BIOSMART MATERIALS - THE ERA OF SMART DENTISTRY

Author: Dr. Dhanya Kumar N.M.
Professor and guide
College of dental sciences
Davangere.

Co-author: Dr Vinita Joshi.
Post graduate student
College of dental sciences
Davangere.

Dept. Of Conservative Dentistry & Endodontics.

INTRODUCTION:

Term **biomimetics** (1972) is defined broadly as "the abstraction of good design from nature". The concept of biomimetic materials was born during the course of studies aimed at mimicking excellent and fascinating biomaterials. Much effort has been devoted to developing biomimetic materials from various points of view. The significance of biomimetic approaches is not only simple mimicry of biomaterials, but also the development of new materials exhibiting unique biomimetic functions

"Smart Materials" are materials that can significantly change their properties in response to their environment. These smart materials are highly responsive and it is for this reason that they are often called as "responsive materials". The recent advances in the design of smart materials have created novel opportunities for their applications in bio-medical fields. One of the applications is the dental restoratives. Teeth are constantly subjected to a number of diseases like dental caries. Loss of tooth structure due to such diseases may be compensated by a number of dental restoratives. Smart materials are used in restoring and preventing dental caries as these materials encounter the carious process and aid in its prevention. Recent developments: The smart materials used in dentistry are the shape memory alloys, ceramics and hollow-core photonic-crystal fibres (PCF). This article discusses biosmart materials research and its future.

Few of the present and potential applications of biosmart materials in dentistry are:

1.GLASS IONOMER CEMENT: The trend to preservative dentistry, formed the view that caries risk assessment should increasingly influence the selection of restorative materials. In low caries risk patients, aesthetic demands typically favour the use of resin-based composites. Interactive (biomimetic) materials based on glass-ionomer chemistry have particular application in high caries risk patients.

2.COMPOSITES:

a. SMART COMPOSITES: These are ion releasing composite materials which release F^- with hydroxyl and calcium ions as pH drops in area immediately adjacent to the restorative material. Based on newly developed alkaline glass filler, which reduce secondary caries formation at the margins of restoration by inhibiting bacterial growth.

b.BLEEDING COMPOSITES: This is a novel composite system which employs a biomimetic approach to perform a self-repairing function. Self repairing composites offer the potential for a substantial improvement in allowable design strain, making the outstanding properties of fibre reinforced polymer (FRP's) more fully exploitable. Such a system performs two functions; the visual enhancement of impact damage by the bleeding action of a highly conspicuous medium such as fluorescent dye, and the restoration of mechanical properties by a healing agent, stored within hollow fibres, infiltrating the damaged area and acting to ameliorate the effect of the damage.

c. **PLANT FIBRE COMPOSITES:** These are mainly under research due to the low fibre weight (density around 0.8-1.6 compared to 2.5 of glass fibres). These are mainly coupled with biodegradable matrix (e.g., starch-sorbitol or polylactic acid) to obtain a fully sustainable composite.

3. **ABALONE:** Abalones are members of a large Class (Gastropoda) of Molluscs having one-piece shells. Abalone shells include microlaminates with outstanding impact resistance i.e., layered, columnar, and foliated structures of crystalline units, allotropic forms of calcium carbonate: this architecture results from an evolutionary design for an ideal impact resistant material providing armour to the mollusk. The structure of abalone suggests that a possibility to have an effective bone graft would be in a composite of these two materials, with the ceramic armour providing the hardness and resistance to impact, whilst a softer, probably polymeric, protein material needs to provide the templating function. Other properties, such as the pore size, could be optimised so as to provide the best conditions for cell growth. Other potential biomedical applications of abalone include improved biosensors, such as a DNA chip used for robotic diagnostic screening for HIV, other viral and microbial infectious agents and genetically inherited diseases.
4. **MINERAL TRIOXIDE AGGREGATE:** MTA has a good biocompatibility, good sealing ability and capability of promoting dental pulp and periradicular tissue regeneration (Abdullah et al.2002). Perez et al. (2003) reported that MTA might be an ideal material because it consistently induced the regeneration of periodontal ligament tissues, the apposition of a cementum-like material and formation of bone. MTA has been reported to be biocompatible in many in vivo and in vitro studies. Koh et al. (1998) reported that MTA offered a biologically active substrate for bone and cells stimulating interleukin production and Mitchell et al. (1999) reported that MTA was biocompatible and suitable for clinical trials. Zhu et al. (2000) reported that osteoblasts have a favourable response to MTA.
5. **SHAPE MEMORY ALLOYS**: shape memory alloys have come into wide use because of their exceptional super elasticity, shape memory, good resistance to fatigue and wear and their biocompatibility. Nitinol endodontic files have a fundamental advantage in providing ease of use and increased patient comfort. When the dental procedure is carried out, the file can fit into miniscule and tight positions without being forced. Super elastic files provide benefit by maintaining close contour to the canal shape without concern for file breakage.
6. **GOOEY GEL:** Titanium implants usually come encapsulated in a thin gooey gel. This will serve two functions. First, it will protect the bioreactive surface from damage during implantation. Second, it will contain active molecules that can be released into the implant site. Upon implantation, the gel will dissolve within a day, liberating molecules to turn on healing.
7. **CERCON- SMART CERAMICS:** The strength and technology of CERCON allows bridges to be produced without metal.The Zirconia based all ceramic material is not baked in layers on metal but created from one unit with no metal.The overall product is biocompatible, metal free,life like restoration with strength that resists crack formation
8. **BIOCERAMIC IMPLANTS:** Ceramic. materials are the most biologically acceptable of all materials. Because of their chemistry, ceramics are much less likely to produce any adverse effects, compared with metals and polymers, which are not as chemically stable.

Ceramics have a very wide application as substitutes for calcified tissues and as aid to bone formation. In the wider biomedical field, ceramic biomaterials have been used as implants for long-bone defects, as orthopedic load-bearing hip prosthesis implants, as coatings for tissue ingrowth, for spinal surgery implants, and as ceramic coatings in metal Orthopedic implants. Ceramics implants can also be used as drug delivery systems (Ikenaga et al., 1991). Strategies such as arc plasma spraying,Chemical Vapor Deposition (CVD), or ion implantation to fuse hydroxyapatite to strong, metallic devices has led to a new generation of implants that will genuinely bond to bone.

9.PLATELET RICH PLASMA: Platelet-Rich Plasma (PRP) is autologous concentration of human platelets in a small volume of plasma. Because it is a concentration of platelets, it is also a concentration of the seven fundamental protein growth factors proved to be actively secreted by platelets to initiate all wound healing. These growth factors include the three isomeres of Platelet-Derived Growth Factor (PDGFaa, PDGFbb, and PDGFab), two of the numerous Transforming Growth Factors-B (TGFb1 and TGFb2), Vascular Endothelial Growth Factor, and Epithelial Growth Factor. All of these growth factors have been documented to exist in platelets (Marx et al, Kevy & Jacobson, 2001). Because these concentrated platelets are suspended in a small volume of plasma, PRP is more than just a platelet concentrate; it also contains the three proteins in blood known to act as cell adhesion molecules for osteoconduction and as a matrix for bone, connective tissue, and epithelial migration. These cell adhesion molecules are fibrin itself, fibronectin, and vitronectin.

10.POSS and POS: Biomaterials, as such Polyhedral Oligomeric Silsesquioxanes (POSS) and Polyhedral Oligomeric Silicates (POS), may be fabricated by the incorporation of POSS molecules into material for the purpose of providing a nanoscopic topology which favors cellular modulation, bioavailability, and differentiation. Highly rigid, shape specific, chemically tailorable nano structures such as POSS molecules are desirable as they coordinate surface characteristics at the nanoscale, and provide a surface that is compatible with all sterilization methods. In vitro immunohistochemistry experiments have shown that certain types of POSS nanostractures cause the proliferation and differentiation of bone stroma cell (BSC) and the deposition of apatite. This proliferation and differentiation of BSC provides an indication that POSS nanostructures of appropriate form are bioactive, and therefore also biocompatible and resorbable.

11.TOOTH MOUSSE: This is a topical crème with bioavailable calcium & phosphate i.e. CPP-ACP. It binds to biofilms, plaque, bacteria, hydroxyapatite & soft tissues thus, localizing bio-available calcium & phosphate. Saliva enhances effectiveness of CPP-ACP. It acts by providing extra protection for teeth, neutralizes acid challenges from acidogenic bacteria from plaque and also from other internal & external acid sources.

12.SPIDER SILK: Spider silk has outstanding mechanical properties despite being spun at close to ambient temperatures and pressures using water as the solvent. The spider achieves this feat of benign fibre processing by judiciously controlling the folding and crystallization of the main protein constituents, and by adding auxiliary compounds, to create a composite material of defined hierarchical structure. The properties of spider silk are being explored as an excellent scaffold material to aid in regeneration processes.

CONCLUSION:

In practice, the biomimetic approach is based on exploiting the knowledge obtained in nature during evolution. In contrast, it includes three main ideas, which can all be included in the concept of biomimetics. All of the following three ideas can be useful in designing tissue-engineering materials..

- -Artificial synthesis of naturally occurring materials, substances or other structural configurations
- -Mimicking biological processes in creating life-like products
- -Mimicking of complex self-organizing natural processes to obtain dynamic artefacts.