Chapter 12
Role and Challenges of Bioprinting in Bone Tissue Engineering

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ABSTRACT

Bone grafting is a type of surgery for reconstructing damaged and defective bones by medical professionals. But the surgery is very complex and challenging as it needs precise and accurate skills of the medical professionals, and it is costly and time-consuming. The grafted bone size and shape should match the targeted area. To overcome these challenges, bioprinting comes into play. By using bioprinting technology, the exact structure that is to be fitted in the targeted location can be fabricated by scanning the target using a 3D scanner or taking medical images like MRI or CT scan and then reverse engineering the same structure needed for the target location using bioprinting technology, which ultimately improves the patient's quality of life and satisfaction. In this chapter, various types of bioprinting types for bone scaffold fabrication, the materials which are used for fabricating bone scaffolds like bioceramic, metals, and polymers are described as well as the limitations and challenges are described briefly.

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1. INTRODUCTIONS

The bones of humans have limited availability to regenerate and self-repair (Khare et al., 2020, Florencio-Silva et al., 2015). It loses its self-healing function and repair when damage exceeds its acceptable capacity. Still, now the ideal treatment procedure for damaged areas will be held by grafting bones from the patient's other body parts. But it is limited to the availability of the donor site of that patient and also complication at the transplantation donor location after bone grafting (Baldwin et al., 2019). Another treatment procedure is that the contributor bonds with the new patient but the availability of a contributor and immunity rejection at the external contributor will make some problems during the repairing of bones (Sohn et al., 2019, Zhang et al., 2017). One of the techniques to overcome the limitation of traditional bone repair is the replacement of damaged bone with grafts. The biometrical field has some unique advantages to generating patient-specific bone models using 3D printing using patients' own CT data. In which cells and biomaterials of discrete origin are compiled to make the customizable bioink and prepare different organ and tissue structures using 3D printing that will solve the insufficient of organs to some extent. 3D printing also offers to minute the complex bone structure and treatment of patient-specific bone defects. The choice of printing materials played an important role during 3D printing Technology can be metal like titanium magnesium or alloys, inorganic nonmaterials such as bioglass, biological ceramics, as well as huge molecular weight materials like poly lactic acid, polycaprolactone, etc (Renata et al., 2019, Ma et al., 2022). Human bone is made up of different complex materials which can mimic the performance and structure of normal bone to a great extent. Among various additive manufacturing technology, extrusion laser melting and laser sintering is the most commonly used one and is exclusion-based bioprinting which permits several materials to combine with the biological cells in bioink form (Lipskas et al., 2019, Turi et al. 2019, Shivakalyani et al., 2017) now to improve the elastic modulus as well as the mechanical strength of the graft used for bone transplant and to avoid stress rejection, research optimization of the inner structures of the implant of bone is needed before printing the bone tissues surface (Christy et al., 2020). In this book chapter, we have focused on materials types for bone grafting, fabrication techniques of bone grafting, and the prospect of the growth of additive manufacturing technology in the orthopedic application to deliver a piece of knowledge for the upcoming studies in this interesting fast-growing field.

2. MATERIALS

Natural bones are very complex in structure based on the different locations of the body. Composite materials can be categorized into different components such as 60% inorganic and 30% of organic materials. The chief components are crystals of hydroxyapatite crystals and organic materials like collagen 1, collagen 5, 3% lipid, and 5 to 10% water. Usually, the bones of humans are classified as compact bone, cancellous bone, and spongy bone. Osteoblast forms original bone tissues in osteoids form that are a composite of other proteins and collagen (Sreenivasan et al., 2016). The bone implant cytocompatibility and its products of degradation is also a significant factor during the consideration of the application of the tissue engineering of bone. The implants of the bone must permit addition for refraction cell differentiation deprived of any adverse effects and immunogenic rejection. Bone tissue Engineering covers bioactivity, osteoconductivity, and osteoinductivity which played an important role during the primary biological process at the implant site (Hossein et al., 2020).