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Advances in new materials for bone tissue engineering simplifying postoperative rehabilitation: Recent Scientific Breakthroughs

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Summary

Introduction: Bone tissue engineering has emerged as a promising field in regenerative medicine, aiming to develop innovative materials and approaches for bone repair and regeneration, which also leads to the simplification and search for new approaches in postoperative rehabilitation. The integration of novel materials into scaffolds and implants plays a crucial role in improving bone tissue engineering strategies. In recent years, scientific research has made significant progress in identifying and characterizing novel materials with superior properties and functionalities.
Aim: This article explores the most recent scientific findings and research breakthroughs concerning novel materials for bone tissues, focusing on their biocompatibility, mechanical properties, bioactivity, and potential clinical applications.
Conclusion: In recent years, the field of bone tissue engineering has witnessed remarkable advancements in the development of novel materials for bone repair and regeneration, which also simplify the medical rehabilitation of the patient. From bioactive glasses and calcium phosphate-based materials to biodegradable magnesium-based materials and graphene-based composites, researchers have explored a wide range of materials with diverse properties and functionalities. As the field continues to evolve, the integration of cutting-edge technologies, such as 3D printing and nanotechnology, is expected to further enhance the efficacy and clinical relevance of these novel materials, ultimately benefiting patients with bone defects and diseases.

Key words: *rehabilitation, operation, artificial bone tissue*

3D Printing and Additive Manufacturing

Recent advancements in 3D printing and additive manufacturing have revolutionized the fabrication of complex structures for bone tissue engineering [1]. Novel materials, such as bioceramics, biodegradable polymers, and composite materials, can be precisely deposited layer by layer to create patient-specific implants and scaffolds [2]. 3D printing also allows the incorporation of growth factors and stem cells within the scaffold, providing a conducive microenvironment for bone regeneration [3]. This technology has the potential to transform the field of bone tissue engineering by enabling personalized and efficient treatment approaches. In the case of 3D printing of expandable bone structures, it is possible to produce a bone replacement that gradually lengthens as the child patient's bone grows. The use of technologies like hyperelastic bone, reduces the need for repeated operations. The result is an increased quality of life for the child patient. However, it is already necessary to look for new long-term rehabilitation procedures that will improve the mobility of patients with modern implants.

Bioactive Glasses

Bioactive glasses are a class of silicate-based materials that have garnered significant attention in bone tissue engineering due to their excellent bioactivity and biocompatibility. These glasses have the ability to form a chemical bond with the surrounding bone tissue, promoting osteointegration and enhancing bone regeneration [4]. Recent research has focused on tailoring the composition of bioactive glasses to optimize their mechanical properties, degradation rates, and ion release kinetics. Additionally, the incorporation of bioactive glass nanoparticles into polymer scaffolds has shown to improve the scaffold's mechanical strength and bioactivity, making them an attractive option for bone tissue engineering applications [5]. The length and process of patient rehabilitation is identical to the rehabilitation of patients with conventional bone substitutes.

Calcium Phosphate-Based Materials

Calcium phosphate (CaP) materials, including hydroxyapatite (HA) and tricalcium phosphate (TCP), are well-known for their compositional similarity to the mineral phase of natural bone. Recent research efforts have aimed to improve the mechanical properties of CaP materials while maintaining their bioactivity [6]. For instance, nanocrystalline HA has been developed to enhance the mechanical strength and cellular response of bone scaffolds. Furthermore, researchers have explored the incorporation of silicon and strontium ions into CaP structures, which have shown to enhance osteogenic activity and stimulate bone formation. Since these are materials that actively support bone growth, it is necessary to design a new and optimal rehabilitation strategy.

Biodegradable Magnesium-Based Materials

Magnesium-based materials have gained interest as potential biodegradable implant materials for bone tissue engineering. Magnesium exhibits biocompatibility and biodegradability, making it an attractive alternative to traditional metallic implants [7]. Recent studies have focused on optimizing the degradation rates of magnesium-based materials to match the rate of bone regeneration, avoiding potential complications caused by rapid degradation. Furthermore, the incorporation of alloying elements and surface modifications has been explored to control the degradation behavior and enhance the mechanical properties of these materials.

Silk Fibroin

Silk fibroin, derived from silkworm silk, is a naturally occurring protein with remarkable biocompatibility and mechanical properties. Recent research has demonstrated the potential of silk fibroin-based scaffolds as carriers for bone growth factors and drug delivery systems. The controlled release of bioactive molecules from silk fibroin scaffolds can enhance cell adhesion, proliferation, and differentiation, promoting bone regeneration. Moreover, researchers have combined silk fibroin with other materials like calcium phosphate and biopolymers to fabricate composite scaffolds with enhanced mechanical and bioactive properties [8].

Graphene-Based Materials

Graphene, a two-dimensional carbon nanomaterial, has shown great promise in various biomedical applications, including bone tissue engineering. Its exceptional mechanical strength, high surface area, and electrical conductivity have attracted researchers seeking advanced materials for bone repair. Recent studies have explored the incorporation of graphene and graphene oxide into polymeric scaffolds and bioceramics to improve their mechanical properties and cell adhesion. Moreover, the electrical conductivity of graphene can be harnessed to stimulate osteogenic differentiation and accelerate bone regeneration [9].

Literatúra

[1] S. Furka et al., "Využitie 3D tlače v rehabilitácii – trendy" 2019. *Rehabilitácia.* Vol 56/4, P301.
[2] C. M. Smith et al., "Advances in 3D Printing for Orthopedic Applications: A Review." 2020. *J. of orthopaedic research,* 38(9), P1086.
[3] S. V. Murphy, A. Atala "3D bioprinting of tissues and organs." 2014. *Nature biotechnology,* Vol 32/8, P773.
[4] J. R. Jones, L. L. Hench, "Regeneration of trabecular bone using porous ceramics." 2003. *Current opinion in solid state & materials science* Vol 7/4-5, P301.

[5] V. Miguez-Pacheco et al., "Bioactive glasses beyond bone and teeth: Emerging applications in contact with soft tissues." 2015. *Acta Biomaterialia*, Vol 13, P1.
[6] J. Zhang et al., "Calcium phosphate cements for bone substitution: Chemistry, handling and mechanical properties." 2018. *Acta Biomaterialia*, Vol 83, P1-30.
[7] A. Zomorodian, M. P. Garcia, "Magnesium in orthopedic implant applications." 2016. *Acta Biomaterialia*, Vol 43, P2.
[8] J. Kundu, S. C. Kundu, "Osteogenic efficacy of drug-loaded calcium phosphate-silk fibroin nanocomposite 3D scaffold." 2014. *Acta Biomaterialia*, Vol 10/12, P5134.
[9] Y. Zhu et al., "Enhanced osteogenesis and osteointegration of graphene oxide coated with hydroxyapatite on titanium. " 2016. *ACS Applied Materials & Interfaces*, Vol 8/42, P28480.