BIOMIMETIC APPROACH IN RESTORATIVE PRACTICE: REDEFINING DENTISTRY

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ABSTRACT

Over the years restorative practice in dentistry has not just merely has taken a shift from conventional design to more conservative preparation to salvage healthy tooth but also travelled a road far in crafting out tooth mimicking like original. With the advent of technologies and recent material sciences tooth is not just restored to meet out the functions but also much needed esthetic demands. Recent research in material sciences has just not met the physical appearance of the tooth but are at par to meet chemical, mechanical and structural properties similar to part of tooth which demands restoration and also facilitating its natural healing in this process. This is where “Biomimetics” steps in. Such materials owing ‘closer to nature’ property play an important role in current restorative dentistry. This article aims to review such biomimetic materials and their approach in redefining restorative dentistry.

KEYWORDS: Biomimetics, Biomimetic Materials & Restorative Dentistry

INTRODUCTION

Biomimetics is the name given to the human made processes, materials or systems that mimic or imitate nature. Biomimetic materials are the ones fabricated by biomimetic techniques based on natural processes found in biological systems. These materials should be essentially synthetic, should bond it the natural structure and should mimic biological function, structure or process. They are different from bioactive materials as the bioactive materials are biologically active materials eliciting a biological response at the interface of the material and host tissue. Both bioactive and biomimetic materials are essentially non toxic. When these principles are applied in dentistry, door to biomimetic restorative dentistry opens.

Why is Biomimetic Restorative Dentistry Important?

Due to different regeneration properties of tooth layers, natural regeneration of a healthy, functional tooth halts in some cases. The concept of biomimetics in dentistry is about restoring the hard tissues which can’t naturally grow back and preserving the natural tooth structure maximally.

A tooth restored using biomimetic techniques have- 1.more longevity, 2.better aesthetics, 3.less risk of future infections and potential need of extraction, as compared to a tooth restored traditionally. This leads to better patient experience and long lasting health, thus higher patient satisfaction.

MATERIALS USED IN BIOMIMETIC RESTORATIVE DENTISTRY

In dentistry, biomimetics is applied in the form of materials and technologies that mimic tooth structure and

Biomimetic materials are synthesised with the aim that it matches tooth’s natural processing in natural environment. Such materials fulfil 2 goals- 1. At Macrostructural level, biomechanics, structure and aesthetics are restored. 2. At microstructural level, it facilitates wound healing and hard tissue regeneration.

Various materials have shown the above mentioned properties and thus provides for better restorations. These materials include-

1 Glass Ionomer Cements

GIC is a restorative material based on the reaction of silicate glass-powder/ fluoroaluminosilicate and polyacrylic acid.

<table>
<thead>
<tr>
<th>Biomimetic Properties</th>
<th>Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Its unique property to release fluoride ions is considered therapeutic and helps maintain oral well being.</td>
<td>As liner and base</td>
</tr>
<tr>
<td>2. Aesthetically, it provides translucency.</td>
<td></td>
</tr>
<tr>
<td>3. remains dimensionally stable under wet conditions.</td>
<td>Class 1, 5 and non carious cervical lesion restoration</td>
</tr>
<tr>
<td>4. Due to good adhesion and similar COTE, marginal adaptation is good and leakage is less.</td>
<td></td>
</tr>
<tr>
<td>5. GIC permanently adheres to untreated enamel and dentin.</td>
<td>As luting agent In endodontic- root canal perforation repair</td>
</tr>
<tr>
<td>6. COTE is similar to teeth’s hard tissue</td>
<td></td>
</tr>
<tr>
<td>7. These are cross-linked cements with high compressive strength and low flexure strength, similar to dentin.</td>
<td>In endodontic- intracanal reinforcement</td>
</tr>
</tbody>
</table>

Gic acts as a substitute for dentin and thus called artificial dentin.

2 Calcium Hydroxide

It is a reparative dentin forming material which works by ionising into Ca++ ion and OH- ion.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>1. Slow working bactericidal activity in root canal.</td>
<td>used as intra-canal medicament</td>
</tr>
<tr>
<td>2. Amorphous matrix arrangement.</td>
<td>Direct pulp capping agent Pulpotomoy</td>
</tr>
<tr>
<td>3. Stimulates fibronectin, etc. secretion thus causing dentinal bridge formation/tertiary dentin formation by inducing inflammatory response and necrosis of adjacent pulp.</td>
<td>Apexification</td>
</tr>
<tr>
<td>4. Releases Ca++ ions to promote hydroxyapatite crystal formation.</td>
<td>Weeping canal (neutralises acidic Ph)</td>
</tr>
<tr>
<td>5. promotes differentiation of adjacent connective tissue cells and deposition of calcified tissue</td>
<td>Root canal perforation repair</td>
</tr>
<tr>
<td>6. high pH/alkaline Ph</td>
<td></td>
</tr>
<tr>
<td>7. promotes cementogenesis</td>
<td></td>
</tr>
</tbody>
</table>

Due to ease of use, pocket friendly-ness and dentinal and cementum reparative properties, calcium hydroxide is one of the most used biomimetic material in dentistry.
3 Calcium Phosphate

This is used as bone cement, coatings of metallic implants and scaffolds for regenerative medicine. It is a material which works by ionising into Ca++ ion and PO4-- ion.

<table>
<thead>
<tr>
<th>Biomimetic Properties-</th>
<th>Indications-</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CaP crystallises to hydroxyapatite which has chemical similarity to bone and teeth structure, thus help in remineralising enamel and dentin.</td>
<td>Bone graft</td>
</tr>
<tr>
<td>2. Its crystal and lattice structure is similar to that found in enamel and bone.</td>
<td>Pulp capping agent</td>
</tr>
<tr>
<td>3. It is osteoconductive in nature i.e. provides scaffold for bone growth.</td>
<td>Apexification</td>
</tr>
<tr>
<td>4. Osseo-integration is also seen at implant coated with CaP and tissue interface</td>
<td>Scaffold for bone regeneration in cases of defects</td>
</tr>
<tr>
<td></td>
<td>Scaffold for dentin regeneration in cases of deep carious lesions</td>
</tr>
<tr>
<td></td>
<td>Dental implant coating</td>
</tr>
</tbody>
</table>

Due to its osteoconductive properties and similar structure, calcium phosphate is an excellent biomimetic material which helps in regeneration of bone and dentin.

4-Composites

It is a polymer-based dental material, eg- DMA, UDMA or Bis-GMA combined with fillers, coupling agents and modifiers used mainly for aesthetic restorations.

<table>
<thead>
<tr>
<th>Biomimetic properties-</th>
<th>Indications-</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shades of composites are similar to enamel.</td>
<td>All types of restorations esp. class I, V</td>
</tr>
<tr>
<td>2. Provides translucency</td>
<td>Non carious lesion filling</td>
</tr>
<tr>
<td></td>
<td>Resin veneers</td>
</tr>
</tbody>
</table>

Due to its high aesthetic value, composites are used to mimic normal enamel surface after restoration in anterior teeth.

5 Ceramics

Porcelain along with filler particles and modifiers used to construct crowns, bridges, veneers and denture teeth.

<table>
<thead>
<tr>
<th>Biomimetic Properties-</th>
<th>Indications-</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ceramics are aesthetically excellent.</td>
<td>Ceramic veneers for anterior teeth</td>
</tr>
<tr>
<td>2. They have colour stability i.e. Discoloration is prolonged.</td>
<td>Crowns</td>
</tr>
<tr>
<td>3. Hardness of this material is similar to enamel.</td>
<td>Anterior FPDs</td>
</tr>
<tr>
<td>4. High compressive strength- Or-Mo-Mers have similar to higher compressive strength as enamel.</td>
<td>Porcelain denture teeth</td>
</tr>
<tr>
<td>5. It is chemically inert i.e. doesn’t react with oral fluids.</td>
<td></td>
</tr>
</tbody>
</table>

High esthetics and almost similar mechanical properties makes porcelain/ceramic excellent artificial enamel.

6 Biodentin

Biodentin is Calcium silicate based material and belongs to the category of MTA. It is a new material introduced in
dentistry as an improved form of MTA.

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<tr>
<th>Biomimetic Properties-</th>
<th>Indications-</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hardness becomes similar to dentin in a month after restoration.</td>
<td>In deep carious lesions as-</td>
</tr>
<tr>
<td>2. Compressive strength of biodentin becomes similar to dentin in a month after restoration.</td>
<td>1. Dentin substitute</td>
</tr>
<tr>
<td>3. Ca++ and OH- is released from biodentin causes dentine mineralisation, dentinal bridge formation and keeps pulp cells vital without inducing inflammatory response.</td>
<td>2. Base under amalgam or composites</td>
</tr>
<tr>
<td>4. Anti bacterial action due to alkaline pH maintained by OH- ions.</td>
<td>Pulp Capping agent</td>
</tr>
<tr>
<td>5. Adheres to natural tooth structure by forming dentinal tags i.e. forms calcium phosphate crystals which grow into the dentinal tubules, anchoring the material to natural dentin. This insures minimal microleakage, less chances of corrosion and low susceptibility to secondary caries.</td>
<td>Apexitification</td>
</tr>
<tr>
<td>6. Radio-opacity</td>
<td>In endodontic- Retrograde filling</td>
</tr>
<tr>
<td>7. Dimensional stability and low solubility in oral fluids acts as advantages to its biocompatibility.</td>
<td></td>
</tr>
</tbody>
</table>

Due to mechanical properties similar to dentin and tertiary dentin formation without any inflammatory response, biodentin is considered a highly acceptable dentin substitute.

7-Emdogain

Emdogain is a gel material containing enamel matrix derivatives, generally protein amelogenin from tooth germ, along with propylene glycol alginate.

<table>
<thead>
<tr>
<th>Biomimetic Properties-</th>
<th>Indications-</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. It is osteopromotive, i.e. when applied on root surface, the protein attracts mesenchymal cells, which attaches, then proliferates and finally lead to bone formation around the root to replace the lost alveolar bone.</td>
<td>Alveolar bone loss and periodontium loss in-</td>
</tr>
<tr>
<td>2. Also promote regeneration of periodontium and cementum, when lost.</td>
<td>1. Periodontitis</td>
</tr>
<tr>
<td></td>
<td>2. Implant placement</td>
</tr>
<tr>
<td></td>
<td>3. Trauma</td>
</tr>
<tr>
<td></td>
<td>4. Tooth extraction</td>
</tr>
</tbody>
</table>

Emdogain is an osteopromotive agent and has pdl regenerative capacity. It is also derived from natural tooth germ of pig. Thus it is a biomimetic agent.

8-Bioglass

It is a silica-based gel which on reaction with oral fluid induces remineralisation by releasing Ca++, Si+ and PO4--- ions.

<table>
<thead>
<tr>
<th>Biomimetic Properties-</th>
<th>Indications-</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Its forms calcium phosphate which crystallizes into hydroxyapatite when in contact with oral fluids, hence promote remineralisation of tissues of teeth.</td>
<td>Mineralisation in caries lesion</td>
</tr>
<tr>
<td></td>
<td>Desensitizing agent in cases of open dentinal tubules/hypersensitivity.</td>
</tr>
<tr>
<td></td>
<td>Root canal sealants.</td>
</tr>
<tr>
<td></td>
<td>As restorative material</td>
</tr>
<tr>
<td>2. Can be a potential osteoconductive material and aid in bone formation.</td>
<td>Bone tissue mineralisation in case of its loss.</td>
</tr>
<tr>
<td></td>
<td>A layer over implant surface to aid in its osseo-integration.</td>
</tr>
</tbody>
</table>
It’s potential to remineralise dentin and bone and thus strengthens its structure making it a biomimetic agent.

### Comparative Study between these Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Properties</th>
<th>Structure</th>
<th>Bonding with tooth Structure</th>
<th>Biocompatibility</th>
<th>Aesthetics</th>
<th>Tissue regeneration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Glass Ionomer Cement</td>
<td></td>
<td>Dentin like</td>
<td>Via ionic and polar bonds</td>
<td>Yes - releases fluoride ions, causes no hypersensitivity reactions.</td>
<td>Is a tooth coloured material</td>
<td>Promotes tissue repair aided by fluoride ion release.</td>
</tr>
<tr>
<td>2. Calcium hydroxide</td>
<td></td>
<td>Dentin like</td>
<td>Natural bonding via bonding between hydroxyapatite crystals and Ca(OH)$_2$</td>
<td>Highly biocompatible due to chemical similarities with natural tissues.</td>
<td></td>
<td>Posesses radio-opacity, Not a primary requirement although shade matching done according to requirements.</td>
</tr>
<tr>
<td>3. Calcium phosphate</td>
<td></td>
<td>Enamel, dentin, bone like</td>
<td>Natural bonds form with enamel, dentin and bone</td>
<td>Highly biocompatible due to chemical similarities with natural tissues.</td>
<td>Not a primary requirement</td>
<td>Aids in bone regeneration,</td>
</tr>
<tr>
<td>4. Composites</td>
<td></td>
<td>Polymeric structure</td>
<td>Micromechanical retention is provided by acid-etching of the tooth structure as natural bonds absent.</td>
<td>Some components are released into the oral environment due to its degradation which maybe cytotoxic.</td>
<td></td>
<td>Highly aesthetic material due to colour similarities</td>
</tr>
<tr>
<td>5. Ceramics</td>
<td></td>
<td>Feldspar glass</td>
<td>Needs physical bonding as naturally it is absent.</td>
<td>It is chemically inert i.e. doesn’t react with oral fluids thus biocompatible.</td>
<td>Provides maximum esthetics out of those listed.</td>
<td>No</td>
</tr>
<tr>
<td>7. EmdoGain</td>
<td></td>
<td>Enamel forming</td>
<td>Not a primary requirement</td>
<td>Yes- causes no hypersensitivity reactions.</td>
<td>Not a primary requirement</td>
<td>Osteopromotive agent, has PDL regenerative capacity</td>
</tr>
<tr>
<td>8. Bioactive glass</td>
<td></td>
<td>forms calcium phosphate</td>
<td>Naturally bonds to tooth structure by chemical bonds</td>
<td>Yes- causes no hypersensitivity reactions.</td>
<td>aesthetic material</td>
<td>Potential osteoconductive material and dentine regeneration.</td>
</tr>
</tbody>
</table>
SUMMARY

Biomimetics in itself is an emerging technology demanding more of ongoing researches. It applies in restorative dentistry as biomimetic materials which are either similar in structure, mechanical properties i.e. GIC, Calcium Hydroxide, Calcium Phosphate, Biodentin; promote regeneration of tissues. Materials like Bioglass, Emdogain have striking similar physical qualities such as Composites and Ceramics. All the materials stated above are essentially synthetic and mimic either the properties or processes of natural tooth and its surrounding tissues- quite rightly classifying them as “biomimetic”. All these materials have certain pros and cons, guiding its usage in the field of restorative and conservative dentistry. Nevertheless, these materials are still under research and constant modifications are needed to overcome the disadvantages, so that their applications can further increase in dentistry.

REFERENCES

11. Biomimetic materials in restorative dentistry and endodontics: A review Indian Journl of forensic medicine and toxicology vol.15(2);2021


