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Bioactive Glass in Dentistry: A Review

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Abstract: Bioactive glasses are new dental materials that are utilized in dentistry and differ from regular glasses. The ingredients in bioactive glasses include calcium and phosphate, both of which are present in a quantity comparable to that of bone hydroxyapatite. These biocompatible glasses adhere to the tissue. They are being used as bone grafts, scaffolds, and coating materials for dental implants and have a wide range of medical and dental applications. This article explains the many qualities of bioactive glasses, their various application in dentistry.

Keywords: Bioactive glass, Dentistry, Application of bioactive glass

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Introduction: Bioactive materials are strong substances that can chemically bond with the nearby bones and, in some circumstances, even with soft tissue. A porous biologically active layer that is a highly advantageous substrate for the rebuilding of bone tissue is created when bioactive materials are implanted in the body. The substance's biological activity makes it perfect for usage as a filler and covering in bone cement. A bioactive ceramic is a ceramic that produces an advantageous reaction in the biological environment of the implants and/or a chemical reaction that modifies the material to some extent below the surface.[1]

Biomaterials have traditionally been used to replace sick or damaged tissues. To reduce the formation of scar tissue at the interface with host tissues, the first generation biomaterials were chosen to be as bio-inert as feasible. When bioactive glasses (BAGs) were produced in 1969, they offered the second generation of implant interfacial interfacing with host tissues for the first time. A third generation of biomaterials is made possible by tissue regeneration and repair employing Bioglass®'s gene activation characteristics.[1]

These materials were initially created by Hench et al. at the University of Florida in the late 1960s, and since then, his research team at Imperial College London and other scientists across the world have continued to improve them. The bone bonding strength of bioglass was summed up by Hench et al. in a review study published in 1982.[2,3] In 1977, Professor Ulrich Gross and colleagues at the Free University of Berlin implanted a BAG-ceramic based on the 45S5 Bioglass® formula with minor K2O and MgO modifications, patented Ceravital. They discovered that a mechanically robust contact allowed the glass-ceramic to adhere to bone. Wilson et al (1981) reviewed previous studies on bioactive glass and proposed that bioactive glasses are safe for clinical use.[4] This article explains the many qualities of bioactive glasses, their various application in dentistry.

Properties of Bioactive Glass: Bioglass is safe for use around living things, non-toxic, and chemically stable. It also has antibacterial properties because it raises the local pH and osmolarity, which makes the environment unfavourable for bacterial development.[5,6]

BAGs are distinguished from most technical glasses by the materials' reactivity with aqueous liquids and with water. The interaction of BAGs with tissue fluids produces a coating of hydroxycarbonate apatite (HCA) on the glass, which gives BAGs their bioactivity.[1]

Glass's composition, structure, manufacturing processes, level of ionic dissolution, and other factors all affect how bioactive it is. The glass with the highest bioactivity has a greater surface area and a quicker rate of dissolving, which causes apatite to form more quickly.

Additionally, they have shown that biomimetic nano-structuring enhances cell adhesion as well as the mechanical qualities of such composites for natural bones.[7]

Bioglass can be utilised as a coating for dental implants since it can be put into both hydrophilic and hydrophobic environments.[8] The antibacterial capabilities are also influenced by particle size; smaller particles have a greater surface area, which enhances the antimicrobial effects.[9]

Utilization of bioactive glass in dental Practice: Bioactive glass was initially employed as a substitute for bone in treatments including dentoalveolar and periodontal regeneration, maxillofacial reconstruction, and implants due to its composition mimicking that of bone and teeth, as well as its bioactive qualities and antibacterial capabilities.

Management of Dental Hypersensitivity: Dentin hypersensitivity is characterized by short duration of pain arising from exposed dentin in response to stimuli, typically thermal, evaporative, tactile, osmotic or chemical and which cannot be attributed to any other dental defect or pathology. There are various strategies which have been implicated in the treatment of dentine hypersensitivity, including lasers, ions and salts, fluoride iontophoresis, dentine sealers, periodontal soft tissue grafting. However it is still not possible to represent the gold standard technique for the treatment of dentine hypersensitivity.

Novamin is a biocompatible bioactive glass used for treating dentin hypersensitivity. Novamin (Calcium sodium phosphosilicate) is a new material of choice, when exposed to body fluids (saliva) which reacts rapidly by releasing mineral ions responsible for the natural remineralization process. It has the ability to deposit hydroxycarbonate apatite and also which reduces the reopening of dentinal tubules. Hydroxycarbonate apatite, a mineral that is chemically similar to the mineral in enamel and dentin. As it is made from the bioactive material which is used in most of the advanced bone regeneration material. The material is safe and non-toxic as it is made with the same minerals which are naturally found in saliva.[10,11]

Enamel Remineralization: Dental caries is one of the causes of tooth loss for all human beings across age and gender. It is generally known that the caries process involves the alternating processes of demineralization and remineralization of tooth mineral (Featherstone 1999). The primary drawback of the anti-caries products now on the market is that the low concentration of calcium and phosphate ions present in saliva restricts their capacity to remineralize enamel. This has prompted the study of numerous novel materials that potentially offer crucial components for remineralization. Some of these include casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) and bioactive glass (BAG).[12,13]

In the aqueous environment around the tooth, i.e., saliva in the oral cavity, sodium ions from the BAG particles rapidly exchange with hydrogen cations (in the form of H_3O^+) and this brings about the release of calcium and phosphate ($PO4^-$) ions from the glass. A localized, transient increase in pH occurs during the initial exposure of the material to water due to the release of sodium. This increase in pH helps to precipitate the extra calcium and phosphate ions provided by the BAG to form a calcium phosphate layer. As these reactions continue, this layer crystallizes into hydroxycarbonate apatite.[14]

Bioactive Glass in Dental Adhesive: Dental adhesives enable the adhesion, or bonding, of a substance or material, such as dental composites or brackets, to the tissue of the natural tooth. The adhesive joins two materials together.

The use of orthodontic brackets frequently results in cases of white spot lesions. Since the orthodontic bracket sticks to the tooth surface, a favourable environment for microbial flora growth is created. Regular teeth brushing and the use of fluoride dentifrices, mouthwash, or varnishes become essential for the prevention of white spot lesions, which increases the expense of care. By encouraging the remineralization of mineral-deficient areas and simultaneously increasing the modulus of elasticity, the bonding mechanism in bioglass minimises micropermeability. This characteristic qualifies Bioglass as a dental adhesive. Biosilicate is a bioactive glass ceramic that, when used beforehand, improves the bond strength system in both mineralized and unmineralized dentins.[15]

Bioactive Glass in Periodontics: In order to permit coronal migration of periodontal progenitor cells, bone augmentation grafts may function as space-maintaining tools. A functional periodontal ligament and osteogenesis, cementogenesis, and cementogenesis should all be able to be sparked by a bone replacement graft. According to a theory, bioactive glass, a type of ceramic, possesses bioactive characteristics that direct and enhance osteogenesis, enabling quick bone growth. For dental applications, bioactive glass is made up of phosphates, silicon dioxide, and sodium and calcium salts. The surface of the particles becomes coated with hydroxy carbonate apatite, integrates organic ground proteins like chondroitin sulphate and glycosaminoglycans, and draws osteoblasts that quickly create bone when this substance comes into touch with tissue fluids.[16]

Studies have found out that the use of bioactive glass allowed the regeneration of a normal periodontium and that it was effective in retarding epithelial down growth than other materials like hydroxyapatite and tricalcium phosphate. The two properties of bioglass that appeared to contribute to these favorable results seem to be first, the increased rate of reaction in vivo that it possesses in comparison to the other materials as a result of its release of silicon and secondly, that it appeared to bond with connective tissue collagen. Because of its high bioactivity, the reaction layers appear to form within minutes of its implantation and the osteogenic cells freed by the surgery can rapidly colonize the particles. This process supplements the bone, which grows by osteoconduction from the alveolus, and these two processes combined have been termed osteoinduction.[17]

Bioactive Glass in Restorative Dentistry: The currently available restorative materials can resemble teeth in terms of look, structure, and functionality, but they lack bioactive characteristics. Glass ionomer cement or resin composite both experience some degree of polymerization shrinkage during cavity restoration. Due to differences in the mechanical characteristics of the tooth and the restorative material, a microgap therefore created may widen. Secondary caries, the most frequent cause of dental restoration failure, is caused by the gap, which is frequently inaccessible to standard dental hygiene measures and provides a favourable environment for bacterial development.[18]

Resin composites with BAG filler particles exhibit antimicrobial and bioactive characteristics, which are instrumental in the prevention of secondary caries. Glass ionomer cement (GIC) primarily consists of fluoride–aluminosilicate glass and polyacrylic acid and may be modified by adding methacrylate resin monomers (resin-modified GIC, rmGIC), for better mechanical properties, stronger adhesion, and lower solubility. GIC is known for its fluoride release, remineralizing properties, and direct chemical bonding to the tooth. BAG particles have been incorporated into formulations of GIC to regulate remineralization.[19,20]

Dental Implantology: In prosthodontic, dental implants are used to improve both the function and aesthetics of the final prosthesis. The implant surface needs to be continuously in contact with the bone tissue for osseointegration, or proper retention in bone, to occur. Titanium-based alloys are often utilised for dental implants; although they are bioinert, they are biocompatible and osteoconductive. Its bioinert property is eliminated by the addition of Bioglass. Implants made of bioglass and alloys based on titanium have active bonding and are antibacterial, which reduces the overall length of the procedure.[21,22]

Bioactive Glass in Oral Surgery: Biogran (Biomet 3i, Palm Beach Gardens, Florida, United States) is a product that may be purchased commercially for maxillofacial purposes. Maxillofacial deformities are routinely treated or fixed with this method. Blood from the area of the defect can be utilised to manufacture putty using NovaBone (NovaBone Products LLC), which is a commercially available product. Bone resorption has been shown to be lessened by bioglass containing strontium oxide. For dental and oral maxillofacial applications, alkali-free Bioglass is better suited since it is more biocompatible and has higher osteoconductive property.[23]

Conclusion: There are presently several uses for bioactive glasses of different compositions. Researchers are now interested in bioactive glasses, and work on many features of these glasses is still ongoing. These glasses have a promising future in the fields of medicine and dentistry given their existing applications**.**

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