3D Bioprinting

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What is It?

3D printing, if simply put, is a process whereby a printer is used to merge together a combination of ingredients in order to create a 3D object with specified dimensions. 3D printing has been used in the field of medicine extensively for almost over a decade. Ranging from printing limb prosthetics to patient-specific surgical models, 3D printing has a wide range of implications. Recently, however, an improved version of 3D printing has been introduced with promising potentials. This new and improved method combines organic ingredients to replicate body parts that imitate natural tissues, and is termed as 3D BIOPRINTING[1].

How Does It Work?

3D Bioprinting works on the same principles underlying 3D printing. A printer takes in ingredients and some information, and prints out the final model – as best as it can. The difference lies in the type of ingredients and the use of the medium, and of course the final products!

Ingredients used for Bioprinting are organic and living: usually living cells in the form of either differentiated cells with regenerative potential, or Pluripotent Stem Cells (Embryonic or induced). The medium or the scaffold material, used to suspend the cells in the right dimensions to produce 3D structures, can be natural polymers or synthetic hydrogels[1].

Main Implications

Bioprinting is far from being perfect, and there is still a long way to go before actual life sized hollow and solid human organs, such as the bladder and the heart, can be formed and transplanted into patients. Despite this, bioprinting has already found ways to influence the progress of medical field and its dimensions.

LOCS

One of the major innovations bioprinting has given us is a lab-on-a-chip (LOC) device. This is essentially a copy of human tissue developed through bioprinting, and mounted on a chip which can then be used in statistical and various other analysis – including PCR and microarrays. The advantage of LOCs is that they can, and have in several studies, replaced animal subjects in the testing phase. The microfluidity and tissue architecture as well as the density mimics that of a natural tissue from an animal's body and, thus, recreates the same environment on a small chip[2].

Bone Grafts

Bioprinting has also been shown to be successful in bone grafts. The most notable progress comes from the researchers at Swansea University at Wales, where they have been able to create artificial bone materials using durable and regenerative materials. AMBER science foundation, and Trinity College, both located in Ireland, have been successful in creating bone materials to help fill the defects caused by bone tumor resection and infections. The University of Nottingham, England, has made it possible to create a bio printed copy of bone, covered with stem cells, creating a scaffold that is put inside the patient where it grows and forms a new bone! This innovation is explained by the model of 4D Bioprinting, which is basically bioprinting combined with the aspect of "time". The notion here is that 3D printed bio-structures are made which can change their shape over time under various stimuli[3].

Skin and Cartilage

Skin is another area proven successful for Bioprinting. Researchers at Wake forest school of Medicine, North Carolina, have been able to help patients with superficial burn wounds which leave a skin defect. The idea here is that the printer analyses the wound information and prints out new skin to be used on the patient. Researchers are hoping to replicate both epidermal and dermal layers of the skin in the near future. Cartilage repair has been looked into with this technology. However, these 3D printed cartilage scaffolds are far from practical as of yet due to limited cytocompatibility. Research has been made into a newer, more practical technique known as In-Situ crosslinking which might prove to be useful in the coming times[4].

Blood Vessels

Bio-printed blood vessels have greater benefits as they have the possibility of both being an excellent graft for patients, as well as being a subject for drug testing and personalized medicine. In fact, the LOCs described earlier contain blood vessels more than any other organ as the "lab" on a chip[5].

Socio-Ethical Dimensions

Bioprinting, however promising, is still in its early stages of life, and to say that the "hype" about it has been out of proportion, no matter the success so far, would not be wrong. A technology as revolutionizing as this, which can eventually eliminate the needs of a donor for organs, requires time and multiple stages before it can be perfected. And the stage of perfection could be away ranging anywhere from a decade to a century – or perhaps, even more. Because of its potential, this revolutionary technology is not without socio-ethical blocks which might alter the prospect of this technology altogether.

One highly worrisome aspect of Bioprinting is that the technology will be expensive, and, thus, will not be available for everyone – as is true for many expensive procedures available today. This is potentially dangerous as it might further propel the rift between the higher and the middle-income classes. Consensus indicates that the high-income class might be the only class to ever benefit from this technology once it becomes available, and the rest may have to rely on presently available system of organ donation.

Since this technology remains an untested clinical paradigm making use of living cells, risks of teratomas, cancer, and dislodgment of implants remain unanswered. Due to infancy of this procedure, there is dearth of studies that describe its long-term effects. More research and analysis are required before the technology actually starts helping people effectively.

One very peculiar risk involved is the issue of ownership. This revolves around the idea of how exactly the law looks at 3D printed grafts. One could consider defining them as machines used for medical purposes, which makes then patentable: meaning that they can be "owned" by the patients. If, however, by definition they are described as medical techniques involving direct printing onto or into the body, the law renders them not patentable. A further evaluation and a strong legal consideration are required to settle the dust on this aspect. A joint consideration of medical and legal faculties is strongly recommended[6].

The Future

Bioprinting shows immense potential and despite the current limitations, many believe it to be the possible highlight of the coming future. Limitations include suitable bio inks with bio compatibility and strength to hold printed layers of organs. The limited success this technology has had in printing solid organs such as heart and kidneys may be a restricting factor for now, but scientists believe that the right blend of bio ink and newer ways for assembly will come and revolutionize the field of medicine once again. Studies in the near future will possibly revolve around printing micro organs, such as pancreas, that may be able to function in the absence of the original organ.

Conclusion

Bioprinting has been drawing increasing attention as a fabrication technology for producing scaffolds of cells meant to replicate human organs. Main advantages lie in precise control, and individual design of the organ which makes it great for replicating disease scenarios.

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