Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies *NLM ID: 101716117*

Journal home page: www.jamdsr.comdoi: 10.21276/jamdsr Indian Citation Index (ICI) Index Copernicus value = 100

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Review Article

Bioemulation in restorative dentistry: A review

Dhairya Waghe[1], Kavita Dube[2], Shivkumar Mantri[3], Bonny Paul[4], Pallavi Sinha[5], Swati Singh[6]

[1,5,6]Postgraduate students,[2,4]Professor,[3]Professor and Head, Department of Conservative Dentistry and Endodontics, Hitkarini Dental College and Hospital, Jabalpur, Madhya Pradesh, India

ABSTRACT:
Biomimetics is a branch of science that cues from or explores the technical beauty of nature. It is based on the concept that nature is the best model for creating anything new and has created exceptional productivity and function. Biomimetics in dentistry serves as a concept to conserve the tooth structure and increase the longitivity of restorative dental treatment and also it enhances the future retreatment cycles. Biomimetics dental materials are biocompatible and with excellent physico-chemical properties. Till date these materials have been used in dentistry providing advantages of enhanced strength and antibacterial abilities. This review aims at some recent development in emerging field of biomimetics especially restorative dentistry. In addition, various such materials are discussed.
Keywords: Biomimetic dentistry, restorative approach, restorative material

Received: 23 May, 2024 Accepted: 27 June, 2024

Corresponding author: Dhairya Waghe, Postgraduate student, Department of Conservative Dentistry and Endodontics, Hitkarini Dental College and Hospital, Jabalpur, Madhya Pradesh, India

This article may be cited as: Waghe D, Dube K, Mantri S, Paul B, Sinha P, Singh S. Bioemulation in restorative dentistry: A review. J Adv Med Dent Scie Res 2024;12(7):58-61.

INTRODUCTION

In dentistry recreating the optical characteristics of a complete tooth is quite challenging in modern dentistry because enamel, the dentinoenamel complex (DEC), and dentin are all inherently translucent [1]. The colour measurement of translucent material presents a significant challenge due to their complex interaction with light, which differ from that of most other material the coronal structure like enamel, dentin and DEC, exhibit various degree of translucency, transparency, and opacity when compared to each other, despite their inherent translucency. Additional details about the definition of surface texture, gloss, and luster (S/G/L) should be evaluated together with translucency, opalescence, and fluorescence (T/O/F) as part of the visual assessment process.[1]

Biomimetic dentistry combines the creative and scientific techniques of fixing destroyed teeth with materials that closely resembles the appearance, function, and durability of natural body parts like enamel, dentin, bone, and cementum. [2] There has been considerable attention given to the molecular level feasibility of biomimetic approaches in aiding in the healing and regeneration of both soft and hard tissues.[3]A main goal of biomimetics in dentistry is to create restorative materials that emulate various mechanical characteristics of a natural tooth.

Biomimetics In Restorative Dentistry

Restorative Approach

a. In the conventional approach to prevention, not only the damaged tooth structure is eliminated but also the intact, healthy tooth structure is removed and substituted with unresponsive material. This method often leads to the weakening of the tooth portion remaining and results in a restoration that has a short lifespan [4].
b. In this approach, the idea of minimally invasive dentistry is considered the ideal approach. It approaches to, concentrating exclusively on repairing the teeth and striving to replicate the natural tooth arrangement as closely as possible. Cavities and other harms are fastidiously repaired with cutting-edge materials and cements to protect the tooth characteristics [4]. The bio-inspired approaches to dental repair strive to reach these results by utilizing methods that reduce stress and improve the strength of bonds.

Biomimetic Advances - Restorative Materials

a. Glass ionomer cement

The term “Glass Ionomer" (GIC) describes a group of substances that contain silicate glass powder and water based polyacrylic acid solution. GICs are acknowledged as cements that mimic biological features because they share a similar rate of thermal expansion like tooth structure, their capacity of enamel and dentin adherence, and their extended dispensing of fluoride over time. [5] These materials experience a significant acid—base reaction during their setting process and exhibit a sustained release of fluoride

Research has demonstrated that ions can migrate from the adhesive to the tooth and into the area where they meet, leading to the formation of a durable layer known as an ion-exchange layer, which has been shown to be extremely stable in real-life applications. [6] The capability of glass ionomers to release ions plays a crucial role

in forming lasting, sturdy connections at the point where a tooth or a restoration meets the natural tooth structure.

Multiple modifications have been made for improvising the characteristics of glass ionomers for their powder and liquid mixtures. Despite these benefits, traditional glass ionomers experience drawbacks including fast evaporation times, extended drying periods, fragility, poor resistance to cracking, and a vulnerability to contamination by moisture or drying out at the beginning of the drying process.

Particles of nano-hydroxyapatite (HA) have been mixed with GIC to create GIC- hydroxyapatite (HA) hybrids. These hybrids demonstrated better for their property of fluoride ions release and enhanced antibacterial and mechanical characteristics [7] .Additionally, Garoushi and collegues [8] conducted a study to examine effects of incorporating both rigid and hollow, discrete glass fibers on the flexural strength and fracture toughness of GIC and RMGICs. The findings indicated a notable improvement in fracture toughness (increases of 280% and 200%) and flexural strength (increases of 170% and 140%) in GICs when 10 wt % of hollow, discrete glass fibers were added.

b. Dental composite resin (dcr)

Almost everything found in nature, like teeth, shells, corals, bones and pearl are made up of mixed inorganic and organic materials, with the arrangement of every constituent influencing the overall behavior of these mixtures. Since the 1960s, dental composite resins have been extensively used in dentistry for correcting damaged or decayed teeth due to their appealing appearance, high compatibility with biological systems, and simplicity of application. DCR represents a group of composite materials, consists of a resin structure and inorganic particles. [9]. Since 1960s, dental composite resins are considerably used for correcting damaged or decayed teeth due to their appealing appearance, high compatibility with biological systems, and simplicity of application.

At the molecular level self-repair occurs, and additional source of energy is needed to guide the chemical interaction of the substances involved [10]. Conversely, materials designed to heal from the outside often depends on polymer-filled capsule, which burst close to the crack, releasing the resin which reacts with a current catalyst, leading to the development of the resin and the healing cracks[11,12]. Additionally, the appearance of the damage can be improved by the leaking of a brightly colored solution, like a fluorescent dye, [11, 12].

The use of a two-layered resin composite material is seen as a novel approach to biomimetic repair, emulating the fibrillary structure of the enamel-dentin complex. This composite is structured with a core that is made of glass fiber reinforced composite resin (FRC) and a top layer featuring resistance to wear and polished resin composite. The purpose of the FRC core within this composite filling material is to act as a barrier that stops cracks from spreading, thereby providing a layer for protection [13].

c. Giomers

A new category of materials is designed to blend the superior attributes of composite resins and glass-ionomers: resistance to decay, strong durability, and attractive appearance. Inquire about discoveries demonstrated that the post-operative affectability, minimal adjustment, and morphology are alike for both tar composites and giomers.These materials are among the latest advancements in fluoride-releasing dental materials, merging beauty with the ability to achieve a polished finish and strong mechanical durability[14].

The Self-healing material is a type of resin composite used in dentistry that mimics natural healing processes. Numerous materials in nature are self-healing, like natural bone, which has the remarkable capacity to mend itself even after severe fractures. Self-healing systems can be categorized as either or extrinsic or intrinsic, depending on whether they create new repair molecules in response to harm (intrinsic) or if these molecules are present already within the material (extrinsic). [15]

d. Compomers

In the early 1990s, Compomers entered the profession of dentistry. These materials, known as polyacid-modified resins, suggest that they are almost identical to resin composites, though they have undergone some changes.

Changes occur when certain elements are added to glass ionomer cements. This involves the fact that as they develop, they absorb a slight amount of moisture, which triggers an acid–base reaction. The primary advantage of this process is that it enables the cements to gradually release a therapeutically effective quantity of fluoride.

A distinctive characteristic of compomers is their absence of water, with the majority of their ingredients mirroring those found in composite resins. The mixture is then populated with inorganic particles that are chemically inert, like quartz or silicate glass. These are large molecular monomers, like Bis-GMA mixed with substances that lower its viscosity, such as triethylene glycol dimethacrylate. Compomers also incorporate extra monomers that set them apart from typical composites, which have acidic functional groups present.

Over time, as compounds have been introduced into the clinical scene, there has been a build-up of evidence showing their high clinical efficacy. These compounds are especially favored in the field of pediatrics, particularly for Lesson II reclamations. They've also proven useful as fissure sealants and as adhesives for orthodontic bands. For adults, they are mainly used in Class V restorations. In the 2 to 3-year period following their use, clinical outcomes have consistently been excellent, with only slight cases of marginal discoloration and, on occasion, a small loss of marginal integrity. Additionally, the durability of these compounds in terms of wear has been favorably noted.[16]

e. Ceramics

In the year 2000, Holland et al. succeeded in creating apatite-leucite glass ceramics. Researchers in biomimetics have been aiming to achieve this objective for a significant period. Dental ceramics are able to mimic the natural appearance of the tooth. These ceramics are made up of needle-like apatite particles, which resemble to the ones found in natural tooth structures. The unique shape of the apatite crystals enhanced both the esthetic and mechanical characteristics of the material. Over past three decade, the demand of dental ceramics has significantly increased.[17-20]

Dental ceramics designed to mimic natural structures should be capable of creating a bond with the restored tooth and also facilitate the growth of new tissues. Goudouri et al [18] managed to embed the capability of forming apatite in a commercially available dental restoration ceramic to improve its bond with the tissues. These samples showed the development of a layer similar to apatite on the surface that did not compromise the material's strength.[21]

The use of dental ceramics in a bio-mimetic manner also extends to the application of bioactive-coated ceramics as dental implants. Various bioactive glass–ceramics are on the market and have been utilized for coating both zirconia and titanium dental implants. This coating enhances the unification with the bone and the bonding with the tissues surrounding the ceramic implants. [22]

Biomimetic ceramics are a form of ceramics that mimic nature. These materials were initially tested to merge the benefits of ceramics and composite materials, aiming to achieve similar physical characteristics to enamel and dentin [23]. Materials with polymer-infused ceramic networks (PICNs) include two components that are intertwined, a porous feldspathic ceramic matrix (comprising 75–80% of the total volume) that is expanded with polymer [24]. Lately, scientists in material science have created advanced PICNs known as functionally graded PICNs. These materials exhibit changes in composition and structure over their length, resulting in a composite structure that closely resembles enamel and dentin.

CONCLUSION

Biomimetic dentistry could herald a new golden age through the effective rehabilitation of damaged dental tissues. In the coming era of restorative dentistry, treatments will no longer rely on passive materials designed simply to fill cavities, but rather, they will primarily utilize bioactive substances capable of regenerating dental tissues.

REFERENCES

1. Bazos P, Magne P. Bio-Emulation: biomimetically emulating nature utilizing a histoanatomic approach; visual synthesis. Int J Esthet Dent. 2014 Sep 1;9(3):330-52.
2. .Bazos P, Magne P. Bio-emulation: biomimetically emulating nature utilizing a histo-anatomic approach; structural analysis. Eur J Esthet Dent. 2011;6(1):8–19.
3. Slavkin HC. Biomimetics: replacing body parts is no longer science fction. J Am Dent Assoc. 1996;127(8):1254–7.
4. Burke FJ. From extension for prevention to prevention of extension: (minimal intervention dentistry). Dent Update. 2003;30(9):492–8.
5. Malhotra S, Hegde M. Analysis of marginal seal of ProRoot MTA, MTA Angelus biodentine, and glass ionomer cement as root-end flling materials: An in vitro study. J Oral Res Rev. 2015;7(2):44–9.
6. Furtos G, Cosma V, Prejmerean C, Moldovan M, Brie M, Colceriu A, Vezsenyi L, Silaghi-Dumitrescu L, Sirbu C. Fluoride release from dental resin composites. Mater Sci Eng C-Biomim Supramol Syst. 2005;25(2):231–6.
7. Alatawi RAS, Elsayed NH, Mohamed WS. Infuence of hydroxyapatite nanoparticles on the properties of glass ionomer cement. J Mater Res Technol. 2019;8(1):344–9.
8. Garoushi S, Vallittu P, Lassila L. Hollow glass fbers in reinforcing glass ionomer cements. Dent Mater. 2017;33(2):e86–93.
9. Ravi RK, Alla RK, Shammas M, Devarhubli A. Dental composites-A versatile restorative material: an overview. Indian J Dent Sci. 2013;5(5):111–5.
10. Diesendruck CE, Sottos NR, Moore JS, White SR. Biomimetic self-healing. Angew Chem Int Ed Engl. 2015;54(36):10428–47.
11. Trask RS, Williams HR, Bond IP. Self-healing polymer composites: mimicking nature to enhance performance. Bioinspir Biomim. 2007;2(1):P1-9.
12. Wertzberger BE, Steere JT, Pfeifer RM, Nensel MA, Latta MA, Gross SM. Physical characterization of a self-healing dental restorative material. J Appl Polym Sci. 2010;118(1):428–34.
13. Lassila L, Sailynoja E, Prinssi R, Vallittu PK, Garoushi S. Bilayered composite restoration: the efect of layer thickness on fracture behavior. Biomater Investig Dent. 2020;7(1):80–5.

14. Rusnac ME, Gasparik C, Irimie AI, Grecu AG, Mesaroș AȘ, Dudea D. Giomers in dentistry–at the boundary between dental composites and glass-ionomers. Medicine and pharmacy reports. 2019 Apr;92(2):123.
15. Fugolin APP, Pfeifer CS. New resins for dental composites. J Dent Res. 2017;96(10):1085–91.
16. Nicholson JW, Swift Jr EJ. Compomers. Journal of Esthetic and Restorative Dentistry. 2008 Feb;20(1):3-4.
17. Cattell MJ, Chadwick TC, Knowles JC, Clarke RL, Samarawickrama DY. The nucleation and crystallization of fne grained leucite glass-ceramics for dental applications. Dent Mater. 2006;22(10):925–33.
18. Fouda AM, Atta O, Kassem AS, Desoky M, Bourauel C. Wear behavior and abrasiveness of monolithic CAD/CAM ceramics after simulated mastication. Clin Oral Investig. 2022;26(11):6593–605.
19. Holand W, Rheinberger V, Wegner S, Frank M. Needle-like apatite-leucite glass-ceramic as a base material for the veneering of metal restorations in dentistry. J Mater Sci Mater Med. 2000;11(1):11–7.
20. Goudouri OM, Kontonasaki E, Papadopoulou L, Kantiranis N, Lazaridis NK, Chrissafs K, Chatzistavrou X, Koidis P, Paraskevopoulos KM. Towards the synthesis of an experimental bioactive dental ceramic. Part I: crystallinity characterization and bioactive behavior evaluation. Mater Chem Phys. 2014;145(1–2):125–34.
21. Goudouri OM, Kontonasaki E, Papadopoulou L, Manda M, Kavouras P, Triantafyllidis KS, Stefanidou M, Koidis P, Paraskevopoulos KM. An experimental bioactive dental ceramic for metal-ceramic restorations: textural characteristics and investigation of the mechanical properties. J Mech Behav Biomed. 2017;66:95–103.
22. Ferraris M, Verne E, Appendino P, Moisescu C, Krajewski A, Ravaglioli A, Piancastelli A. Coatings on zirconia for medical applications. Biomaterials. 2000;21(8):765–73.
23. Dirxen C, Blunck U, Preissner S. Clinical performance of a new biomimetic double network material. Open Dent J. 2013;7(1):118–22.
24. Albero A, Pascual A, Camps I, Grau-Benitez M. Comparative characterization of a novel cad-cam polymer-infltrated-ceramic-network. J Clin Exp Dent. 2015;7(4):e495-500.
25. Michailova M, Elsayed A, Fabel G, Edelhof D, Zylla IM, Stawarczyk B. Comparison between novel strength-gradient and color-gradient multilayered zirconia using conventional and high-speed sintering. J MechBehav Biomed. 2020;111: 103977