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Opinion

# Current Advances and Future Perspectives of 3D Printing in Biomedical Applications

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## Opinion

It has long been desired to develop materials and devices that can perfectly reproduce and regenerate damaged or diseased tissues or organs. Thanks to its unique and significant advantages in high-precision, personalized manufacturing and complex shape construction, 3D printing has penetrated into all walks of life and led to innovation, triggering revolutionary changes in the global manufacturing industry, including the field of biomedicine [1].

Biological 3D printing as an important branch of 3D printing is based on the principle of "material" made by means of a special biological "printers", to processing active materials including biological materials, such as growth factors, cells, aiming to restore the body's tissues and organs. It is also the core component of 3D printing with more vitality and development potential. It is one of the highest levels of 3D printing technology at present [2,3]. Especially for the construction of whole organs and large tissues, the method of cells layer by layer accumulation makes the construction of scaffolds and the implantation of cells and biomaterials highly controllable, accurate and efficient. 3D printing technology can print out human organs with biological activity, make tissue and organ substitutes, and make customized grafts and prostheses, including bones, teeth, joints, artificial livers and artificial blood vessels. 3D printing technology can also be used for face modification and cosmetology. Damaged tissues of the face, such as ears, nose and skin, can be produced by 3D printing technology, and the corresponding tissues can be precisely matched with the patients, so as to reshape the complete image of the head for the patients and achieve aesthetic effects. In addition, 3D printing technology can also be used to quickly build medical models, medical props, organ models and medical supplies. In terms of drug development, release and dosage form, 3D printing makes it possible to individualize treatment and print more novel dosage forms, such as micrograph printing of antibiotics, mesoporous bioglass stent, nano suspension, multi-layer drug release device, and other new drugs with multiple drug release curves.

According to the substrate materials, biological 3D printing is divided into metal 3D printing, ceramic 3D printing, polymer 3D printing, cell biological 3D printing, etc., which involve different printing equipment, technology and process. Based on the technology generation time and biological properties of materials, it can be divided into four levels of applications:

1. The printing materials are engineering materials without biocompatibility and degradability, which are mainly used to make *in vitro* models for surgical planning, prosthesis design and testing standards. Common cases include surgical design of the auxiliary model, dental surgery guide plate [4,5].

2. The printing materials are biocompatible but not biodegradable. After implanted into the human body, it becomes a permanent implant, including metal and ceramic materials. Common cases include non-biodegradable prostheses, prosthetic ear grafts [6,7].

3. The materials have both good biocompatibility and matching degradation performance. After implantation, the product can promote tissue regeneration and reconstruct the repair mechanism of tissue. Common cases include bone tissue scaffolds and skin tissue scaffolds [8,9].

4. Living cells, proteins and their extracellular matrix materials were used to construct 3D cell structures, *in vitro* 3D cell models and embryo bodies of tissues or organs [10,11]. Now the cells are added to the active printing material, which is called the biological 3D printing in the modern sense.

These four levels of 3D printing have an important role in promoting basic research, drug screening and clinical application in the field of biomedicine. However, due to the limitations of 3D printers, currently suitable 3D printing biological materials are scarce, and the quality remains to be further improved. Therefore, the solution of the problem of 3D printing biomaterials can facilitate the clinical application of 3D printing technology of biomaterials.

In recent years, the importance of bionics for the research and development of ideal biomaterials has been brought out gradually. Studies have shown that adding active cell factors to the printing materials or adding biomimetic components to the bio-printing constructs can build a microenvironment suitable for the growth of cells and promote the self-function [12,13]. One of the challenges of this research is to develop methods that can properly integrate the right materials into the building blocks through bio-printing technology, while ensuring that the materials have the right degradation time and by-products, and that these materials have clear and controllable structural characteristics and biological functions. Therefore, it is impossible for any material of a single component to have all the characteristics necessary to reconstruct the organizational function. It has become an inevitable trend to develop composite 3D printing materials, so as to better maintain the activity of printed cells and achieve *in vitro* reconstruction of tissue and organ functions. New types of biological 3D printing materials need to be developed and endowed with more abundant forming methods, so as to optimize the mechanical properties of the materials and make their more printable. By means of bionics and loading biological activity factors, the biological properties of printing materials can be improved by combining other materials . Design to regulate the degradability of the materials and promote their vascularization to improve the survival and functional maintenance of printed cells, tissues and organs .The establishment of biological 3D printing material standards and production process specifications will be an important research direction in the future. We believe that with the expansion of the types of printing materials and the improvement of performance, biological 3D printing will bring revolutionary changes in health and medical applications. It should be emphasized that the future of biological 3D printing is the future of biomaterials and bionics is a necessary means.

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