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Review Article

Regeneration in dentistry- A review

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Abstract

Regeneration in dentistry is a rapidly evolving field that involves biomedical engineering for hard and soft tissue regeneration. It helps to meet the rising treatment expectations and demands of patients. Its foundation is tissue engineering that focuses on 3 key components- stem cells, bioactive molecules and scaffolds. This article highlights the regenerative aspects in prosthodontics, periodontics and endodontics.

In prosthodontics, regenerative therapy plays a pivotal role in chondrogenesis, neurogenesis, osteogenesis and angiogenesis. Its practical applications are of benefit in periimplantitis, craniofacial skeletal bone defects, physiologic bone loss, trauma, pathologic conditions of bone, mandibular atrophy and maxillary sinus elevation. In endodontic for regeneration in pulp revascularisation and in Periodontics for guided tissue regeneration. This is an overview of regeneration in dentistry for clinical practice, role of dental stem cells and potential future technologies to treat and cure dental diseases.

Keywords: Dental stem cells, Regeneration, Tissue engineering.

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1. Introduction

Regeneration in dentistry is a rapidly evolving field that focuses on restoring the structure and function of damaged oral and craniofacial tissues. Once these tissues are affected by dental caries, periodontal diseases, maxillofacial pathologies, or trauma, their ability to regenerate naturally is very limited. Hence, dental and craniofacial tissue engineering has been developed as a promising solution to overcome these challenges.[1]

The foundation of this field lies in tissue engineering, which is based on three essential components—stem cells, bioactive molecules, and scaffolds. These work together to stimulate cell growth, differentiation, and repair potential of resident cells.[2] Two main strategies are applied in regenerative dentistry: the cell-free approach (cell homing), where endogenous cells are recruited to the defect site, and the cell-based approach, where cultured stem cells are transplanted to promote tissue repair and regeneration.[3,4]

Over the years, regenerative dentistry has gained attention in various dental specialties, including endodontics, periodontics, and prosthodontics, offering new opportunities for clinical practice. These advances are expected to improve treatment outcomes and meet the rising expectations of patients by moving beyond traditional restorative therapies toward biologically driven regeneration.

2. Aim

The aim of this review is to provide a comprehensive overview of regenerative approaches in dentistry, with special emphasis on their applications in endodontics, periodontics, and prosthodontics. It focuses on the fundamental role of stem cells, scaffolds, and bioactive molecules as the core components of tissue engineering. The review further aims to discuss the clinical applications, associated challenges, and potential risks linked with regenerative therapies, while also highlighting the future perspectives such as cell sheets, organoids, 3D bioprinting,

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and biobanking. Overall, this article intends to summarize the current knowledge and advancements in regenerative dentistry and to outline its potential to become a part of routine clinical practice in the future.

3. Related Challenges and Future Perspectives

Regenerative dentistry, though highly promising, faces some significant challenges that limit its routine application. One of the main concerns is the risk of undesired tissue formation, metastasis, and tumorigenesis, particularly with stem cell-based therapies.[5] In addition, techniques such as spheroid formation remain debatable since their exact mechanisms are not yet fully understood.[6] Variability in clinical outcomes, lack of standardized treatment protocols, and uncertainty about long-term stability also present hurdles for widespread adoption.

Despite these limitations, the field continues to advance with exciting possibilities. Emerging technologies such as cell sheets, spheroids, organoids, and 3D bioprinting provide opportunities to better replicate natural tissue structures. Similarly, layered scaffolds and exosome-based therapies are being investigated for their ability to improve cellular communication and enhance regeneration. Another important development is biobanking of dental stem cells, which may ensure an accessible source of patient-specific cells for future personalized treatment.[1]

Thus, while certain biological and clinical challenges remain, ongoing research and technological progress strongly indicate that regenerative dentistry has the potential to become an integral part of daily clinical practice in the near future.

4. Endodontics

Regenerative endodontics mainly aims at the regeneration of the dentin–pulp complex. Its goal is pulp revascularisation, especially in immature permanent teeth with necrotic pulp and apical periodontitis or abscess, so that root development can continue.[7]

The procedure begins with chemical disinfection of the root canal using intracanal medicaments and antibiotics. This is followed by induction of bleeding inside the canal, which forms a blood clot acting as a natural scaffold. The clot supports macrophages, fibroblasts, and homing of stem cells, creating a favorable niche for regeneration.[8,9] Deposition of hard tissue further reinforces the dentinal walls, ensuring structural stability.

Thus, regenerative endodontics goes beyond conventional treatment by utilizing biological principles to restore both structure and function. Clinical and experimental studies show positive outcomes, making it a promising therapy for the future.[10]

5. Periodontics

Regenerative periodontics aims to restore the original structure and function of the periodontium, including both hard and soft tissue components. This is typically achieved using bone grafts, which may include autografts, allografts, xenografts, or synthetic materials that promote new bone formation.[11-13]

A key technique is guided tissue regeneration (GTR), which uses barrier membranes to direct the growth of specific cells while preventing unwanted tissue invasion. Its success depends on the technique and membrane properties.[14,15]

Overall, regenerative approaches in periodontics create a biologically favorable environment that encourages the patient's own cells to repair and rebuild the periodontium, offering better long-term outcomes compared to conventional therapies.

6. Prosthodontics

In prosthodontics, regenerative therapy plays a key role in bone and soft tissue regeneration, including chondrogenesis, neurogenesis, osteogenesis, and angiogenesis. Collagen-based scaffolds are commonly used due to their biocompatibility and similarity to native bone matrix, while synthetic polymers and ECM-based scaffolds provide a favorable environment for cell growth and differentiation.[16,17] Scaffolds can include metals, ceramics, natural polymers, or synthetic polymers, and their mechanical properties such as porosity and stiffness influence cell adherence and differentiation.[18,19]

Previously, conventional prosthetic materials were prone to infections, inflammation, and poor compatibility, but tissue engineering has reduced these issues.[20] Clinical applications include peri-implantitis, craniofacial defects, mandibular atrophy, maxillary sinus elevation, and temporomandibular joint disorders. By combining dental stem cells, growth factors, and scaffolds, regenerative prosthodontics not only restores function but also recreates tissue architecture, improving long-term outcomes and patient satisfaction.

7. Discussion

Hard and soft tissues of the oral and craniofacial region are highly interdependent, and their integrity is essential for proper function. Any pathological condition, trauma, or physiological change can adversely affect bone, cartilage, or soft tissue, making regeneration challenging.[21] In this context, tissue engineering plays a crucial role by combining stem cells, scaffolds, and bioactive molecules to promote tissue repair and regeneration.

In osteogenesis, commonly used dental stem cells include dental pulp stem cells (DPSCs), stem cells from human exfoliated deciduous teeth (SHED), and periodontal ligament stem cells (PDLSCs). These cells, in combination with scaffolds possessing suitable biological, mechanical, and structural properties, facilitate effective bone regeneration.

The clinical applications of regenerative dentistry in prosthodontics are diverse, ranging from craniofacial defects, maxillary sinus elevation, and peri-implantitis to trauma, temporomandibular joint disorders, chondrogenesis in masticatory muscles, neural regeneration in nerve trauma, and angiogenesis.[22] Thorough treatment planning and appropriate use of biomaterials ensure improved success rates and long-term outcomes.

Bone marrow has traditionally been considered a primary source of multipotent mesenchymal stem cells for regenerative medicine. However, dental stem cells are becoming increasingly preferred due to their easy accessibility, reduced donor site morbidity, and comparable regenerative potential.[23] The combination of stem cells with collagen-based scaffolds, platelet-rich fibrin (PRF), fibroblast growth factor (FGF), and platelet-derived growth factor (PDGF) has shown promising results in enhancing revascularisation, tissue repair, and functional recovery.

Overall, regenerative dentistry represents a biologically driven, patient-specific approach to tissue repair, offering advantages over conventional therapies. While challenges remain, ongoing research and technological advancements continue to expand its clinical applicability and potential to become a routine part of dental practice.

8. Conclusion

Regenerative dentistry, supported by tissue engineering, represents a significant advancement in clinical dentistry, offering the potential to restore the structure and function of damaged hard and soft tissues. The integration of dental stem cells, scaffolds, and bioactive molecules such as platelet-rich fibrin (PRF), fibroblast growth factor (FGF), and platelet-derived growth factor (PDGF) plays a central role in promoting revascularisation, tissue repair, and functional regeneration.

In specific clinical applications, bone marrow mesenchymal stem cells (BMMSCs) have shown promising results in temporomandibular joint disorders, improving pain, chewing efficiency, and mouth opening. Similarly, adipose-derived MSCs (AMSCs) in salivary gland regeneration have enhanced salivary flow, reduced fibrosis, and increased acinar and ductal areas.

Overall, dental stem cells combined with suitable scaffolds and growth factors provide a biologically driven, patient-specific approach to tissue repair. If challenges such as cost and accessibility are addressed, regenerative dentistry has the potential to become a routine part of clinical practice, offering long-term benefits and improved quality of life for patients. With ongoing research and technological advancements, the field is poised to transform conventional dental treatments into predictable, biologically based regenerative therapies.

9. Source of Funding

None.

10. Conflict of Interest

None.

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