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Review Article

Biosmart Materials- Gateway to the Future Dentistry

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***ABSTRACT*:**
Change is inevitable, progress is a choice; with the advent of innovative novel technologies, contemporary dentistry now has access to many outstanding restorative materials. A paradigm shift has occurred from conventional dentistry to futuristic concept of developing bioesthetic restoration. Biomimetic Material, with their biocompatible nature & excellent physico – chemical properties are widely used nowadays. They can function as long lasting esthetic & restorative materials, cement, root repair materials, root canal sealers & filling materials which have advantage of enhanced biocompatibility, high stress, sealing ability & antibacterial properties. The concept of developing smart materials in dentistry has gathered pace since their properties simulate natural tooth substance such as enamel or dentine.
Examples: Piezoelectric materials which produce voltage when stress is applied/ vice versa, shape memory alloy which are thermoresponsive, ph sensitive polymers, Zirconia.
Key words: bioesthetic restoration, Biomimetic materials, biocompatible.

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INTRODUCTION

Dental profession continues its voyage in pursuit of a biomimetic ideal restorative dental material that may synergistically emulate enamel & dentin. With the advent of innovative novel technologies the concept of developing smart materials in dentistry has gathered pace due to their biological & physico-chemical properties, potential biocompatibility with the living tissues, acting synergistically with body tissues, thus depicting their repair role in eliminating body defects like bone loss.

Biomimetic term was coined by Otto Schmitt in 1950.

Biomimetic is defined as the study of structure & function of biological systems as models for design & engineering of materials & machines. Biomimetic materials transcend the regular biomaterial in utility & will suitably perform the function of biological molecule that needs to be replaced.[1][2]

The application of biomimetic technology has demonstrated promising results in the field of dentistry. But the broad array of choices currently available poses clinicians into dilemma whether to proceed towards the surge of revolutionary cosmetic dentistry/ revert to fundamental postulates of amalgam. [4]

Material science is not what is used to be. Traditionally materials used in dentistry were designed to be passive & inert, that is to exhibit little or no interaction with body tissues & fluids.

1st inclination that an 'active' rather than 'passive' material could be attractive in dentistry was the realization of the benefit of fluoride release from materials.

Materials used in dentistry can be classified as bioinert (passive), bioactive, & bioresponsive/ smart materials based on their interaction with the environment.

BIOMIMETIC PARADIGMS:

1. Maximum bond strength – Reduced polymerization stress to the developing hybrid layer results in increase in bond strength. This strong bond allows the biomimetically restored tooth to function & handle functional stresses like an intact natural tooth.
2. Long term marginal seal: a strong & secure bond allows for long term marginal seal to be established & maintained during functional stresses.
3. Increase Pulp Vitality
4. Reduced Residual stress – Reduced residual stress while maintaining the maximum possible bond strength

is the ultimate goal of any biomimetic restorative technique.[7][9]

SMART MATERIALS IN DENTISTRY

There is no single material in dentistry that is ideal in nature & fulfills all the requirements of an ideal material.

As the quest for an ideal restorative material continues, a newer generation of materials was introduced.

These materials are termed as 'Smart' as these materials support the remaining tooth structure to the extent that more conservative cavity preparation can be carried out.

These materials may be altered in a controlled fashion by stimulus such as stress, temperature, moisture, ph, electric/ magnetic field.

These are known as 'Biomimetic' in nature as their properties mimic natural tooth substance such s enamel or dentin.

The use of smart materials has revolutionarized dentistry which includes the use of restorative materials such as smart composites, smart ceramics[Cercon Zirconium], Smart impression materials, smart GIC, compomers, resin modified GIC, Amorphous Calcium Phosphate releasing pit & fissure sealants, Fluoride releasing pit & fissure sealants etc. & other materials such as orthodontic shape memory alloy, smart impression material, smart suture, smart burs etc.[16]

PROPERTIES OF SMART MATERIALS:

1. SHAPE MEMORY – After deformation these materials can remember their original shape & return to it when heated.

2. THERMOCHROMIC – These materials change colour in response to changes in temperature.

3. PHOTOCHROMIC – These materials change colour in respone to change in light condition.

4. BIOFILM FORMATION – Presence of biofilm on the surface of material alters the interaction of the surface with the environment.

BENEFITS OF BIOMIMETIC DENTISTRY:

Biomimetically restored tooth flexes in asimilar manner as natural dentin. Such restoratios are cost effective, aesthetic & long lasting with minimum to non-existent post operative sensitivity than traditional restorations.

Biomimetic approach to restore tooth structure is based on regenerative procedure by application of tissue engineering which opens up a whole new arena for the practioner. The key elements of tissue engineering are stem cells, morphogen & scaffold of extracellular matrix.

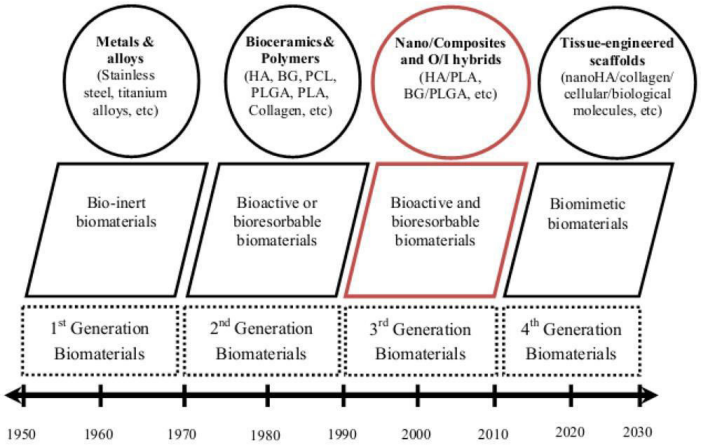
Stem cells are cells that have the ability to continuously divide & produce progeny cells that develop into various other cells/ tissues. [5]

Today 8 types of human dental stem cells have been isolated & characterized:

1. Dental Pulp Stem Cells(DPSC's)
2. Stem Cells from Human Exfoliated Deciduous teeth(SHED)
3. Stem cells from Apical Papillae(SCAP)
4. PDL Stem Cells(PDLSC)
5. Epithelium originated dental stem cells(EpSC)
6. Mesenchymal Stem Cells
7. Stem Cells from dental follicle(DFSC)
8. Endothelial progenitor cells(EPC's)

Biomimetic approaches for regeneration tooth & its associated structure:

1) Root Canal Revascularization: It is the procedure to establish the vitality in a non-vital tooth to allow repair & regeneration of tissues.
2) Stem Cell Therapy: The simplest method to administer cells of appropriate regenerative potential is to inject the postnatal stem cells into the disinfected root canal system.
   Advantages: Autogenous stem cells are relatively easy to harvest & to deliver by syringe & cells have the potential to induce new pulp regeneration.
   Disadvantage: 1. Cells may have low survival rates.
   2. Cells might migrate to different location within body.



Generations of biomaterials

Ni-Ti Smart Alloys – These are used in orthodontic wires. The smart behaviour of Ni-Ti alloys is because of 2 salient features called 'Superelasticity' & 'Shape memory'.

Nitinol basically exists in two phases. The low temperature phase is called the martensitic & a high temperature phase is called the austenitic. Ni-Ti wires because of their superelasticity & shape memory, apply continuous gentle

force on teeth, which are in physiologic range over a longer period of time.

Smart Composites – ACP (Amorphous Calcium Phosphate) based materials were developed for a no. of applications like base/ liners, orthodontic adhesives, endo sealers & as pit & fissure sealants .

ACP containing composites in addition to excellent biocompatibility, release Ca ions & phosphate ions into saliva. These ions can be deposited into tooth structure as apatitic mineral, which is similar to hydroxyapatite found naturally in teeth & bone. When low pH values occur during a carious attack, ACP converts into HAP & precipitates, replacing HAP lost to acid.

Smart Ceramics – Aesthetics is one of the major concerns in dentistry. Ceramics, though available since a long time to fabricate crowns, have been used with a metal substructure as PFM crowns. A high tech ceramic Zirconia is now available that has already proven in many extreme situations such as spherical head of artificial hip joints.

Zirconia is polycrystalline ceramics that does not contain glass.

The Fracture toughness & flexural strength of zirconia is significantly higher than that of alumina or any other currently available ceramic.[18][22]

CONCLUSIONS

The numerous applications of smart materials have revolutionarized many areas of dentistry & there is no doubt that 'Smart Materials' hold a real good promise for the future.

These innovations in the material science have marked the beginning of an era of bio-smart dentistry, a step into the future.

It is the designing of biomaterials that stimulates physical & mechanical properties of the lost tissues, thus providing an opportunity to introduce & change treatment modalities for the disease. Biomimetic dentistry is an interdisciplinary approach & has potential for transforming everyday dental practice. It brings the power of modern biological, chemical & physical science to solve real clinical problems.

Biomimetic material function as root canal sealer, filling material, cement & root & crown repair material & possesses features as like strengthening the root following obturation, good sealing ability, enhanced biocompatibility & antibacterial properties.

There is much room for the improvement & further development of materials used in dentistry. The most sophisticated class of smart materials in the foreseeable future will be that which emulate biological systems. This class of multi functional materials will possess the capability to select & execute specific function intelligently in order to respond to change in local environment.

The benefits for the patient & quality of dental therapy will undergo a significant improvement if such materials are developed & introduced.

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