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Review Article
USE OF BIOMATERIALS IN BONE DEFECT HEALING

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Abstract: Bone defects, resulting from trauma, congenital anomalies, present significant challenges in orthopedics, necessitating innovative approaches for effective and functional tissue regeneration. This reviews the utilization of biomaterials in addressing bone defects for enhancing healing. It synthesizes advancements in biomaterial design and application for optimal bone regeneration. Key focus areas include biocompatibility, mechanical properties, and bioactivity of diverse materials, emphasizing their roles in fostering osteogenesis. It highlights significant studies and trends, underscoring the potential of biomaterials in overcoming challenges associated with bone repair. By providing a concise overview, this aims to inform researchers and clinicians about the ongoing progress in effective bone defect healing.

Keywords: *Fracture fixation, Biomaterials, Nanocomposites*

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Introduction
Modern fracture fixation treatment procedures have attained a high technological standard, ensuring methodological soundness of surgery and, overall, good quality in medical therapy [1]. Bone loss, lack of vascularization, soft-tissue damage, insufficient mechanical stability, infections, and tumors continue to be major obstacles to successful bone healing [2]. They impede or entirely prevent clinical rehabilitation, with few intervention strategies available to successfully overcome these obstacles [3]. In contrast to pure technology approaches, regenerative medicine may be a game changer and, when combined with fracture stabilization technologies, may provide unique solutions for difficult patient scenarios. Defects are one of the most significant unsolved difficulties in bone regeneration. Biomaterials are utilized to fill such deficiencies, restoring both structure and function and, in most cases, replacing lost bone.

The appropriate characteristics for such biomaterials might vary significantly depending on the location of the bone defect and the kind of bone loss [cortical versus cancellous]. An ideal biomaterial would be capable of releasing compounds that address the underlying cause of bone loss. This functionalization of biomaterials may be one of the most significant advances in modern biomaterial development. However, autologous bone transplantation is the gold standard for the treatment of bone abnormalities, followed by allogeneic bone, which lacks osteogenetic characteristics but is nearly as successful in some cases [4].

Biomaterial properties
Biomaterials, often known as implant materials, are synthetic or nonvital natural materials used in medicine for therapeutic purposes that are placed within the human body or come into touch with patient tissue in some other way. These materials interact with the recipient's biological system in a chemical, physical, or biological way within the body. Biomaterials are utilized in bone regeneration to replace tissue lost due to disease, injury, or ageing. In any case, the degradation should occur without the production of harmful byproducts that may hinder the healing process or, at a later time, create issues within the human body.

Another crucial factor to consider while advancing bone development with biomaterials is vascularization. As vascularization plays a pivotal role during the healing process [5,6] it has been proven, that a delayed revascularization is coupled to a delayed bone healing [7]. As a result, a biomaterial employed in bone production should, if not actively promote angiogenesis, at least not obstruct the naturally occurring revascularization process.

The primary component of bone is hydroxyapatite [HA], which forms from particular zones on collagen fibers deposited by osteoblasts, the bone-forming cells [8]. Subsequently, Hydroxyapatite has been widely investigated as a bone substitute and has been proven to have high osteoconductive potential [9]. When it comes to long-term clinical outcomes, studies have demonstrated that Hydroxyapatite bone graft substitutes operate just as well as bone allografts, demonstrating their relevance as a biomaterial in bone replacement [10].

Various forms of biomaterials and their applications
Nanocomposites are emerging as a viable class of materials because they so closely mimic the hierarchical, nanoscale composite structure of bone. Nano-hydroxyapatite [nHA] particles added to natural and manufactured polymeric scaffolds have been proven to boost yield strength and compressive modulus [11], Mechanical qualities tend to improve as HA concentration increases, although increasing strength may reduce other attributes like as strain to failure [12]. Nanocomposites made from polymeric microspheres and nanosized HA particles are attractive as injectable bone defect fillers. This paradigm's structure and composition closely resemble the extracellular bone matrix, especially when collagen is employed as the microsphere matrix. Calcium phosphate ceramic materials are attractive in nanocomposite design because they are the main constituent of bone. Hydroxyapatite [HA], calcium phosphates such as b-TCP, calcium carbonates, and bioactive glasses are some of the ceramics utilized as reinforcement phases. Because of their closeness to bone calcium, HA and b-TCP are widely employed [13-15]. The structure and properties of poly [diol citrate] nanocomposite elastomers are promising for soft tissue orthopaedic applications, with the potential to be used in hard tissue applications by shortening the diol chain. At 10% wt/wt, poly[1,10-decanediol citrate] [PDC] was reinforced with a PLLA nanofibrous network, and 85% porous scaffolds were created [16]. These nanocomposite scaffolds combine the greatest properties of each constituent: PLLA's increased mechanical strength and PDC's quicker breakdown rate and higher biocompatibility.

Conclusion

Defects are one of the most significant unsolved difficulties in bone regeneration. Biomaterials are utilized to fill such defects, restoring both form and function and, in most cases, replacing the lost bone. Depending on the location of the bone defect and the type of bone lost [cortical versus cancellous], the adequate properties for such biomaterials and their advantages are discussed.

Application of research: Study of biomaterials and their application in bone defect healing.

Research Category: Tissue engineering, Bone regeneration

Abbreviations: HA-Hydroxyapatite, nHA- nano hydroxyapatite, PDC- Poly decanediol citrate, β-TCP- Beta tricalcium phosphate, PLLA- Poly L-Lactic acid

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