Three-Dimensional Printing in Tissue Engineering and Regenerative Medicine

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Tissue engineering strategies have been attempted to help the body's ability to regenerate damaged tissues by combination of cells, growth factors and biomaterial scaffold since Langer and Vacanti [1] firstly challenged the technique although there is a continued demand on enhancing the function of tissue-engineered organs through the development of a new fabrication method.

Recently, three-dimensional (3D) printing technologies have emerged as a powerful method in the field of tissue engineering and regenerative medicine because the inherent limitations of fabrication of 3D scaffolds can be overcome with geometric accuracy at the macroscale and microscale [2] and living cells can be included in the printing process to position living cells together with desired biomaterial scaffolds [3].

Although the optimistic promise of 3D printing improves tissue engineering and regenerative strategies and the field is still at a relatively early stage, many challenges such as increase of resolution, printing speed, and relevant biomaterials for creation of more complex tissue/organ structures must be solved for clinical trials [4]. Also, multidisciplinary collaborations among biologists, material scientists, engineers and medical doctors should be necessary to achieve successful 3D tissue/organ printing.

In the special issue, renowned authors in 3D printing fields provide a concise and up-to-date overview of different issues regarding application of 3D printing in tissue engineering and regenerative medicine. This issue covers five different topics. The first one discusses 3D cell-based bio-printing technologies and their applications in soft tissue regeneration through placement of cell-laden hydrogel-based bioinks in a layer-by-layer fashion. The second one discusses the characteristics of printing biomaterials including hydrogels, synthetic polymers and

composite materials as well as recent advances in soft tissue regeneration using 3D printing inks. The third one discusses characteristics of the 3D printing techniques, used biomaterials for development of 3D tissue/organ analogues and *in vitro* models. The fourth one discusses 3D potential practice in regenerative medicine to fabricate the transplantable hard tissues such as cartilage and bone and current technical development of 3D bio-printing for engineering hard tissues. The fifth one discusses the history and types of 3D printers, the classification of 3D printers and the technology used to manufacture artificial tissues/organs.

We expect that this review will provide scientists, researchers and healthcare industrial persons in the fields of 3D printing fundamental concepts and practical tools for their successful application of reliable fabrication techniques to replace and regenerate defective tissues or injured tissues and organs.

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