

3D BIOPRINTING IN MEDICINE

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Introduction. The primary purpose of printable organs is in transplantation. Research is currently being conducted on artificial heart, kidney, and liver structures, as well as other major organs. For more complicated organs, such as the heart, smaller constructs such as heart valves have also been the subject of research. Some printed organs have already reached clinical implementation, and primarily include hollow structures such as the bladder, as well as vascular structures such as urine tubes. 3D printing allows for the layer-by-layer construction of a particular organ structure to form a cell scaffold. This can be followed by the process of cell seeding, in which cells of interest are pipetted directly onto the scaffold structure. Additionally, the process of integrating cells into the printable material itself, instead of performing seeding afterwards, has been explored. Modified inkjet printers have been used to produce three-dimensional biological tissue. Printer cartridges are filled with a suspension of living cells and a smart gel, the latter used for providing structure. Alternating patterns of the smart gel and living cells are printed using a standard print nozzle, with cells eventually fusing together to form tissue. 3D printing for producing a cellular construct was first introduced in 2003. Since Boland's initial findings, the 3D printing of biological structures, also known as bioprinting, has been further developed to encompass the production of tissue and organ structures, as opposed to cell matrices. Additionally, more techniques for printing, such as extrusion bioprinting, have been researched and subsequently introduced as a means of production. Organ printing has been approached as a potential solution for the global shortage of donor organs. Organs that have been successfully printed and implemented in a clinical setting are either flat, such as skin, vascular, such as blood vessels, or hollow, such as the bladder. When artificial organs are prepared for transplantation, they are often produced with the recipient's own cells. More complex organs, namely those that consist of solid cellular structures, are undergoing research; these organs include the heart, pancreas, and kidneys. Estimates for when such organs can be introduced as a viable medical treatment vary. The company Organovo produced a human liver using 3D bioprinting, though it is not suitable for transplantation, and has primarily been used as a medium for drug testing.

Aim. It is essential to investigate the using and mechanisms of 3D printing techniques. **Materials and methods.** Data analysis of literature and Internet sources.

Results and discussion. 3D printing for the manufacturing of artificial organs has been a major topic of study in biological engineering. As the rapid

manufacturing techniques entailed by 3D printing become increasingly efficient, their applicability in artificial organ synthesis has grown more evident. Some of the primary benefits of 3D printing lie in its capability of mass-producing scaffold structures, as well as the high degree of anatomical precision in scaffold products. This allows for the creation of constructs that more effectively resemble the microstructure of a natural organ or tissue structure. Organ printing using 3D printing can be conducted using a variety of techniques, each of which confers specific advantages that can be suited to particular types of organ production. Two of the most prominent types of organ printing are drop-based bioprinting and extrusion bioprinting. Numerous other ones do exist, though are not as commonly used, or are still in development. Drop-based bioprinting creates cellular constructs using individual droplets of a designated material, which has oftentimes been combined with a cell line. Polymerization is instigated by the presence of calcium ions on the substrate, which diffuse into the liquified bioink and allow for the formation of a solid gel. Drop-based bioprinting is commonly used due to its efficient speed, though this aspect makes it less suitable for more complicated organ structures. Extrusion bioprinting involves the constant deposition of a particular printing material and cell line from an extruder, a type of mobile print head. This tends to be a more controlled and gentler process for material or cell deposition, and allows for greater cell densities to be used in the construction of 3D tissue or organ structures. Such benefits are set back by the slower printing speeds entailed by this technique. Extrusion bioprinting is often coupled with UV light, which photopolymerizes the printed material to form a more stable, integrated construct.

Materials for 3D printing usually consist of alginate or fibrin polymers that have been integrated with cellular adhesion molecules, which support the physical attachment of cells. Such polymers are specifically designed to maintain structural stability and be receptive to cellular integration. The term "bioink" has been used as a broad classification of materials that are compatible with 3D bioprinting. Printing materials must fit a broad spectrum of criteria, one of the foremost being biocompatibility. The resulting scaffolds formed by 3D printed materials should be physically and chemically appropriate for cell proliferation. Biodegradability is another important factor, and insures that the artificially formed structure can be broken down upon successful transplantation, to be replaced by a completely natural cellular structure. Hydrogel alginates have emerged as one of the most commonly used materials in organ printing research, as they are highly customizable, and can be fine-tuned to simulate certain mechanical and biological properties characteristic of natural tissue.

Conclusions. A printable organ is an artificially constructed device designed for organ replacement, produced using 3D printing techniques.