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Tissue engineering approaches for treating bone defects

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The conventional methods that are used to treat bone disorders include grafting techniques, such as autografts, allografts, and cell therapy. The autografts contain an individual’s cells and hence have the highest degree of biocompatibility and safety. Allografts are similar to autologous grafts in terms of mechanical and other biological properties but the difference lies in the harvesting of grafts, which is from the other individuals. The major limitations of the autograft include the requirement of a second surgery to harvest it from the individual and the availability of enough volume of tissue to be grafted at the injured site. This leads to immense discomfort, chronic pain, and various side effects and complications. In the case of allogeneic grafts, immune-rejection owing to unacceptance of the tissue by the body of the individual is a huge disadvantage. The third method that is practised is the cell therapy, which includes direct injection of mesenchymal stem cells (MSCs), which involves systemic as well as local injection. Through this method, MSCs are delivered to the body so that they get recruited by the site of injury for bone healing and repair. However, a few disadvantages have been reported in this, such as entrapment of cells in lungs forming microemboli and local ischaemia. Also, in large bone defects, a direct injection method has been found to be ineffective hence tissue engineering that combines cells with biomaterials could be successful in increasing and accelerating functional new bone formation.

Tissue engineering here involves artificial tissue or organ generation (i.e. a functional prefabricated bone) with the help of biomaterials (scaffolds or carriers, growth factors, and cells such as MSCs). The cells specific to bone tissue formation are obtained from multipotent stem cells that can be harvested from the patient. They are treated with osteogenic differentiation medium to produce osteocytes, which are cultured with biomaterials in 3D conditions. These cells are then used as bio-ink to print tissues using a 3D bioprinter and grafted into the area of injury. The biomaterials provide an in vivo 3D environment by acting as scaffolds for the growth and development of the cells. For bone tissues, biocompatible and biodegradable biomaterials with high mechanical strength and properties, such as osteoconduction, osteoinduction, and osteogenesis are preferred. A few examples include bioceramics, polymers, metals, hydrogels, and composites. If a clear understanding of the exact mechanisms of MSCs in bone healing processes is obtained, this method could become a good therapeutic option for fracture healing in the future.

Keywords: Bone tissue engineering, 3D bioprinter, Stem cells, Biomaterials, Scaffolds

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