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Commentary

Advancement of Bone Repairing and Regeneration to Enhance Osteogenesis

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DESCRIPTION

Even though bone has remarkable abilities to regenerate itself, serious injuries frequently necessitate extra surgical intervention, such as the use of artificial bone structures. To encourage the regeneration of damaged bone and more importantly, to provide support in the interim, these structures must fulfill a number of requirements relating to their composition, functionality, and rate and process of erosion and fracture when implanted. Advancements in imaging and additive manufacturing technologies have made it possible to make significant progress in creating customized implants that meet the needs of each individual injury. From the perspective of biomaterials, greener, more sustainable biomaterials derived from renewable resources are needed for bone regeneration; additionally, engineering performance and qualities, such as mechanical capabilities, are required for bone repair.

There are currently 4D and 5D printing techniques that take into account rotational, temporal, and dimension degrees of freedom in addition to 3D printing techniques. The utilization of metallic substances, their alloys, ceramics and plastics is made possible by a wide range of the aforementioned procedures and techniques, offering an incredibly broad range of opportunities for implant design. The key elements of green biomaterials used in the development of bone tissue are discussed here, along with their uses in bone regeneration and repair, and new prospects for bone tissue engineering research are suggested. Finally, a summary of the most recent developments in the use of green biomaterials in clinical settings is provided.

For use in bone healing, an injectable, transparent, Mg^{2+}-loaded hydrogel that can scavenge nearby oxygen species that are reactive was created in this work. Alendronate sodium was added to the hydrogel using a Schiff's base process with oxidized dextran, which has a particular binding affinity for Mg^{2+}. In a rat-femur defect model, the porous hydrogel demonstrated improved cell viability, differentiation and proliferation of human stromal cells from bone marrow *in vitro*, and osteogenic capability. It was linked together by catechol-modified chitosan to preserve its mechanical properties. A progressive recovery process was indicated by the hydrogel's promotion of bone tissue regeneration, including ossification and especially endochondral ossification. The dense, stratified nature of the produced bone tissue demonstrated its efficacy in osteogenic differentiation.

The hydrogel has the ability to lessen local inflammation and aid in bone repair. It also had an impact on macrophage polarization and reduced the M1 phenotype linked to tissue repair and regeneration. Overall, the hydrogel's several biofunctions, such as improved osteogenesis and endochondral ossification as well as inflammatory management, point to it being a potential biomaterial for bone repair.

Obstacles to bone restoration include inadequate bone regeneration capacity and slow repair rates. Bone abnormalities may cause nonunion or delayed healing, which can have a serious negative impact on a patient's quality of life. With the benefit of being painless and non-invasive, Photobiomodulation (PBM) uses various light sources to produce positive therapeutic effects and offers a potential method for quickening bone restoration. The analysis conclude the present clinical use of PBM devices in bone regeneration and provide an overview of the parameters, processes, and consequences of PBM regulating bone repair. The most often utilized characteristics are the wavelength of 635-980 nm, an output power of 40-100 mW, and an energy density of less than 100 J/cm^2.

New technologies provide references to realize a safe and effective bone restoration method, such as biocompatible and implanted optical fibers and needle devices. To improve clinical trial techniques and determine the credibility of results from *in vitro* and *in vivo* studies, more research is needed. Patients with Diabetes Mellitus (DM) have disturbed glucose metabolism, which impacts bone metabolism and its microenvironment. This has a major negative impact on bone regeneration, making bone lesion repair in DM patients extremely difficult. Even though autologous and heterologous bone grafts are often used therapeutic strategies, they frequently fail to produce the intended therapeutic result, particularly when trying to treat DM patients' complex pathologic milieu at the lesion site. As a result, a number of biomaterials have been created to help with DM bone repair.

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Bioactive biomaterials have replaced physiologically as one of the main focus due to developments in bone tissue engineering. Unfortunately, numerous biomaterials have failed to produce adequate therapeutic effects because the pathologic milieu of diabetic bone abnormalities is not well understood. The processes that the diseased microenvironment uses to influence bone repair are examined here. Next, a thorough examination is conducted from seven perspectives of the most current developments in biomaterial therapy techniques that are based on these chronic environments. Ultimately, viable approaches for development and viewpoints are provided, along with an analysis of the present constraints that still require attention. This review will undoubtedly generate fresh concepts for the creation of more adaptable, high-performance biomaterials to enhance the healing of pathologically-induced bone deformities.