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Review Article

Biomimetic Dentistry in Modern Restorative Practice: Principles, Materials and Clinical Applications.

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Abstract:

Biomimetic dentistry represents a paradigm shift in modern restorative practice, emphasizing the preservation and reinforcement of natural tooth structure through biologically and mechanically compatible materials. Unlike traditional restorative approaches that rely on extensive tooth preparation and full-coverage restorations, biomimetic strategies aim to replicate the structural, functional, and esthetic properties of intact teeth. This review explores the fundamental principles of biomimetic dentistry, including maximal conservation of enamel and dentin, stress-reduced adhesive protocols, immediate dentin sealing, and the peripheral seal concept.Advancements in adhesive systems, low-shrinkage resin composites, fiber-reinforced materials, and bioactive restorative agents have significantly enhanced the predictability and longevity of conservative restorations. Contemporary clinical protocols such as selective caries removal, deep margin elevation, and cusp coverage techniques allow clinicians to manage structurally compromised teeth while maintaining pulp vitality and improving fracture resistance. The integration of these materials and techniques reduces polymerization stress, enhances bond durability, and optimizes biomechanical performance.

Keywords: Biocompatible Materials, Dental Restoration, Dentin-Bonding Agents, Minimally Invasive Surgical Procedures.

Introduction:

The concept of biomimetics is derived from the Greek words "bios," meaning life, and "mimesis," meaning imitation. In dentistry, biomimetics refers to the replication of the structural, functional, and biological characteristics of natural dental tissues.[1] The primary objective of biomimetic dentistry is to restore damaged teeth in a manner that closely resembles their original form and function while preserving as much healthy tooth structure as possible. This philosophy represents a significant departure from traditional restorative principles that often relied on extensive tooth preparation and mechanical retention. [2-5]

The development of adhesive dentistry has played a crucial role in the evolution of biomimetic restorative techniques. Modern adhesive systems enable clinicians to achieve strong bonds between restorative materials and dental tissues, thereby reducing the need for aggressive tooth preparation. As a result, restorative procedures have become more conservative and biologically oriented. Biomimetic dentistry integrates principles from restorative dentistry, dental materials science, biomechanics, and tissue preservation to achieve long-term clinical success. [6]

Principles of Biomimetic Dentistry

Preservation of healthy tooth structure is the cornerstone of biomimetic dentistry. The amount of remaining enamel and dentin significantly influences the longevity and fracture resistance of restored teeth. Therefore, clinicians are encouraged to remove only diseased tissue while preserving healthy dental structures. This conservative approach not only enhances the mechanical performance of the tooth but also contributes to improved long-term outcomes.

Another fundamental principle of biomimetic dentistry is stress reduction. Natural teeth are capable of efficiently distributing occlusal forces through the enamel, dentin, and dentino-enamel junction. Restorative procedures should therefore aim to recreate these biomechanical properties. Techniques such as incremental composite placement, fiber reinforcement, and the use of low-shrinkage restorative materials help minimize polymerization stress and reduce the risk of crack formation and propagation. Maximization of adhesive bond strength is another key objective of biomimetic restorative treatment. Strong and durable adhesion allows restorations to function as an integral part of the tooth structure. Procedures such as immediate dentin sealing, selective enamel etching, and resin coating techniques enhance bond durability and contribute to the long-term success of restorations. [7]

Preservation of pulp vitality is equally important in biomimetic dentistry. Contemporary caries management protocols advocate selective caries removal rather than complete excavation of affected dentin. This approach minimizes the risk of pulp exposure and promotes the maintenance of pulpal health. Preserving vital pulp tissue enhances the tooth's natural defense mechanisms and improves the overall prognosis of restorative treatment.

The principle of biomineralization is also central to biomimetic restorative practice. Biomimetic materials are designed to interact with surrounding tissues and facilitate the deposition of mineral components similar to those found in natural dental tissues. Such materials support remineralization processes and contribute to the repair and regeneration of damaged tooth structures. [8]

Biomimetic Materials

Resin-based composite materials are among the most commonly used restorative materials in biomimetic dentistry. Modern nanohybrid and nanofilled composites possess mechanical properties that closely resemble those of dentin and enamel. These materials provide excellent aesthetics, adequate strength, and the ability to bond conservatively to tooth structure. Their repairability further enhances their suitability for minimally invasive restorative procedures.

Glass ionomer cements have also gained prominence because of their ability to chemically bond to dental tissues and release fluoride ions over an extended period. These characteristics contribute to caries prevention and support the preservation of tooth structure. Glass ionomers are particularly useful in cervical lesions, pediatric restorations, and atraumatic restorative treatment procedures. [9]

Resin-modified glass ionomer cements combine the advantages of conventional glass ionomers with improved mechanical properties and enhanced aesthetics. These materials exhibit greater strength, improved moisture tolerance, and sustained fluoride release, making them suitable for various restorative applications.

Calcium silicate-based materials such as mineral trioxide aggregate and Biodentine have revolutionized vital pulp therapy and restorative dentistry. These materials demonstrate excellent biocompatibility, bioactivity, and sealing ability. Their capacity to stimulate dentin bridge formation and promote tissue healing makes them valuable for direct pulp capping, pulpotomy, perforation repair, and management of deep carious lesions.

Bioactive restorative materials represent a significant advancement in biomimetic dentistry. These materials actively interact with the surrounding biological environment by releasing ions that promote remineralization and tissue repair. The release of calcium, phosphate, and fluoride ions contributes to the formation of hydroxyapatite and enhances the biological performance of restorations. [10-12]

Bioactive glasses are another important group of biomimetic materials. These materials release calcium and phosphate ions that facilitate the formation of a mineralized surface layer resembling natural hydroxyapatite. Their remineralization potential makes them useful in the management of dentin hypersensitivity and early carious lesions.

Recent research has also focused on biomimetic peptides that mimic the function of natural enamel matrix proteins. These peptides have shown promising potential in promoting enamel regeneration and enhancing remineralization. Although still largely experimental, peptide-based technologies may play a significant role in the future of regenerative dentistry. [13]

Clinical Applications

Biomimetic principles have significantly influenced contemporary caries management. Selective caries removal techniques allow clinicians to preserve affected but remineralizable dentin while reducing the risk of pulp exposure. This conservative approach aligns with the biological objectives of maintaining pulpal vitality and maximizing tooth preservation. Direct composite restorations represent one of the most common clinical applications of biomimetic dentistry. Advances in adhesive systems and composite materials have enabled clinicians to restore teeth with minimal removal of healthy tissue while achieving excellent functional and aesthetic outcomes. [14]

Indirect adhesive restorations such as ceramic inlays, onlays, and overlays are increasingly favored over conventional full-coverage crowns. These restorations preserve a greater amount of healthy tooth structure and provide superior biomechanical performance. Adhesively bonded indirect restorations distribute occlusal forces more effectively and reduce the likelihood of catastrophic tooth fractures. Deep margin elevation is another biomimetic technique that has gained widespread acceptance. This procedure involves the placement of composite resin to relocate deep cervical margins to a more accessible supragingival position. The technique facilitates isolation, improves bonding procedures, and enhances restorative outcomes. [15]

Vital pulp therapy has experienced substantial advancements due to the introduction of bioactive calcium silicate materials. Procedures such as direct pulp capping, partial pulpotomy, and full pulpotomy can now be performed with greater predictability and success. These treatments preserve pulpal vitality and support the long-term survival of natural teeth. The management of cracked teeth also benefits from biomimetic restorative approaches. Adhesive restorations reinforced with fibers or cuspal coverage designs can effectively distribute functional stresses and prevent crack propagation. Such treatments restore structural integrity while conserving healthy dental tissues. Biomimetic concepts have also been incorporated into preventive and regenerative dentistry. Remineralization therapies utilizing bioactive materials, calcium phosphate technologies, and biomimetic peptides offer promising strategies for managing early carious lesions and promoting natural tissue repair. [16]

Advantages and Limitations

Biomimetic dentistry offers numerous advantages, including maximum preservation of healthy tooth structure, improved aesthetics, enhanced fracture resistance, and greater preservation of pulp vitality. These benefits contribute to improved long-term clinical outcomes and increased patient satisfaction. Furthermore, biomimetic restorations can often be repaired rather than replaced, thereby extending their service life and reducing the restorative cycle. Despite its advantages, biomimetic dentistry presents certain challenges. Many biomimetic procedures are technique-sensitive and require meticulous attention to adhesive protocols. Clinical procedures may be more time-consuming, and some advanced biomimetic materials are associated with higher costs. Additionally, although substantial evidence supports biomimetic principles, long-term clinical studies evaluating some newer materials remain limited. [17-19]

Future Perspectives

The future of biomimetic dentistry is closely linked to advances in material science, regenerative medicine, and nanotechnology. Emerging innovations include smart restorative materials capable of responding to environmental changes, self-healing composites, and bioengineered materials that promote tissue regeneration. The integration of stem cell therapy, peptide-based remineralization technologies, and artificial intelligence-driven treatment planning may further transform restorative dentistry in the coming decades. These developments have the potential to shift the focus of treatment from simple restoration toward true biological regeneration of dental tissues. [20]

Conclusion

Biomimetic dentistry represents a paradigm shift in restorative dental practice by emphasizing preservation, regeneration, and biological compatibility. Through the application of minimally invasive techniques and advanced biomimetic materials, clinicians can restore teeth in a manner that closely replicates their natural structure and function. As research continues to advance, biomimetic principles are expected to play an increasingly important role in modern restorative dentistry, ultimately improving clinical outcomes and enhancing patient care.

References:

1. Singer L, Fouda A, Bourauel C. Biomimetic approaches and materials in restorative and regenerative dentistry: review article. BMC Oral Health. 2023 Feb 16;23(1):105. doi: 10.1186/s12903-023-02808-3. PMID: 36797710; PMCID: PMC9936671.
2. Hwang J, Jeong Y, Park JM, Lee KH, Hong JW, Choi J. Biomimetics: forecasting the future of science, engineering, and medicine. Int J Nanomedicine. 2015;10:5701–5713.
3. Zafar MS, Amin F, Fareed MA, Ghabbani H, Riaz S, Khurshid Z, Kumar N. Biomimetic aspects of restorative dentistry biomaterials. Biomimetics (Basel) 2020;5(3):34.
4. Malhotra S, Hegde M. Analysis of marginal seal of ProRoot MTA, MTA Angelus biodentine, and glass ionomer cement as root-end filling materials: An in vitro study. J Oral Res Rev. 2015;7(2):44–49.
5. Fugolin APP, Pfeifer CS. New resins for dental composites. J Dent Res. 2017;96(10):1085–1091.
6. 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):428–434.

7. Cattell MJ, Chadwick TC, Knowles JC, Clarke RL, Samarawickrama DY. The nucleation and crystallization of fine grained leucite glass-ceramics for dental applications. Dent Mater. 2006;22(10):925–933.
8. 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):11–17.
9. Dirxen C, Blunck U, Preissner S. Clinical performance of a new biomimetic double network material. Open Dent J. 2013;7(1):118–122.
10. Sauro S, Osorio R, Osorio E, Watson TF, Toledano M. Novel light-curable materials containing experimental bioactive micro-fillers remineralise mineral-depleted bonded-dentine interfaces. J Biomater Sci Polym Ed. 2013;24(8):940–956.
11. Shen C, Zhang NZ, Anusavice KJ. Fluoride and chlorhexidine release from filled resins. J Dent Res. 2010;89(9):1002–1006.
12. Liu Y, Mai S, Li N, Yiu CK, Mao J, Pashley DH, Tay FR. Differences between top-down and bottom-up approaches in mineralizing thick, partially demineralized collagen scaffolds. Acta Biomater. 2011;7(4):1742–1751.
13. Fernando D, Attik N, Pradelle-Plasse N, Jackson P, Grosgogeat B, Colon P. Bioactive glass for dentin remineralization: a systematic review. Mater Sci Eng C Mater Biol Appl. 2017;76:1369–1377.
14. Rajkumar Y Patel, Priyank Sen, Mohammad Ali R Patel, Bharath Kandanattu. Surgical Modalities for Periimplantitis: Efficacy, Challenges, and Emerging Techniques. Jour MedDent Fron 2024;1(1):16-21.
15. Preeti Kale, Amit Mani, Ankita Agrawal et.al. Growth factors: key biological mediators involved in periodontal regeneration. International Journal of Research and Review. 2022; 9(11): 21-23.
16. Liang C, Liang Q, Xu X, Liu X, Gao X, Li M, Yang J, Xing X, Huang H, Tang Q, Liao L, Tian W. Bone morphogenetic protein 7 mediates stem cells migration and angiogenesis: therapeutic potential for endogenous pulp regeneration. Int J Oral Sci. 2022;14(1):38.
17. Gong T, Heng BC, Lo EC, Zhang C. Current advance and future prospects of tissue engineering approach to dentin/pulp regenerative therapy. Stem Cells Int. 2016;2016:9204574.
18. Zhang J, He X, Yu S, Zhu J, Wang H, Tian Z, Zhu S, Cui Z. A novel dental adhesive containing Ag/polydopamine-modified HA fillers with both antibacterial and mineralization properties. J Dent. 2021;111:103710.
19. Guentsch A, Seidler K, Nietzsche S, Hefti AF, Preshaw PM, Watts DC, Jandt KD, Sigusch BW. Biomimetic mineralization: long-term observations in patients with dentin sensitivity. Dent Mater. 2012;28(4):457–464.
20. Baino F, Hamzehlou S, Kargozar S. Bioactive glasses: Where are we and where are we going? J Funct Biomater. 2018;9(1):25.

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