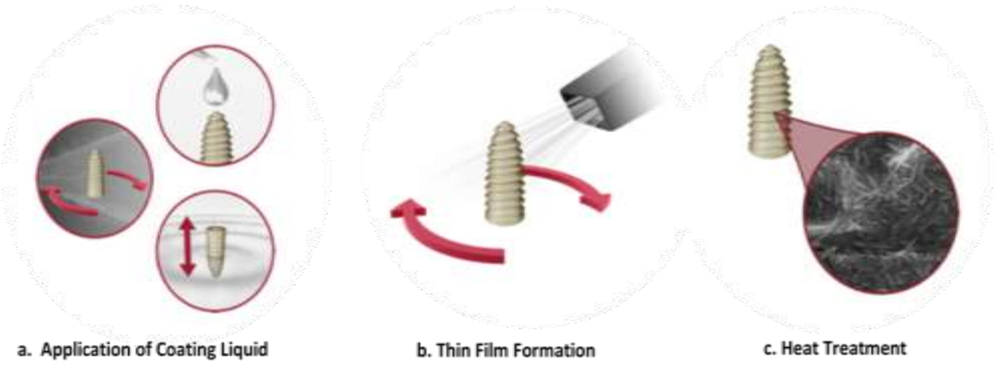


Figure 12: Wet Chemical Process (Modification of an implant with Hydroxyapatite Surface)

## Conclusion

In essence, the unique properties of bioceramics make them versatile and effective materials in various dental applications, offering both structural support and biological compatibility for optimal clinical outcomes. The commitment to developing such materials is a testament to the continuous improvement in dental technology and patient care.

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