International Journal of Dental Research
& Development (IJDRD)
ISSN (P): 2250–2386; ISSN (E): 2321–0117
Vol. 12, Issue 1, Jun 2022, 1–8


TRANS STELLAR
•Journal Publications •Research Consultancy

# BIOMIMETIC APPROACH IN RESTORATIVE PRACTICE: REDEFINING DENTISTRY

**DR. POOJA KABRA[1] & SHIVANGI VARSHNEY[2]**

[1]*MDS Associate Professor, S.D.S, Sharda University, Greater Noida*

[2]*BDS student, S.D.S, Sharda University, Greater Noida*

***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***

**Received**: Mar 10, 2022; **Accepted**: Mar 30, 2022; **Published**: Apr 18, 2022; **Paper Id**.: IJDRDJUN20221

Original Article

## 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

function. Such materials show properties like-1. Natural bonding with tooth structure, 2. Absorption and distribution of stress like tooth structure, 3. Synthetic in nature, 4. Biocompatibility.

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.

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

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.

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

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.

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

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.

| Biomimetic properties- | Indications- |
|---|---|
| 1. Shades of composites are similar to enamel. | All types of restorations esp. class I, V<br>Non carious lesion filling<br>Resin veneers |
| 2. Provides translucency | |

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.

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

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

| Biomimetic Properties- | Indications- |
|---|---|
| 1. Hardness becomes similar to dentin in a month after restoration. | In deep carious lesions as-<br>1.Dentin substitute<br>2.Base under amalgam or composites |
| 2. Compressive strength of biodentin becomes similar to dentin in a month after restoration. | |
| 3. Ca++ and OH- is released from biodentin causes dentine mineralisation, dentinal bridge formation and keeps pulp cells vital without inducing inflammatory response. | Pulp Capping agent<br>Pulpotomy |
| 4. Anti bacterial action due to alkaline pH maintained by OH- ions. | |
| 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.<br>This insures minimal microleakage, less chances of corrosion and low susceptibility to secondary caries. | Root perforation<br>Apexification<br>In endodontic- Retrograde filling |
| 6. Radio-opacity | |
| 7. Dimensional stability and low solubility in oral fluids acts as advantages to its biocompatibility. | |

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.

| Biomimetic Properties- | Indications- |
|---|---|
| 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. | Alveolar bone loss and periodontium loss in-<br>1. Periodontitis<br>2. Implant placement<br>3. Trauma<br>4. Tooth extraction |
| 2. Also promote regeneration of periodontium and cementum, when lost. | |

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.

| Biomimetic Properties- | Indications- |
|---|---|
| 1. Its forms calcium phosphate which crystallizes into hydroxyapetite when in contact with oral fluids, hence promote remineralisation of tissues of teeth. | Mineralisation in caries lesion<br>Desensitizing agent in cases of open dentinal tubules/hypersensitivity.<br>Root canal sealants.<br>As restorative material |
| 2. Can be a potential osteoconductive material and aid in bone formation. | Bone tissue mineralisation in case of its loss.<br>A layer over implant surface to aid in its osseo-integration. |

It's potential to remineralise dentin and bone and thus strengthens its structure making it a biomimetic agent.

**Comparative Study between these Materials**

| Material | Properties | Structure | Bonding with tooth Structure | Biocompatibility | Aesthetics | Tissue regeneration |
|---|---|---|---|---|---|---|
| 1. Glass Ionomer Cement | | Dentin like | Via ionic and polar bonds | Yes- releases fluoride ions, causes no hypersensitivity reactions. | Is a tooth coloured material | Promotes tissue repair aided by fluoride ion release. |
| 2. Calcium hydroxide | | Dentin like | Natural bonding via bonding between hydroxyapetite crystals and $Ca(OH)_2$ | Highly biocompatible due to chemical similarities with natural tissues. | Posses radio-opacity, Not a primary requirement although shade matching done according to requirements. | Promotes calcification, possess anti-bacterial properties. |
| 3. Calcium phosphate | | Enamel, dentin, bone like | Natural bonds form with enamel, dentin and bone | Highly biocompatible due to chemical similarities with natural tissues. | Not a primary requirement | Aids in bone regeneration, |
| 4. Composites | | Polymeric structure | Micromechanical retention is provided by acid-etching of the tooth structure as natural bonds absent. | Some components are released into the oral environment due to its degradation which maybe cytotoxic. | Highly aesthetic material due to colour similarities | No |
| 5. Ceramics | | Feldspar glass | Needs physical bonding as naturally it is absent. | It is chemically inert i.e. doesn't react with oral fluids thus biocompatible. | Provides maximum esthetics out of those listed. | No |
| 6. Biodentin | | Dentin like | Adheres naturally to tooth structure by forming dentinal tags | Radio-opaque, Dimensional stability and low solubility in oral fluids aids in its biocompatibility. | Not a primary requirement. | Dentin mineralisation, dentinal bridge formation, provides pulp cells vitality with no inflammatory response. |
| 7. EmdoGain | | Enamel forming | Not a primary requirement | Yes- causes no hypersensitivity reactions. | Not a primary requirement | Osteopromotive agent, has PDL regenerative capacity |
| 8. Bioactive glass | | forms calcium phosphate | Naturally bonds to tooth structure by chemical bonds | Yes- causes no hypersensitivity reactions. | aesthetic material | Potential osteoconductive material and dentine regeneration. |

## 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***


1. 1.*Dubey, Alok. Calcium hydroxide in dentistry: A Review.. Chetinad Health City Medical Journal.2016; 5. 30-33.*
2. *Willems G, Lambrechts P, Braem M, Vanherle G. Composite resins in the 21st century. Quintessence Int. 1993 Sep;24(9):641-58.*
3. *Özlem Malkondu, Meriç Karapinar Kazandağ, Ender Kazazoğlu, "A Review on Biodentine, a Contemporary Dentine Replacement and Repair Material", BioMed Research International, vol. 2014*
4. *Birang R, Abouei MS, Razavi SM, Zia P, Soolari A. The effect of an enamel matrix derivative (Emdogain) combined with bone ceramic on bone formation in mandibular defects: a histomorphometric and immunohistochemical study in the canine. ScientificWorldJournal. 2012 ;12:1967-91*
5. *Esposito M, Grusovin MG, Coulthard P, Worthington HV. Enamel matrix derivative (Emdogain) for periodontal tissue regeneration in intrabony defects. Cochrane Database Syst Rev. 2005 Oct 19;(4)*
6. *Esposito M, Grusovin MG, Papanikolaou N, Coulthard P, Worthington HV. Enamel matrix derivative (Emdogain) for periodontal tissue regeneration in intrabony defects. A Cochrane systematic review. Eur J Oral Implantol. 2009;2(4):247-66.*
7. *Kashmira Sawant, Ajinkya M Pawar: "Bioactive glass in dentistry: A systematic review" Review article Year : 2020; 7( 1) : 3-10*
8. *Salonen JI, Arjasmaa M, Tuominen U, Behbehani MJ, Zaatar EI, "Bioactive glass in dentistry" Journal Of Minimum Intervention In Dentistry, First published in Dental Update 1999; 6(4): 11-15.*
9. *Nsween Basheer, M. Madhubala, S.Mahalaxmi: Future perspectives of biomemitics in restorative dentistry Jour of pharma res. 2020;32(22):19-28.*
10. *Jabr S. Al-Sanabani, Ahmed A. Madfa, Fadhel A. Al-Sanabani, "Application of Calcium Phosphate Materials in Dentistry", International Journal of Biomaterials2013; 12: 201-8,*
11. *Biomimetic materials in restorative dentistry and endodontics: A review Indian Journl of forensic medicine and toxicology vol.15(2);2021*
12. *Afzal Ali, Prahalad Saraf et al: Biomimitic materials in dentistry Research and reviews:Journal of material sciences 2017;5(4): 1-8*
13. *Karma M, et al. Biomimetics in dentistry. Indian J Dent Edu 2010;3:107-113*
14. *Bruyen D, et al. The use of glass ionomer cements in both conventional and surgical endodontics. Int Endod J 2004;37:91-104.*

15. *Madan, et al. Tooth remineralization using bio-active glass - A novel approach. J Academy Adv Dental Research 2011;2:45-49.*
16. *Chen MH. Update on Dental Nanocomposites. J Dent Res 2010;89:549-560*
17. *Legeros RZ. Calcium phosphate materials in restorative dentistry: a review Adv Dent Res 1988; 2:164-180.*
18. *Nadimpalli, Satish Kumar. "Sanskrit: A Vaaradhi to English Vocabulary." International Journal of Linguistics and Literature (IJLL) 5 (2016).*
19. *Guramwar, Umesh W., and M. Ghosal. "Reading Cultural Traits in Manju Kapur's Novel,"The Immigrant"." International Journal of Linguistics and Literature (IJLL) 6.2 (2017): 1-6.*
20. *Zahir, S. H. E. H. Z. A. D., and Jayedi Aman. "Evolution of Home Based Work." International Journal of Civil Engineering (IJCE) 6.1 (2017): 1-8.*